Part D

Environmental Impact Assessment

TABLE OF CONTENTS

List of Tables

List of Figures

D. ENVIRONMENTAL IMPACT ASSESSMENT

This section of the Pengrowth Lindbergh SAGD Expansion Project (the Project, or Phase 2) application constitutes the Environmental Impact Assessment (EIA) for the Project. Environmental baseline reports and impact assessments for each environmental discipline are contained in Consultant Reports (CR #1 to CR #11). This section includes Pengrowth'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 the Project. 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.

The Project will expand bitumen production of the Lindbergh SAGD Project (Phase 1) from 1,987 m^3/day (12,500 barrels per day (bpd)) to 4,770 m^3/day (30,000 bpd).

Pengrowth is currently constructing Phase 1 and is expected to commence circulation and steam injection in Q4 2014. Major project components associated with Phase 1 include a central processing facility (CPF), well pads, borrow pits, construction and operations camps, and access and utility corridors. The Project is designed to process an additional 2,782 m^3/d (17,500 bpd) of bitumen for approximately 25 years. The Phase 2 expansion components for the CPF will be built within the existing Phase 1 CPF footprint. Over the life of the Project, a number of well pads, borrow pits and access roads will be required to maintain production. The total combined design capacity of the Lindbergh SAGD Expansion Project (Phase 1 + Phase 2) will be 4,770 m^3/d (30,000 bpd).

Pengrowth has identified two development scenarios, the Initial Development footprint required to bring production up to the design capacity of 4,770 m^3/day (30,000 bpd) and the Future Development required to sustain production for the life of the Project. The Project is expected to produce approximately 43.7 million m^3 (275 million barrels) of bitumen over 25 years. The Project footprint includes new clearing as well as previously disturbed area:

Initial Development Footprint (ha)

Well Pads – 21.4

- Borrow Pits – 9.3
- Soil Storage – 10.4
- Access and Utility Corridor – 24.4

Future Development (ha)

- Well Pads – 211.1
- Borrow Pits – 100.1
- Soil Storage – 132.5
- Access and Utility Corridor – 303.6

The Final Terms of Reference (FTOR) were issued for the Project on December 13, 2013 and contained a number of conditions related to the information requirements for this EIA. These conditions from the FTOR have been addressed in this section of the report and in the specific Consultant's Reports.

The Project 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 the Project; 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 FTOR 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 the Project 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 the Project 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

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

The final Terms of Reference (TOR) for the Project (ESRD 2013a) are provided in the Project Application. The following TOR relating to air quality have been addressed in this report:

2.5 Air Emissions Management

[A]. Discuss the selection criteria used, options considered, and rationale for selecting control technologies to minimize air emission and ensure 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) control technologies used to reduce emissions;

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

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

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

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

m) 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 critical loading criteria;

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

f) describe air quality impacts resulting from the Project, and their implications for other environmental resources.

[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.

[C] Summarize the results of the noise assessment conducted for the AER, 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 AER's Directive 38: Noise Control.

The air quality regional study area (RSA), local study area (LSA) and modelling domain are shown on CR #1, Figure 2.3-1. The 40 by 40 km LSA was designed to meet the recommendation that the predicted Project-only concentration at the edge of the LSA is equal to 10% of the *Alberta Ambient Air Quality Objectives* (AAAQO), or the ambient background, whichever is greater (ESRD 2013b). Additionally, the LSA was selected to include key areas for effects assessment, such as Muriel Lake, and to exclude large regional sources as much as possible so that the impacts of the Project could be differentiated from regional projects.

The RSA was based on the location of major regional industrial emission sources. The RSA is 200 km by 200 km, extending east beyond the Saskatchewan border and equidistant from the Project to the west. The study area extends south to Vermillion and northward beyond Cold Lake and Primrose Lake. The RSA was chosen to include all oil sands and conventional emissions in the Cold Lake area. The influence of northern oil sands emissions beyond 100 km from the Project was accounted for in background concentrations.

For the Project, the main emission sources are steam generation, cogeneration units and small stack sources. Additionally, the following chemicals of potential concern were identified:

- sulphur dioxide (SO_2);
- oxides of nitrogen ($NO_{X)}$;
- carbon monoxide (CO);
- hydrogen sulphide (H_2S) and other reduced sulphur compounds;

- volatile organic compounds (VOC);
- polycyclic aromatic hydrocarbons (PAH);
- particulate matter with a mean aerodynamic diameter of 2.5 µm or smaller ($PM_{2.5}$); and
- GHGs.

The Project is also a source of trace quantities of H_2S and reduced sulphur compounds. These compounds are emitted from fugitive sources, and they can contribute to potential odour issues. H_2S and other reduced sulphur compounds were considered to be a key indicator.

The air quality modelling approach, including CALMET and CALPUFF modelling parameterization, used for the Project is described in CR #1, Appendix A. An overview of Project emissions is presented in CR #1, Section 4, with emissions basis and regional emissions presented in CR #1, Appendix B. The dispersion model was applied to the three assessment scenarios, including Baseline Case, Application Case, and Planned Development Case. Predictions were made at specific locations in the discrete, community and health receptors. Receptor locations are presented in Table D.1.1-1 and also shown on CR#1, Table 2.5-3. Maximum points of impingement concentration in the RSA and LSA were based on modelling within the grid of receptors.

Table D.1.1-1 Location Air/Health Receptors

Receptor	Description	Category	UTM-E [m]	UTM-N [m]	Distance to Project[(a)] [km]
1	Pengrowth - Supervisors Camp	Camp	525407	5984439	4
2	Pengrowth Operator's Camp	Camp	524868	5986973	1
3	Kehewin	Community	516892	5997241	12
4	Gurneyville	Community	516096	5998898	14
5	NW Muriel Lake Residences	Community	516684	6002188	16
6	Lindbergh	Community	521543	5969485	19
7	Riverview	Community	523434	5968015	20
8	Chief Napeweaw Comprehensive School	Community	539598	5968935	24
9	Morning Sky Health & Wellness Centre	Community	539785	5969053	24
10	Hoselaw	Community	506413	6003396	24
11	Elk Point	Community	506489	5972153	24
12	North Beach Along Frog Lake	Recreational	542166	5981371	19
13	Riel Beach - Frog Lake	Recreational	542173	5981369	19
14	Kehewin Provincial Recreational Area	Recreational	506241	5987665	19
15	Elk Point Municipal Recreational Area	Recreational	505173	5970648	26

Table D.1.1-1 Location Air/Health Receptors

Receptor	Description	Category	UTM-E [m]	UTM-N [m]	Distance to Project[(a)] [km]
16	South Muriel Lake Residences - A	Residential	520726	5995548	9
17	South Muriel Lake Residences - B	Residential	519336	5996452	10
18	South Muriel Lake Residences - C	Residential	516468	5996665	12
19	East Muriel Lake Residences	Residential	525372	6001028	13
20	Farm	Residential	509620	6006903	24
21	Farm - East of Buffalo Trail	Residential	506428	6004836	25
22	Lakeview Drive - Laurier Lake	Residential	532599	5968485	56
23	Kehewin IR #123 - Northwest	First Nations	506309	6000172	22
24	Kehewin IR #123 - Northeast	First Nations	514236	5998981	15
25	Kehewin IR #123 - Southwest	First Nations	507281	5990270	18
26	Kehewin IR #123 - Southeast	First Nations	515518	5990397	10
27	Puskiakiwenin IR # 122 - NW Corner	First Nations	531732	5984761	8
28	Puskiakiwenin IR # 122 - SE Shore	First Nations	540536	5975429	20
29	Puskiakiwenin IR #122 - SW Corner	First Nations	531930	5971789	18
30	Bonnyville	Community	517498	6013272	26
31	Sputinow / Fishing Lake Metis Settlement	Community	548138	5974890	27
32	Frog Lake	Community	539400	5965078	27
33	Tulliby Lake	Community	548184	5965563	32
34	St. Paul	Community	480606	5982466	45
35	City of Cold Lake Grand Centre	Community	551023	6029768	49
36	Riverhurst Community Centre	Community	541585	6034437	49
37	City of Cold Lake - North	Community	553280	6035587	55
38	Cold Lake	Community	553740	6035616	56
39	Pierceland	Community	579443	6021976	64
40	Beauvallon	Community	475840	5945623	65
41	Innisfree	Community	464682	5914616	95
42	Elizabeth Metis Settlement	First Nations	558430	6008287	39

Table D.1.1-1 Location Air/Health Receptors

Receptor	Description	Category	UTM-E [m]	UTM-N [m]	Distance to Project[(a)] [km]
43	Cold Lake IR # 149 - Northwest	First Nations	540545	6022928	38
44	Cold Lake IR # 149 - Northeast	First Nations	551250	6022839	44
45	Cold Lake IR # 149 - Southwest	First Nations	540664	6010465	27
46	Cold Lake IR # 149 - Southeast	First Nations	551416	6010511	35
47	Cold Lake IR # 149B - Southwest	First Nations	544870	6037030	53
48	Cold Lake IR #149B - Southeast	First Nations	549681	6037078	55
49	Cold Lake IR #149B - Centre	First Nations	548570	6039415	57
50	Cold Lake IR #149B - Lake Shore	First Nations	551306	6042823	61
51	Cold Lake IR # 149B - Northeast	First Nations	548659	6044268	61
52	Cold Lake IR #149C - Southwest	First Nations	559160	6062714	82
53	Cold Lake IR #149C - Northwest	First Nations	562015	6064550	85
54	Cold Lake IR #149C - Northeast	First Nations	564078	6064155	86
55	Cold Lake IR #149C - Centre	First Nations	559643	6067130	86
56	Cold Lake IR #149C - East	First Nations	564004	6067190	88
57	Unipouhenous IR #121 - SE Corner	First Nations	547899	5964415	33
58	Unipouhenous IR #121 - SW Corner	First Nations	537430	5965299	26
59	Big Island Cree Nation / Pierceland SK	First Nations	579408	6021975	64
60	Big Island Lake Cree Nation-1 (formerly Joseph Bighead First Nation)	First Nations	589813	6033934	80
61	Big Island Lake Cree Nation-2	First Nations	585828	6028384	73
62	Big Island Lake Cree Nation-3	First Nations	590512	6031178	79

Table D.1.1-1 Location Air/Health Receptors

Receptor	Description	Category	UTM-E [m]	UTM-N [m]	Distance to Project[(a)] [km]
63	Big Island Lake Cree Nation-4	First Nations	595113	6034218	84
64	Big Island Lake Cree Nation-5	First Nations	595524	6028960	82
65	Onion Lake First Nation - School 1	First Nations	568724	5951895	57
66	Onion Lake First Nation - School 2	First Nations	570055	5943902	63
67	Cabin northwest of Marie Lake	First Nations	539701	6057310	71
68	Centre Osum Lease Cabin	First Nations	557206	6059346	78
69	East Osum Lease Cabin	First Nations	559429	6058441	78
70	Northeast Osum Lease Cabin	First Nations	557492	6060111	79
71	Cabin north of May Lake	First Nations	537369	6066184	79
72	Whitefish (Goodfish) Lake First Nation #128	First Nations	444619	6029040	90
73	Saddle Lake IR #125 - NW Corner	First Nations	447798	5991500	77
74	Saddle Lake IR #125 - SE Corner	First Nations	467492	5973172	59
75	Makapoo IR #120 - SW Corner	First Nations	561725	5943526	58
76	Makapoo IR #120 - NW Corner	First Nations	561727	5952290	51
77	Seekaskootch IR#119 - NE Corner	First Nations	578331	5957940	61
78	Seekaskootch IR#119 - SE Corner	First Nations	578666	5943667	70
79	Makwa Sahgaiehcan First Nation	First Nations	620442	5988074	96
80	Island Lake First Nation	First Nations	587052	5990057	62
81	Canadian Forces Base Cold Lake	Industrial	546889	6029024	47
82	Elk Point Golf Course	Recreational	504928	5970619	26
83	Mannville Riverview Golf Course	Recreational	490234	5913677	82
84	Lea Park Golf Club	Recreational	543937	5930713	60

Table D.1.1-1 Location Air/Health Receptors

Receptor	Description	Category	UTM-E [m]	UTM-N [m]	Distance to Project[(a)] [km]
85	Kitscoty Golf Club	Recreational	544722	5910035	80
86	Myrnam Derwent Golf & Country Club	Recreational	484714	5945783	58
87	St. Paul Golf Club	Recreational	479432	5982107	46
88	Whitney Lake Provincial Park - Ross Lake Campground	Recreational	533939	5963651	26
89	Moose Lake Provincial Park Campground	Recreational	504426	6012880	32
90	Franchere Bay Campground	Recreational	499727	6012183	35
91	Franchere Bay Campground	Recreational	499690	6012211	35
92	Stoney Lake Municipal Recreational Area	Recreational	494530	5968708	36
93	Whitney Lake Provincial Park - Whitney Lake Campground	Recreational	529648	5964473	24
94	Cold Lake Municipal District Park	Recreational	551639	6036859	56
95	Cold Lake Provincial Park (Lund's Point)	Recreational	556307	6035894	57
96	French Bay Provincial Recreation Area	Recreational	563145	6032174	58
97	Ethel Lake Provincial Recreation Area and Campground	Recreational	543069	6044258	59
98	Ski Hill at French Bay	Recreational	563680	6032810	59
99	English Bay Provincial Recreation Area And Campground	Recreational	550525	6048019	65
100	Marie Lake Campground	Recreational	548196	6051938	68
101	Northeast Marie Lake (Shelter Bay)	Recreational	540900	6056040	70
102	Northwest Marie Lake	Recreational	547535	6056383	72
103	Meadow Lake Provincial Park (Hirtz Lake)	Recreational	577567	6037412	72
104	NW Cold Lake Campsite	Recreational	554491	6054842	73
105	North Cold Lake Campground	Recreational	560232	6053308	74
106	Garner Lake Provincial Park	Recreational	452346	6003974	74
107	Meadow Lake Provincial Park (Sandy Beach)	Recreational	581381	6038060	76
108	Cold Lake Provincial Park	Recreational	557874	6056182	76
109	Fork Lake Recreational Area	Recreational	464418	6034085	76

Table D.1.1-1 Location Air/Health Receptors

Receptor	Description	Category	UTM-E [m]	UTM-N [m]	Distance to Project[(a)] [km]
110	Hidden Lake Campground	Recreational	524119	5911421	77
111	Northwest Meadow Lake Provincial Park	Recreational	574853	6046706	77
112	Vermillion Provincial Park	Recreational	506575	5913062	77
113	Meadow Lake Provincial Park (Howe Bay)	Recreational	586880	6038429	80
114	Makwa Lake Provincial Park	Recreational	615015	5991291	90
115	Pine Cove Campground	Recreational	616234	5995411	92
116	Loon Lake Golf and Country Club	Recreational	617633	5986408	93
117	Chickenhill Lake M.D. Park	Recreational	493431	5995973	32
118	Floating Stone Lake Recreational Area	Recreational	459404	6007372	68
119	Two Hills Lions Golf and Country Club	Recreational	450130	5951878	83
120	Bonnyville Beach	Residential	508613	6008615	26
121	Pelican Narrows	Residential	507445	6011238	29
122	Residence	Residential	518852	5940994	47
123	Crane Lake Residences	Residential	528529	6039217	51
124	Tucker Lake Residences	Residential	523120	6042742	55
125	Hilda Lake Residences	Residential	537912	6041282	55
126	South Marie Lake Residential Area	Residential	545469	6049883	65
127	West Cold Lake Residential Area	Residential	551061	6049476	67
128	East Marie Lake Residential Area	Residential	549449	6053978	70
129	Northwest Cold Lake Residential Area	Residential	553838	6053793	72
130	North Cold Lake Residential Area	Residential	554456	6054656	73
131	South Burnt Lake Cabins	Residential	537827	6072111	85
132	Bluebird Drive - Laurier Lake	Residential	532873	5966714	23
133	Laurier Avenue - Laurier Lake	Residential	531675	5966495	23

[(a)] Distance to Cogeneration Unit #3 (Phase 2)

D.1.2 BASELINE CONDITIONS

D.1.2.1 Background Concentrations

Background concentrations must be considered in the assessment (ESRD 2013b). According to guidance (ESRD 2013b), 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. For this Project, background concentrations of SO_2 and NO_x were obtained from the St. Lina, for the period January 2008 – December 2012. The $PM_{2.5}$ background concentration was taken from the Cold Lake monitoring station, for the period January 2008 – December 2012. The CO background concentration was obtained from the Fort McMurray Athabasca Valley monitoring station for the period January 2008 – December 2012, as there are no CO continuous measurements in the LICA network. Background concentrations that were added to predictions are listed in Table D.1.2-1.

Background values were not added to the modelling predictions for VOCs and PAHs as background measurements were only available from heavily industrialized areas, which is not indicative of this Project area.

Table D.1.2-1 Ambient Background Concentrations of Modelled Criteria Air Contaminants (CACs)

Compounds	Hourly ($\mu g/m^3$)	8-Hour ($\mu g/m^3$)	24-Hour ($\mu g/m^3$)	Monthly ($\mu g/m^3$)	Annual ($\mu g/m^3$)	Data Source
SO_2	2.6	–	1.6	0.9	0.0	St. Lina, 2008 – 2012 (LICA)
NO_X	9.4	–	–	–	1.9	St. Lina, 2008 – 2012 (LICA)
$PM_{2.5}$	12	–	10	–	–	Cold Lake, 2008 – 2012 (LICA)
CO	344	344	–	–	–	Athabasca Valley, 2008-2012 (WBEA)

– averaging period not assessed for chemical

D.1.2.2 Baseline Concentrations

Sulphur Dioxide

The CALPUFF model was used to estimate the concentration of SO_2 that would occur for the three assessment scenarios (CR #1, Table 5.1-1). No exceedances of the SO_2 AAAQO were predicted at any location for any averaging period.

Nitrogen Oxides

The CALPUFF model was used to estimate the concentration of NO_2 that would occur for the three assessment scenarios. Using the ozone limiting method to convert NO_x to NO_2, the model

resulted in no predicted exceedances of the AAAQOs of NO_2 at any averaging period for the Baseline Case (CR #1, Table 5.2-1 and 5.2-2).

Carbon Monoxide

The CALPUFF model was used to estimate the concentration of CO. The results indicate that there are no exceedances of the AAAQOs at the MPOI or any of the receptors for the Baseline Case or averaging period (CR #1, Table 5.3-1). Predicted concentrations at Health Receptors were well below AAAQOs.

$PM_{2.5}$

The CALPUFF model was used to estimate the concentration of ground-level $PM_{2.5}$ (CR #1, Table 5.4-1) for each of the three assessment scenarios. The secondary production of nitrates and sulphates within the dispersion model was included in the predicted results along with direct emissions. $PM_{2.5}$ concentrations were not depleted by deposition.

The AAAQG for the 9th highest hourly ground-level prediction is exceeded at both the RSA-MPOI and LSA-MPOI, as well as at several health receptors.

For the maximum daily predictions, exceedances at the MPOIs were predicted in the Baseline Case. There is a higher level of uncertainty and conservatism in regional community and highway emission estimates, particularly for $PM_{2.5}$, which led to these exceedances.

Potential Acid Input

Deposition includes both wet and dry processes and can result in the long-term accumulation of atmospheric emissions (primarily, NO_X and SO_2) in aquatic and terrestrial ecosystems. The PAI modelling assumed a regionally varying background based on Cheng (2009). The results of CALPUFF modelling are shown in CR #1, Table 5.5-1.

The maximum predicted PAI value in the RSA is approximately 0.18 keq/ha/yr in the Baseline Case. In the LSA, the maximum predicted PAI is 0.12 keq/ha/yr in the Baseline case, located near the community of Elk Point. The spatial distribution of PAI across the study areas is shown in CR #1, Figures 5.5-1 to 5.5-3.

Nitrogen Deposition Leading to Eutrophication

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. NO_2 was assumed to be deposited by dry processes only, based on annual average predicted concentrations and a locally determined deposition velocity. CALPUFF calculates nitrogen deposition from all these sources.

The results of CALPUFF modelling are listed in CR #1, Table 5.6-1, indicating that the regional maximum predicted nitrogen deposition was 5.3 kg/ha/yr for the Baseline Case.

Hydrogen Sulphide

The Project emits H_2S as low-level fugitive emissions emanating from the process and storage areas in the CPF. Fugitive H_2S emissions from regional sources were included in the Baseline assessment. All predictions, for both hourly and daily averaging periods, in the LSA and RSA were within or met the AAAQOs (CR #1, Table 5.7-1).

Other Trace Components

Trace emissions of some VOCs and PAHs will be produced by incomplete combustion from Project sources. CR #1, Appendix B provides a more detailed discussion of emission sources and estimates, both for the Project and regionally.

Ground-level concentration predictions of other trace compounds at MPOI, community, and receptor locations near the Project, for compounds which are subject to AAAQOs, are presented in CR #1, Tables 5.8-1 to 5.8-9. Effects from a longer list of compounds are presented in the odour assessment (CR #1, Section 5.9) and the human health risk assessment (CR #5). A summary of modelling results for all chemicals is presented in CR #1, Appendix D. Model predictions for all but one chemical were below AAAQOs in all emission scenarios.

Exceedances of the AAAQO at the regional MPOI were predicted for benzo(a)pyrene in the Baseline Case. This exceedance was not increased by the addition of the Project. Regional traffic emissions are the primary source of benzo(a)pyrene in this assessment; as with NO_X, CO and $PM_{2.5}$, these emission estimates are assumed to be conservative (CR #1, Appendix B).

Odour

A summary of the chemicals included in the odour assessment is presented in CR #1, Table 5.9-1.

The odour threshold was exceeded for H_2S. CR #1, Table 5.9-2 compares the predicted 3-minute concentrations of H_2S the odour threshold. The RSA-MPOI in the Baseline is located at the Cenovus Foster Creek facility, with a frequency of exceedance of 0.13%. In the LSA, and along the CPF fence, there is a small potential for odour in the Baseline Case (from the Lindbergh SAGD Project).

Odour potential, from the aggregate exposure of multiple odorous compounds, is not expected at any health receptors in the Baseline Case.

Ozone

Surface O_3 can be formed through photochemical production 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°C) and stagnant weather conditions (*i.e.*, low wind speeds).

Observations of O_3 at Cold Lake and St. Linea in the LICA region have been summarized in CR #1, Appendix C for 2008-2012. The maximum hourly values were 139 µg/m^3 at Cold Lake

South and 126 µg/m^3 at St. Lina. Median O_3 concentrations have peaks in May or June with the highest peak values in April and May. Median measurements were 55 µg/m^3 at St. Lina and 51 µg/m^3 at Cold Lake South. Median O_3 concentrations at both stations peak in mid-afternoon. The 4th highest 8-hour concentrations were 106 µg/m^3 at St. Lina and 110 µg/m^3 at Cold Lake South (compared to the CWS of 128 µg/m^3).

D.1.3 PREDICTED CONDITIONS

D.1.3.1 Project Emissions

Combustion

The Project (Phase 2) includes the addition of three high-pressure steam boilers, one utility boiler, and three cogeneration units. The LP and HP flares are included in the Phase 1 design (CR #1, Section 4.1.1), and will be integrated with operations in the expanded facility. An emergency generator is also included in the design, and is assessed as an upset case. Emission rates of CACs associated with these sources are summarized in CR #1, Table 4.1-2.

Fugitive

Fugitive VOC emissions are expected from storage losses and from leaks from process fittings in the CPF area. The bulk fugitive emission rates from storage losses and from the processing area were based on estimates made for the Osum Taiga project (Osum 2009) and then pro-rated on the basis of bitumen production. Emission rates for individual VOC components were then determined using the speciation profile presented in the Osum Taiga EIA (Osum 2009). A vapour recovery unit (VRU) will be installed to control emissions from the storage tanks and 99.75% control efficiency was assumed for the VRU unit.

Fugitive emissions are summarized in CR #1, Table 4.1-3; detailed emission estimates of speciated VOC compounds from fugitive sources are presented in CR #1, Appendix B.

Trucking Emissions

It is anticipated that a pipeline will be ultimately constructed to serve the product transmission needs of the Project. As such arrangements have yet to be determined, this air quality assessment considered the trucking of bitumen for the purpose of providing a conservative assessment. Trucking emissions were based on the fuel consumption required to haul 12,500 bpd in the Baseline Case (Pilot + Phase 1), and 17,500 bpd for the expansion, resulting in 30,000 bpd in the Application Case. Trucking CAC emissions are summarized in CR #1, Table 4.1-4

Construction and Reclamation Emissions

Construction emissions (for both the well pads and the CPF) were estimated based on projected fuel consumption during the construction phase, which is expected to last approximately one year. It was estimated that 5,000,000 L of diesel will be required for the CPF construction phase, with an additional 2,000,000 L required for the construction of well pads. Construction phase emissions are expected to be emitted from construction equipment such as bulldozers, hoes,

excavators, graders, and haul trucks. Emissions from fugitive dust were not included in this assessment.

The construction, operations, and decommissioning/reclamation emission rates for the Project are compared in Table D.1.3-1. Reclamation emissions were assumed to be equal to construction emissions (Devon 2003, DOC 2011). Over the life of the Project, construction emission rates range from 0.9% to 14% of the typical operations emissions. As such, emissions from the construction phase were not assessed as their maximum air quality impacts are expected to be small compared to the impacts from normal operations.

Table D.1.3-1 Comparison of Construction and Operations Emissions

Contaminant	Construction Emission [t/d]	Operations Emissions [t/d]	Reclamation Emissions [t/d]	Ratio of Construction to Operations [%]
SO_2	0.016	1.777	0.016	0.92
NO_x	0.382	2.808	0.382	13.6
CO	0.236	2.143	0.236	11.0
$PM_{2.5}$	0.014	0.198	0.014	6.9

Water Vapour Emission Rates

The primary sources of water vapour emissions from the Project are the steam boilers. The cogeneration units were also considered as secondary sources. CR #1, Table 4.1-12 shows the calculated water vapour emission rates for each emissions source. The water vapour emissions were calculated as part of the engineering process simulation, and total emissions from Project were estimated at 2,002 tonnes/day. Visibility was assessed considering sources from Phase 1 and Phase 2 operating simultaneously.

Upset Emissions

The Project design includes a flare stack to be used as an emergency system. Upset Case 1 has been identified as the worst-case scenario (CR #1, Table 4.1-13), which results when the boilers are offline, causing all produced gas to be routed to the HP flare. This event is expected to occur up to eight times per year, lasting up to 4 hours.

Upset Case 2 results when there is a regulator failure at the let-down station for pipeline fuel gas (natural gas) to boilers (CR #1, Table 4.1-13). This scenario is estimated to occur once per year, and will last up to 15 minutes.

It is estimated that there will be up to four power outages per year which will require back-up power to be provided by two emergency diesel generators. Upset Case 3 includes all Project emissions from normal operations, plus emissions from each of the two emergency generators (CR #1, Table 4.1-14).

D.1.3.2 Regional Emissions

Emissions within the RSA from existing operating facilities, approved but not yet operating facilities, and proposed facilities including those under regulatory review, were collected from various public domain documents. 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.1.3-2).

The bases of regional emissions estimations are outlined in detail in CR #1, Appendix B. The RSA emission rates of CACs and total VOCs for the three emission scenarios are summarized in Table D.1.3-2. The project inclusion list for each of the scenarios is presented in Table D.1.3-2.

Table D.1.3-2 Summary of Emission Rates by Emission Case

Emission Scenarios	Emission Rates [t/d]				
	SO_2	NO_x	CO	VOC	$PM_{2.5}$
Baseline	39	112	133	13	17
Application	40	114	135	13	17
Planned Development Case	41	118	146	14	18
Lindbergh – Existing and Approved	0.64	1.24	0.98	0.13	0.09
Lindbergh – Expanded Facility	1.84	2.92	2.27	0.31	0.21
Lindbergh – Expansion Only	1.2	1.68	1.29	0.18	0.12

D.1.3.3 Predicted Concentrations

Sulphur Dioxide

The CALPUFF model was used to estimate the concentration of SO_2 that would occur for the three assessment scenarios. The results at the local and regional maximum points of impingement (RSA- and LSA-MPOIs), along the AQ Project Modelling boundary, as well as for the Health Receptors, are summarized in CR #1, Table 5.1-1. No exceedances of the SO_2 AAAQO were predicted at any location for any averaging period.

The RSA-MPOI (277 µg/m^3) for the 9th highest (99.9th percentile) hourly averaging period is located near the Imperial Oil Cold Lake Project, just east of the Maskwa Plant. Within the LSA, the 99.9th percentile hourly MPOI is located near the CPF, and increases to 118 µg/m^3 in the Application Case (from 95 µg/m^3 in the Baseline Case). It did not increase further in the PDC. The patterns of SO_2 concentration for the 9th highest 1-hour averaging period are shown on CR #1, Figures 5.1-1 to 5.1-3.

The RSA-MPOIs for the maximum daily, maximum 30-day and annual averaging periods are all also located near the Imperial Oil Maskwa Plant. The addition of the Project of the proposed developments in the PDC does not cause any increase at the RSA-MPOI. The location of the MPOI did not change with the addition of the Project, but increased in magnitude with the

additional emissions. The patterns of SO_2 concentration for the maximum daily averaging period are shown on CR #1, Figures 5.1-4 to 5.1-6.

The RSA-MPOIs for the maximum 30-day averaging periods is located near the Imperial Oil Maskwa Plant for all assessment cases. With the Lindbergh SAGD Expansion Project, the 30 day LSA-MPOI shifts to just east of the CPF, with the magnitude marginally increasing. This prediction marginally increased in the PDC, but did not change locations. The patterns of SO_2 concentration for the maximum 30-dayaveraging period are shown on CR #1, Figures 5.1-7 to 5.1-9.

The RSA-MPOI (8.2 µg/m^3) for the annual averaging period is located near the Imperial Oil Cold Lake Project, just east of the Maskwa Plant. The LSA-MPOI for the annual averaging period shifts to the vicinity of the Lindbergh facility in the Application Case. The prediction marginally increases from the Baseline to Application Case, and does not change with the PDC. The patterns of SO_2 concentration for the annual period are shown on CR #1, Figures 5.1-10 to 5.1-11.

Nitrogen Dioxide

The CALPUFF model was used to estimate the concentration of NO_2 that would occur for the three assessment scenarios. The model resulted in no predicted exceedances of the AAAQOs of NO_2 for any of the assessment scenarios at any averaging period (CR #1, Table 5.2-2).

The same as the Baseline Case, the RSA-MPOI and LSA-MPOI were co-located in the northwest corner of the LSA for the Application Case and the PDC. The 9th highest hourly predictions were driven by regional vehicle emissions, along highways and in communities. The addition of the Project did not contribute appreciably to the predictions at this location. Along the CPF fenceline, there is a 21% increase in NO_2 predictions in the Application Case over the Baseline Case, and no further increases in the PDC. NO_2 hourly predictions, as calculated using OLM, were below the relevant AAAQOs. The patterns of NO_2 concentration for the hourly averaging period are shown on CR #1, Figures 5.2-1 to 5.2-2.

The patterns of NO_2 concentration for 9th highest 1-hour and annual averages are shown on CR #1, Figures 5.2-1 to 5.2-6, respectively. Ground-level NO_2 concentrations, as calculated using OLM, were below the relevant AAAQOs. The patterns of NO_2 concentration for the annual averaging period are shown on CR #1, Figures 5.2-1 to 5.2-2.

Carbon Monoxide

The CALPUFF model was used to estimate the concentration of CO that would occur for the three assessment scenarios. Results indicate that there are no exceedances of the AAAQOs at the MPOI or any of the receptors for any emission scenario or averaging period (CR #1, Table 5.3-1). Predicted concentrations at Health Receptors were well below AAAQOs.

For the 9th highest hourly predictions, the RSA-MPOIs occur near Bonnyville for both the Application Case and the PDC, same as with the Baseline Case. The addition of the Project does not influence the regional MPOI. There is a marginal increase in the predicted value in the PDC,

as a result of projected increase in anthropogenic emissions from the community from population growth. The LSA-MPOI is located in the north-west corner of the LSA for the Application Case and the PDC, same as with the Baseline Case, influenced by regional emissions.

The patterns for the 2nd highest 8-hour predictions follow those of the hourly predictions. Again, the RSA-MPOI is located near Bonnyville for both the Application Case and the PDC, same as with the Baseline Case. The LSA-MPOI is located in the NW corner of the LSA, as shown in CR #1, Figures 5.3-4 to 5.3-6. The use of numerous assumptions in the estimation of community and transportation emissions, and the methodology of apportioning regional emissions to specific areas, results in an increased level of uncertainty and conservatism in the emissions estimates, particularly for CO and NO_X (CR #1, Appendix B). In areas where several highways intersect, near communities such as Bonnyville, the predicted ground level concentrations are likely conservative.

$PM_{2.5}$

The CALPUFF model was used to estimate the concentration of ground-level $PM_{2.5}$ for each of the three assessment scenarios CR #1, Table 5.4-1. The secondary production of nitrates and sulphates within the dispersion model was included in the predicted results along with direct emissions. $PM_{2.5}$ concentrations were not depleted by deposition.

The AAAQG for the 9th highest hourly ground-level prediction is exceeded at both the RSA-MPOI and LSA-MPOI, as well as at several health receptors. These exceedances exist in the Baseline Case and were not increased by the addition of the Project for the Application Case and the PDC. The RSA-MPOIs occur near Bonnyville, with the LSA MOIs located in the northwest corner of the LSA, influenced by Bonnyville and transportation emissions.

The maximum daily predictions follow the same pattern as the hourly predictions, with the RSA-MPOI located near Bonnyville, and the LSA-MPOI in the northwest corner of the LSA. Exceedances at the MPOIs were predicted in the Baseline Case, and were increased by the addition of the Project in the Application and Planned Development Cases. Increases in maximum predictions were observed in the PDC, due to the increase in projected community emissions. The maximum 24-hour $PM_{2.5}$ concentrations are shown in CR #1, Figures 5.4-1 to 5.4-3.

There is a higher level of uncertainty and conservatism in regional community and highway emission estimates, particularly for $PM_{2.5}$ (see CR #1, Appendix B). Furthermore, an ambient background concentration, derived from monitoring data, was added to the CALPUFF predictions.

Potential Acid Input

The results of CALPUFF modelling are shown in CR #1, Table 5.5-1. The maximum predicted PAI value in the RSA is approximately 0.18 keq/ha/yr in the Application Case and the PDC. In the LSA, the maximum predicted PAI is 0.15 keq/ha/yr in the Application Case, located near the Lindbergh SAGD Facility. The spatial distribution of PAI across the study areas is shown in CR #1, Figures 5.5-1 to 5.5-3.

PAI averaged over 1º latitude by 1º longitude grid cells (CR #1, Table 5.5-2 and Figures 5.5-4 and 5.5-5) indicates an increase in the grid-average deposition by approximately 37% in the grid cell (southwest corner at 54º latitude and 111º longitude) in which the Project is located. The absolute magnitude of the predicted deposition is small, increasing from 0.05 keq/ha/yr in the Baseline to 0.06 keq/ha/yr in the Application Case. The increase is a result of the Project being added to an area in which the Baseline predictions are small.

Nitrogen Deposition Leading to Eutrophication

The results of CALPUFF modelling are listed in CR #1, Table 5.6-1, indicating that the regional maximum predicted nitrogen deposition was 5.4 kg/ha/yr for the Application case and 5.5 kg/ha/yr for the PDC. While there is just a small increase (2.1%) from the Baseline Case to the Application Case, the RSA-MPOI shifts to align with the LSA-MPOI near the Project rather than located near Bonnyville. Projected increases in community emissions in the PDC then shift the RSA-MPOI back to Bonnyville.

With the addition of the Project in the Application Case, the LSA-MPOI increases from 4.6 kg/ha/yr to 5.4 kg/ha/yr and shifts to the Lindbergh SAGD Project Area from the NW area of the LSA. The LSA-MPOI remains unchanged in the PDC.

The Project increase to the area of deposition above the threshold of 5 kg/ha/yr is marginal, less than 1 km^2 in the immediate vicinity of the CPF (CR #1, Figures 5.6-1 to 5.6-3). There were no areas in the study area with a load of greater than 10 kg/ha/yr.

Hydrogen Sulphide

The Project emits H_2S as low-level fugitive emissions emanating from the process and storage areas in the CPF. CALPUFF model predictions demonstrated there were no exceedances of 1-hour or 24-hour AAAQOs at or immediately beyond the Project facilities where the Project influence was greatest.

For the 9th highest hourly, the RSA-MPOIs were located near the Cenovus Foster Creek facility, as shown in CR #1, Figures 5.7-1 to 5.7-3, for the Application Case and the PDC. The addition of the Project in the Application Case did not increase the predictions at the RSA-MPOI (CR #1, Table 5.7-1). All LSA predictions were less than the AAAQO. The LSA-MPOI is located near the CPF as fugitive emissions from the facility (Phase 1) are the primary source of H_2S within the LSA. The addition of fugitive emissions from the Project increased the predicted value, but the location did not change. Predictions in the LSA did not increase further in the PDC.

With trends similar to above, the RSA-MPOI for the maximum daily predictions is also located near the Cenovus Foster Creek facility for the Application Case and the PDC. The Project contribution was negligible at this location; however, proposed expansion of the Foster Creek facility included in the PDC results in an increase in predictions in this assessment case. The LSA-MPOI is located along the CPF fenceline of the Project in both the Application Case and the PDC, the same as in the Baseline Case. Fugitive emissions from Phase 1 are the primary source for Application Case predictions as well, which increase by 56% with the addition of the Project emissions.

Other Trace Compounds

Trace emissions of some VOCs and PAHs will be produced by incomplete combustion from Project sources. CR #1, Appendix B provides a more detailed discussion of emission sources and estimates, both for the Project and regionally.

Ground-level concentration predictions of other trace compounds at MPOI, community, and receptor locations near the Project for compounds which are subject to AAAQOs are presented in CR #1, Tables 5.8-1 to 5.8-9. A summary of modelling results for all chemicals is presented in CR #1, Appendix D. Model predictions for all but one chemical were below AAAQOs in all emission scenarios.

Exceedances of the AAAQO at the regional MPOI were predicted for benzo(a)pyrene in the Application and Planned Development Cases as well. This exceedance was not increased by the addition of the Project.

Odour

A summary of the chemicals included in the odour assessment is presented in CR #1, Table 5.9-1 and indicates where the mean odour threshold was met or exceeded by the 3-minute prediction.

The odour threshold was exceeded for H_2S (CR #1, Table 5.9-2). The RSA-MPOI in the Application Case and the PDC is the same as the Baseline Case, located at the Cenovus Foster Creek facility; however, the proposed expansion of the Foster Creek Facility increases the magnitude and frequency of exceedance in the PDC. In Application and PDC, the LSA-MPOI is located along the CPF Boundary. The frequency of exceedance at this location is below 0.04%.

The results of the aggregate odour assessment demonstrate that the predicted frequency of odour potential is increased (CR #1, Table 5.9-3). The RSA-MPOI for odour potential is also located near the Cenovus Foster Creek facility. The addition of the Project does not contribute to any additional odour potential at this location (Application Case). The Foster Creek Expansion increases the odour potential at this location (Planned Development Case). In the LSA, and along the CPF fence, the addition of the Project increases the small potential for odour that was determined to be present in the Baseline Case.

Odour potential, from the aggregate exposure of multiple odorous compounds, is not expected at any health receptors, in any of the assessment cases.

Ozone

Using the CMAQ model, Fox and Kellerhals (2008) predicted base case 4th highest 8-hour concentrations in the area of the Project to range from 55 to 58 ppb (about 110 to 116 µg/m^3, similar to observations). In their future case, the 4th highest 8-hour concentrations increased by about 1%, consistent with the small predicted growth in oil and gas activity.

From CR #1, Table 4.3-1 for the PDC emission scenario, the Project contribution to RSA emissions is about 2.5% for NO_x and 2.2% for VOCs. Since Fox and Kellerhals forecast little increase (1%) in oil and gas emissions, the Project incremental contribution to local ozone

concentrations is likely to be about 2.5% of 1%. The CMAQ model approach indicated a negligible change in regional O_3 concentrations with the addition of the Project.

Water Vapour Plume Visibility

Predicted frequencies of visible plume occurrence are expected 16% of the time, with 73% of all visible plumes occurring in the winter months (CR #1, Table 5.11-1). The most frequently predicted plume height range (CR #1, Figure 5.11-1, left) was about 110-200 m above ground level in all seasons. The highest predicted plume heights were 600-700 m, occurring at a maximum frequency of 11% over the five-year period modelled. All plume tops, when visible, were above the tree canopy. The most frequently predicted plume lengths (CR #1, Figure 5.11-1, right) were about 500 m, with the potential for plumes to exceed 5 km in length. According to model results, about 10% of the predicted visible plumes may be longer than 5 km.

Upset Conditions

Upset Case 1 (CR #1, Section 4.1.7) is a worst-case SO_2 scenario, in which the produced gas to the steam boilers is re-routed to the HP flare. Dispersion modelling of Project SO_2 emissions predicted an increase in 1-hour concentrations at the LSA-MPOI and CPF Boundary, from 118 /m^3 in normal operations (Application Case) to 146 µg/m^3 under upset conditions (CR #1, Table 5.12-1). There was no change to the RSA-MPOI as this is located near the Imperial Oil Cold Lake facilities and is not influenced by the Project.

Upset Case 2 occurs when there is a regulator let-down failure necessitating all natural gas to be routed to the HP flare. The LSA-MPOI (Application Case) increases from 129 /m^3 to 176 µg/m^3 under upset conditions (CR #1, Table 5.12-2). The predicted concentration on the CPF Boundary decreases from 88 µg/m^3 to 78 /m^3 as all NO_2 emissions are being routed through the flare. The RSA-MPOI also increases from 129 /m^3 to 183 /m^3 and the location does not change.

The third upset case modelled is not a worst case scenario, but instead reflects additional emissions associated with the monthly testing of the emergency back-up generator for a maximum of hours. No changes in SO_2 and CO predictions between normal and upset conditions were predicted (CR #1, Table 5.12-3). The combustion of diesel fuel increases ground-level NO_2 predictions from 88 µg/m^3 to 204 µg/m^3 at the CPF Boundary. These predictions represent Lindbergh-only sources and do not include regional contributions.

Project Contribution to Regional Emissions

The Project will be developed in an airshed that has other emission sources, and the addition of the Project will decrease air quality. Table D.1.3-3 lists key emissions for each of the assessment cases and shows the contribution of the Project to the Baseline scenario. The contribution to emissions in the RSA ranges from 0.9% for $PM_{2.5}$ to 3.4% for SO_2, and all are considered negligible to small.

Table D.1.3-3 Comparison of Baseline, Application, and PDC Scenario Emissions					
Scenario	**SO_2**	**NO_X**	**CO**	**VOC**	**$PM_{2.5}$**
Lindbergh Expansion Project (t/d)	1.84	2.92	2.27	0.31	0.21
Baseline (t/d)	39	112	133	13	17
Application (t/d)	40	114	135	13	17
Application increase relative to Baseline (%)	*3.4*	*1.7*	*2.1*	*1.4*	*0.9*
PDC (t/d)	41	118	146	14	18
PDC increase relative to Baseline (%)	*4.6*	*5.4*	*10*	*6.0*	*3.3*

Table D.1.3-4 summarizes air quality concentrations predicted by CALPUFF. The air quality effects on key indicators are summarized:

- the AAAQOs were met for all averaging periods for SO_2, NO_2, and CO, at both the regional and local MPOIs, and at all receptor locations;
- $PM_{2.5}$ predicted concentrations were above the AAAQO in all assessment scenarios and at local and regional MPOIs. Exceedances were also predicted at a number of receptors in all assessment scenarios. The Project contribution to regional, local and facility boundary MPOIs was negligible;
- the AAAQOs for H_2S were met for all averaging periods and at all locations. Odour due to H_2S was predicted along the CPF boundary;
- the Project did not introduce any new, or contribute to any existing exceedance of the AAAQO, for modelled VOCs, RSCs, or PAHs. A regional exceedance of benzo(a)pyrene was predicted in the Baseline Case, and is attributed to highway emissions;
- the maximum PAI and nitrogen deposition loads in the RSA are not affected by the addition of the Project; and
- potentially visible (water vapour) plumes were predicted to occur about 16% of the time and most of them during winter night-time conditions.

Table D.1.3-4 Summary of Key Predicted Air Quality Concentrations (µg/m^3)

	SO_2					NO_2			$PM_{2.5}$			CO				H_2S		
	Max 1-hr	9th Highest 1-hr	Max 24-hr	Mthly	Annual	Max 1-hr	9th Highest 1-hr	Annual	Max 1-hr	9th Highest 1-hr	Max 24-hr	Max 1-hr	9th Highest 1-hr	Max 8-hr	2nd Highest 8-hr	Max 1-hr	9th Highest 1-hr	Max 24-hr
Baseline Case																		
RSA Maximum	928	277	78	16	8.2	245	129	32	314	104	45	6404	2130	1413	1409	8.1	5.3	2.0
LSA Maximum	322	95	34	5.0	2.4	245	129	32	314	101	32	6404	2075	1242	1049	8.1	5.3	2.0
CPF Boundary	165	95	34	3.9	1.4	95	73	14	27	21	15	849	651	522	515	8.1	5.3	2.0
Application Case																		
RSA Maximum	928	277	78	16	8.2	245	129	32	314	104	45	6404	2130	1413	1409	13	7.6	3.2
LSA Maximum	517	118	42	5.1	2.5	245	129	32	314	101	32	6404	2075	1242	1049	13	7.6	3.2
CPF Boundary	193	118	42	4.8	1.8	99	88	17	29	21	15	1197	862	654	612	13	7.6	3.2
Planned Development Case																		
RSA Maximum	928	277	78	16	8.2	245	129	32	314	107	47	6409	2160	1440	1436	13	7.6	3.2
LSA Maximum	517	118	42	5.2	2.5	245	129	32	314	101	33	6409	2075	1246	1052	13	7.6	3.2
CPF Boundary	193	118	42	4.8	1.8	99	88	17	29	21	15	1199	862	655	613	13	7.6	3.2
ESRD AAAQO[a]	**n/a[b]**	**450**	**125**	**30**	**20**	**n/a[b]**	**300**	**45**	**n/a[b]**	**80[c]**	**30**	**n/a[b]**	**15000**	**n/a[d]**	**6000**	**n/a[c]**	**14**	**4**

[a] Source: ESRD (2013c).
[b] The hourly AAAQO is to be applied to the 99.9th percentile hourly predictions (ESRD 2013b).
[c] Air Quality Guideline, not Objective.
[d] The 8-hour AAAQO is to be applied to the maximum 24-hour predictions (ESRD 2013b).

D.1.4 MITIGATION AND MONITORING

D.1.4.1 Mitigation

Pengrowth will manage NO_x emissions through the following measures:

- the selection of low NO_x emissions technology, as required by the CCME National Emission Guideline for Commercial / Industrial Boilers and Heaters and the *Interim Emission Guidelines for Oxides of Nitrogen (NO_X) for New Boilers, Heaters and Turbines using Gaseous Fuels Based on a Review of Best Available Technology Economically Achievable (BATEA) Interim Guideline* (AENV 2007); and
- energy conservation initiatives.

Pengrowth will manage fugitive emissions through the following measures:

- the use of good process design practices that reduce VOC emissions;
- plant-wide fugitive emissions identification and control using the protocol recommended by the CCME guideline "Environmental Code of Practice for the Measurement and Control of Fugitive Emissions from Equipment Leaks" (CCME 1993); and
- a vapour recovery unit to condense and recover emissions.

To reduce GHG emissions, the Project will:

- use process equipment that will minimize GHG emissions including high-efficiency boilers, VRUs to reduce fugitive methane vapours, optimized and insulated piping to reduce pumping energy requirements and heat loss, *etc.*;
- commit to continuously improving Project technologies;
- comply with emission limits imposed on the Project as per the Specified Gas Emitters Regulation either through efficiency improvements, purchase of GHG offsets, or contributing to Alberta's Climate Change and Emissions Management Fund; and
- design the process with appropriate heat integration strategies to improve heat recovery and reduce energy demand.

D.1.4.2 Monitoring

Pengrowth will conduct the following source monitoring:

- produced gas will be tested for H_2S content, and SO_2 emissions will be estimated from the produced gas flow rate;
- produced gas composition and fuel use will be monitored to determine GHG emissions; and
- NO_x emissions from one of the Project steam boilers will be tested within six months of Project start-up, and thereafter surveyed annually.

Pengrowth has reviewed the need for continuous emissions monitoring. Pengrowth proposes that one CEMS unit on one of the steam boilers, measuring NO_X, be incorporated into the design.

There are no predicted exceedances of SO_2 AAQOs at any location, so Pengrowth does not recommend measuring SO_2 continuously. Exceedances of AAQOs for $PM_{2.5}$ are predicted in all assessment scenarios in the LSA and RSA with no evidence of a local Project effect. This is a result of conservative emissions estimations approaches for anthropogenic emissions from communities. Monitoring of $PM_{2.5}$ is not deemed necessary at this time as ambient levels are not unduly influenced by the Project. Therefore, Pengrowth proposes to conduct passive monitoring associated with emissions of its central processing facility near the Project for SO_2, NO_2, and H_2S. The locations will be determined at a future date in consultation with ESRD.

Pengrowth also proposes that leak detection and repair (LDAR) program be initiated. The program should include a portable H_2S detection monitor with detection limits at or below 1 $\mu g/m^3$ to address the potential for H_2S-caused odour.

D.1.5 SUMMARY OF VECS

Table D.1.5-1 summarizes air quality impact ratings including Project residual effects. Project residual effects are those associated with maximum Project emissions, mitigated as described here. Project emissions cease after operations cease. For most air quality emissions, effects are largest nearest the source and decrease with distance from emission sources. Impact ratings were are based on effects at the LSA and CPF MPOIs rather than the RSA-MPOIs, because maximum concentrations at these locations are associated with emissions from other industrial facilities.

Table D.1.5-1 also identifies cumulative regional effects assuming all projects considered in the assessment operate at full capacity. In fact, not all will be operating at capacity and not all projects may be built. The following comments refer to cumulative regional effects and the PDC case:

- The magnitude of cumulative regional impacts was generally considered to be low to moderate, as increases in concentration or deposition were typically greater than 10%. In some cases, exceedances of objectives or thresholds were predicted at the regional and local MPOIs. However, these exceedances were predicted in the Baseline and did not change with the addition of the Project or regional planned projects.
- Regional and local (with the addition of the Project) potential for odour detection was predicted. However, these effects were not widespread and were limited to the Project fenceline, and the area immediately around the non-Project regional sources.
- Visible plumes were predicted, most frequently in the winter during early morning hours. These effects are local and are not present beyond a few kilometres from the Project.
- All effects were regional and lasted for the length of regional oil sands and oil and gas operations.

- Confidence was generally lower for cumulative effects due to uncertainties in emissions from approved (but not built) and planned facilities, as well as from projected background concentration increases as a result of growth in traffic and communities within the region.
- All effects will be reversible (emissions cease when operations cease).

The impact rating for the PDC case considered that predictions of air quality objective exceedances, when they were predicted, were usually very localized near specific industrial facilities / roadway segments and do not represent regional air quality. In addition, the CALPUFF model predictions are considered to be conservative.

Table D.1.5-1 Summary of Impact Rating on Residual Effects for Air Quality

Indicator	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]
NO_2 Concentration	Potential human health effects	The selection of low NO_x emissions technology	Application	Local	Medium Term (life of Project)	Continuous	Reversible in Short-Term	Low	Negative	High	High	Low
			Cumulative	Regional	Long	Continuous	Reversible in Long-Term	Low	Negative	Moderate	Medium	Low
SO_2 Concentration	Potential human health and vegetation effects	Not required	Application	Local	Medium Term	Continuous	Reversible in Short-Term	Low	Negative	High	High	Low
			Cumulative	Regional	Long	Continuous	Reversible in Long-Term	Low	Negative	Moderate	Medium	Low
$PM_{2.5}$ Concentration	Potential human health effects and visibility impairment	Use of gaseous fuels to produce steam	Application	Local	Medium Term	Continuous	Reversible in Short-Term	Low (Project does not increase predictions)	Negative	Moderate (greater uncertainty in PM secondary formation)	High	Low
			Cumulative	Regional	Long	Continuous	Reversible in Long-Term	High	Negative	Moderate	Medium	Moderate
CO Concentration	Potential human health effects	Meet ESRD Compliance Standards. Use of gaseous fuels to produce steam	Application	Local	Medium Term	Continuous	Reversible in Short-Term	Low	Negative	High	High	Low
			Cumulative	Regional	Long	Continuous	Reversible in Long-Term	Low	Negative	Moderate	Medium	Low
PAI Deposition	Potential acidification of sensitive soils, water bodies, and vegetation	Based on management of precursors	Application	Local	Medium Term	Continuous	Reversible in Short-Term	Low	Negative	Moderate	Medium	Low
			Cumulative	Regional	Long	Continuous	Reversible in Long-Term	Low	Negative	Low	Low	Low

Table D.1.5-1 Summary of Impact Rating on Residual Effects for Air Quality

Indicator	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]
Nitrogen Deposition	Potential eutrophication of sensitive ecosystems	Based on management of precursors	Application	Local	Medium Term	Continuous	Reversible in Short-Term	Moderate	Negative	Moderate	Medium	Moderate
			Cumulative	Regional	Long	Continuous	Reversible in Long-Term	Moderate	Negative	Low	Medium	Moderate
Ozone Concentration	Potential human health effects	Based on management of precursors	Application	Local	Medium Term	Continuous	Reversible in Short-Term	Negligible	Negative	Moderate	High	Low
			Cumulative	Regional	Long	Continuous	Reversible in Long-Term	Negligible to Low	Negative	Low	Medium	Low
H_2S Concentration	Potential human health effects	Use of a VRU and fugitive emissions controls	Application	Local	Medium Term	Continuous	Reversible in Short-Term	Moderate (increase greater than 25%)	Negative	Moderate	Medium	Moderate
			Cumulative	Regional	Long	Continuous	Reversible in Long-Term	Moderate (increase greater than 25%)	Negative	Low	Medium	Moderate
VOC and PAH Concentration	Potential human health effects	Use of a VRU and fugitive emissions controls	Application	Local	Medium Term	Continuous	Reversible in Short-Term	Low	Negative	Moderate	Medium	Low
			Cumulative	Regional	Long	Continuous	Reversible in Long-Term	Moderate (increase greater than 25%)	Negative	Low (regional emissions less certain)	Medium	Moderate

Table D.1.5-1 Summary of Impact Rating on Residual Effects for Air Quality

Indicator	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]
Odour	Potential nuisance effects	Use of a VRU and fugitive emissions controls	Application	Local	Medium Term	Continuous	Reversible in Short-Term	High (due to new exceedance)	Negative	Moderate	Medium	Moderate
			Cumulative	Regional	Long	Occasional	Reversible in Long-Term	Moderate (odour potential, but very local to facility boundaries)	Negative	Low (regional emissions less certain)	Medium	Moderate
Visibility	Potential aesthetic effects	None	Application	Local	Medium	Occasional	Reversible in Short-Term	Low	Negative	Moderate	Medium	Low
			Cumulative	Not Assessed								

[1.] Local, Regional, Provincial, National, Global; [2.] Short, Long, Extended, Residual; [3.] Continuous, Isolated, Periodic, Occasional; [4.] Reversible - in short term, Reversible - in long term, Irreversible; [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 AQUATICS

D.2.1 INTRODUCTION AND TERMS OF REFERENCE

Pengrowth Energy Corporation (Pengrowth) conducted a surface aquatic assessment for the proposed Project. The following section is a summary of the Aquatic Resources Baseline and Effects Assessment that was prepared by Hatfield Consultants, included as Consultant Report #2 (CR #2). For full details of the assessment please refer to CR #2.

ESRD issued the Terms of Reference for the project on December 13, 2013. The specific requirements for the surface aquatics component are provided in Section 3.4 and 3.5, as follows:

3.4 Surface Water Quality

3.4.1 Baseline Information

[A]. Describe the baseline water quality of watercourses and waterbodies and their seasonal variations. Consider appropriate water quality parameters.

3.4.2 Impact Assessment

[A]. Describe the potential impacts of the Project on surface water quality.

3.5 Aquatic Ecology

3.5.1 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 General Status of Alberta Wild Species (Alberta Environment and 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 map existing critical or sensitive areas such as spawning, rearing, and over-wintering habitats, seasonal habitat use including migration and spawning routes.

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

3.5.2 Impact Assessment

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

a) habitat loss and alteration;

b) increased fishing pressures in the region that could arise from the increased human activity and improved access from the Project. Characterize the current use of local and regional fisheries resources to support the assessment of potential changes in angling pressure;

c) increased habitat fragmentation;

d) acidification;

e) groundwater-surface water interactions; and

f) entrapment and entrainment of fish at water intakes.

[B] Identify the key aquatic indicators that the Proponent used to assess project impacts. Discuss 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.

The Local Study Area (LSA) includes the watershed of all watercourses that are potentially affected by the Project footprint (CR #2, Figure 1). It is the same LSA as for the hydrology component of this Application (CR #6). The Regional Study Area (RSA) includes all watersheds within the LSA plus any other watersheds that contributed flow to the watersheds within the LSA but which are not directly affected by the Project footprint. The RSA was also set to match that of the RSA for hydrology as it represents the area in which there is potential for alterations in flow to affect fish habitat.

Potential effects of acidifying emissions on aquatic resources were assessed on the lakes for which water quality data is available and which are also located within the Air Quality Regional Study Area (CR #2, Figure 2).

The identification of key issues relevant to aquatic resources confirmed that surface water quality and fish resources are the Valued Environmental Components (VECs) to be considered in this assessment.

D.2.2 BASELINE CONDITIONS

The aquatic resources baseline case first describes surface water quality, fish resources, and aquatic habitat for the watercourses and water bodies within the LSA, followed by those within the RSA.

Baseline information was collected for different parts of the LSA in different years. Baseline field programs in 2011 and 2012 focused on Mooswa Creek and Garnier Creek and the lower reaches of their tributaries. There was a defined channel at most of the locations and water was present during the entire open water season. Numerous named lakes were also sampled.

Baseline studies conducted in 2013 focused on the upper reaches of tributaries to Garnier Creek and Muriel Lake, the main watercourses and water bodies in a number of additional lease areas. These watercourses contained mostly poorly-defined and/or intermittent drainages with low potential for fish habitat. Lakes in this area were small, shallow and had poorly-defined shorelines.

For the RSA, Moosewa Creek was surveyed (Site MOC-1) to collect surface aquatic resources information for the Baseline Case. Water quality at this location was sampled in spring, summer, and fall only, as there was no flowing water at the site or at the upstream culvert in the winter.

D.2.2.1 Water Quality

Detailed water quality information is provided in CR #2, Appendix A2. A summary of surface water quality variables is provided in CR #2, Table 6 (2011 and 2012) and CR #2, Table 7 (2013). Watercourses within the LSA have water quality that:

- are neutral to slightly alkaline (pH between 6.96 and 8.45) with the exception of summertime pH in Reita Lake which recorded a field pH 10.49;
- have total dissolved solids range from 127 mg/L (Michel Lake) to 2,210 mg/L (Garnier Lake);
- have concentrations of total suspended solids range from below the detection limit (<3 mg/L) to 120 mg/L; and
- are classified as eutrophic ecosystems with high total nitrogen (ranging from 1.6 to 3.7 mg/L) and total phosphorus (0.05 to 0.14 mg/L).

Other than summertime pH in Reita Lake, there were no other measured pH exceedances for watercourses within the LSA; however, sulphide concentrations were high in many of these samples. The concentration of dissolved oxygen was below the acute dissolved oxygen guidelines for surface water in Alberta in most of the watercourses during the summer and several of the sites in the fall, but generally above this guideline in the spring.

Concentrations of phenols, total phosphorous, and total Kjeldhal nitrogen exceeded water quality guidelines at the majority of the watercourse sites over all four seasons, with a number of metals concentrations exceeding guidelines, including total iron, total aluminum, and total arsenic. Ammonia concentrations exceeded guidelines at Site GAL-1 (CR #2, Figure 3) during the winter.

Within the RSA, water quality showed to be similar to that of the LSA watercourses. Measured concentrations and levels of conventional variables such as conductivity, DOC, hardness, pH, and TDS were also similar to levels measured in the LSA, while colour was lower and TSS concentrations higher. Water quality variables with concentrations that exceeded water quality guidelines in the RSA were also similar to those in the LSA.

D.2.2.2 Fish Resources

The Baseline Case for fish resources within the LSA was developed from a review of the area's fish resources as documented by the Fisheries and Wildlife Management Information System (FWMIS) database (ESRD 2013e) in conjunction with fish inventory surveys conducted during the field programs in support of this EIA.

A review of the FWMIS database shows that brook stickleback, fathead minnow, lake chub, and finescale dace have been captured in the tributaries leading into Muriel Lake, with brook stickleback and fathead minnow being the most common. In Muriel Lake, recent surveys in the FWMIS database show that brook stickleback, fathead minnow, spottail shiner, yellow perch, Iowa darter, and longnose sucker have been captured in the past 15 years. Recent FWMIS records for Garnier Lake show that yellow perch, brook stickleback, northern pike, and logperch have been captured at the lake, while historic records show burbot as having also been captured

in Garnier Lake. No FWMIS records are available for either Dion or Michel Lake. FWMIS information on Reita Lake is limited to surveys in 1977 and 1982 during which northern pike and white sucker were captured (ESRD 2013).

Baseline fish inventories were conducted at fifteen locations in 2011 to 2012 (CR#2, Table 8) and eight locations in 2013 (CR#2, Table 9). A total of 1,564 fish were captured across all seasons, representing eleven different species: brook stickleback; finescale dace; yellow perch; fathead minnow; lake chub; northern pike; longnose dace; longnose sucker; pearl dace; log perch; and Iowa darter.

Fish species captured at site MOC-1 during baseline surveys consisted of brook stickleback, longnose dace, finescale dace, and longnose sucker, with finescale dace being the most abundant species captures (54%) (CR#2, Table 8). The FWMIS database indicates that Brook stickleback and fathead minnow have been recorded in Moosewa Creek (ESRD 2013). Brook stickleback are also recorded in Moosehills Creek, a tributary to the North Saskatchewan River similar to Moosewa Creek, while walleye, northern pike, sauger, and goldeye have been recorded in the North Saskatchewan River within 2 km of the outflow of Moosehill and Moosewa Creeks within the past ten years (ESRD 2013).

D.2.2.3 Aquatic Habitat

The Baseline Case for aquatic habitat for the LSA is provided in CR#2, Appendix A3. Physical habitat surveys were conducted for all aquatic sampling sites during at least one sampling season.

The aquatic habitat in the LSA is characterized by:

- small, unnamed tributaries draining into Moosewa Creek, Garnier Creek, or Muriel Lake with no or poorly-defined channels in the upper and mid-regions;
- watercourses with water present, but generally not flowing during the time the baseline studies were conducted;
- defined channels with some flow and habitat in the lower regions of the unnamed tributaries close to the confluence with a given named water body;
- watercourses designated as Class C and restricted, with the exception of a portion of Garnier Creek, which is Class B;
- the prevalence of organic material in those watercourses with defined channels and water present;
- instream and overhead cover that ranged between 20 to 100% coverage; and
- riparian vegetation that is dominated by grasses, sedges, shrubs, and willow mixed forests.

D.2.2.4 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.

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 2000). Chemical characteristics of the lakes within the AQLSA are shown in CR#2, Table 10.

D.2.3 PREDICTED CONDITIONS

D.2.3.1 Surface Disturbances during Construction, Operation and Reclamation

Surface disturbance and construction activities will take place within the LSA during the Project and may result in an increase in sediment loading in watercourses and water bodies. These activities may have consequent effects on water quality, aquatic habitat and fish populations and include:

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

These Project disturbances will be located within tributary watersheds that are part of the Moosewa Creek and Muriel Lake watersheds (CR #6).

With implementation of the mitigation measures, 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 best management practices to control sediment and erosion;
- potential adverse effects associated with sedimentation will be localized, occurring mainly during periods of construction and reclamation and confined to the immediate and downstream areas of the surface disturbance activities;
- with the exception of crossings, a minimum 100 m buffer will be maintained from fish bearing water bodies and a minimum 50 m buffer from the edge of the stream bank for all watercourses with defined channels;
- surface run-off from active areas such as well pads and roads will be managed in a manner in which erosion from surface water runoff will be minimized; 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.

The residual (after mitigation) effects of the Project on aquatic resources through surface disturbance and construction activities are assessed as ***Low Impact*** in the LSA. Because the residual effects of the Project 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. The residual effects are summarized in CR #2, Table 12.

D.2.3.2 Instream Construction Activity

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. There are 19 potential watercourse crossings in the Project area (CR #6). Eighteen of the crossings are for access roads and all but one of the crossings is on a watercourse identified as having no fish habitat potential based on undefined or poorly defined channels and lack of flow. The one watercourse with fish habitat is Garnier Creek, which has a proposed clear span crossing downstream of Garnier Lakes (CR #2, Figure 3). Garnier Creek provides habitat for sport fish, including northern pike, as well as forage fish habitat.

Only one of the proposed crossings has the potential to affect fish habitat. The use of a clear span bridge for this one crossing will substantially reduce the amount of instream activity required and with the application of the mitigation measures summarized in CR #2, Section 4.2.2, the potential impacts of instream construction activities are predicted to be low.

The residual (after mitigation) effects of the Project on aquatic resources through in-stream construction activities are assessed as ***Low Impact*** in the LSA. Because the residual effects of the Project 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. The residual effects are summarized in CR #2, Table 12.

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 the project development area; and
- changes in shallow groundwater quality.

With implementation of the mitigation measures summarized in CR #2, Section 4.3.2, 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 Project-affected waters will take place**;**
- 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 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 water bodies 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 (CR #5).

The residual (after mitigation) effects of the Project on aquatic resources due to changes in surface water quality are assessed as ***Low Impact*** in the LSA. Because the residual effects of the 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. The residual effects are summarized in CR #2, Table 12.

D.2.3.4 Changes to Surface 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 Project;
- release of Project-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:

- Only small increases in surface water runoff volumes are predicted as a result of surface disturbances. The Hydrology assessment (CR #6) predicts maximum changes in average runoff volume of between 1.2% and 6.1% above Baseline Case conditions in the unnamed watercourses in the LSA. Minor changes in peak annual flows and low flow rates are anticipated in streams in the LSA;
- no planned discharges of Project-affected waters will take place and 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 the Project on surface aquatic resources due to changes in surface water flow rates are assessed as ***Low Impact*** in the LSA. Because the residual effects of the Project 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. The residual effects are also summarized in CR #2, Table 12.

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 Project could increase fishing pressure and fish harvest in local fish-bearing lakes. This could, in turn, result in a decreased abundance of sportfish if fishing pressure and/or fish harvest were not appropriately managed.

There are limited angling opportunities with the LSA. The streams contain forage fish and juveniles of larger bodied species. Only the two larger lakes (Garnier and Muriel) are known to contain sport fish, but recent surveys on Muriel lake have concluded that the sport fish population has been extirpated, likely as a result of declining water levels and poor water quality (ESRD 2013b). The limited sport fishing opportunities mean that any increase in access to the lakes in the LSA will not impact the aquatic resources within the LSA and the effects of angling on LSA populations is expected to be low.

The Project is expected to result in a local population increase of approximately 60 people. This may result in an additional five anglers in the region which is a negligible change in fishing pressure.

The residual (after mitigation) effects of the Project on aquatic resources from improved or altered access to fish bearing watercourses are assessed as ***Low Impact*** in the LSA. Because the residual effects of the Project 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. The residual effects are also summarized in CR #2, Table 12.

D.2.3.6 Fish Tainting through Changes in Water Quality

Changes in water quality have the potential to affect the health of fish and other aquatic organisms. No ongoing release of water is anticipated and with implementation of the mitigation measures summarized in CR #2, Section 4.1.2, Section 4.2.2, and Section 4.3.2, potential impacts to fish health through potential changes in water quality are predicted to be low.

The residual (after mitigation) effects of the Project on fish health through changes in water quality are assessed as ***Low Impact*** in the LSA. Because the residual effects of the Project 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. The residual effects are also summarized in CR #2, Table 12.

D.2.3.7 Acidifying Emissions

Activities associated with the Project will result in the release of acidifying emissions as described in the Air Quality Assessment (CR #1). Therefore, the potential for acidifying emissions from the Project to affect surface aquatic resources in the Air Quality RSA is considered a valid impact pathway. Mitigation measures are also described in the Air Quality Assessment Report (CR #1).

Application Case

The predicted PAI for the Baseline and Application cases (CR #1) for lakes in the AQLSA is presented in CR #2, Table 11. Predicted PAI values at all lakes in the AQLSA for the Application Case are below Alberta's Clean Air Strategic Alliance (CASA) target load for sensitive grid cells of 0.22 keq H^+/ha/yr (AEP 1999b), and are also below the critical and target loads for those lakes.

Planned Development Case

The predicted PAI for the Planned Development Case (CR #1) for lakes in the AQLSA is presented in CR #2, Table 11. Predicted PAI values at all lakes for the Planned Development Case in the AQLSA are below the CASA target load for sensitive grid cells of 0.22 keq H^+/ha/yr (AEP 1999b), and are also below the critical and target loads for those lakes.

The residual (after mitigation) effects of the Project in the Application Case and Planned Development Cases on surface aquatic resources through acidifying emissions are assessed as ***Low Impact***.

D.2.4 MITIGATION AND MONITORING

D.2.4.1 Mitigation

It is recommended that Pengrowth undertake the following mitigation measures to eliminate and/or reduce to acceptable levels, potential effects on surface aquatic resources:

- A sediment control plan will be developed.
- A 100 m setback will be applied to all waterbodies with fish habitat potential (CR #2, Figure 4), while a 50 m setback will be applied at all defined channels with no fish habitat. These setbacks will not apply at stream crossings.
- Sediment control measures such as those described in the *Alberta Code of Practice for Watercourse Crossings* (AENV 2000) and associated guidelines will be implemented for earthworks which take place within or in close proximity to watercourses. These measures may include, as required: the use of cutoff trenches, silt fences, flow barriers, temporary and/or permanent sediment control ponds and/or traps, and ditches to minimize or eliminate sediment transport from exposed soil areas into receiving watercourses and waterbodies.

- Whenever possible, surface disturbance activities in close proximity to watercourses will be carried out during periods of relatively low surface runoff in late fall, winter and early spring (from October to April).
- The time interval between clearing/grubbing and subsequent earthworks will be minimized, particularly at or in the vicinity of watercourses or in areas susceptible to erosion.
- Where relevant, slope grading and stabilization techniques will be adopted. Where possible, slopes will be contoured to produce moderate slope angles to reduce erosion risk. Other stabilization techniques used to control erosion may include: ditching above the cutslope to channel surface runoff away from the cutslope, leaving buffer (vegetation) strips between the disturbance area and a watercourse, placing large rock rip rap to stabilize slopes.
- Where required, surface runoff collection and treatment systems will be used to direct surface runoff from both disturbed areas and constructed areas (well pads and roads) into settling impoundments/sumps for removal of settleable solids.
- Progressive disturbance and reclamation will be undertaken to reduce the amount of disturbed area at any given time. During reclamation, permanent plant cover and re-vegetation will be established as soon as possible following earth works. Soil erosion will be reduced by minimizing the time that reclaimed surfaces are left bare.
- Where necessary, interim erosion/sediment control measures will be utilized until long-term protection can be effectively implemented.
- Whenever possible, instream construction activities will be carried out during periods of relatively low surface runoff in late fall, winter and early spring (from October to April).
- All watercourse crossings including the crossing of Garnier Creek with a clear span bridge will be designed and constructed in compliance with the *Alberta Code of Practice for Watercourse Crossings* (AENV 2000) and associated guidelines. For watercourse crossings these requirements include: aquatic and biological assessments; watercourse crossing design and construction; post-construction clean-up and reclamation; contingency measures; and watercourse crossing site monitoring. Implementation of appropriate mitigation measures means that all stream crossings constructed and operated for the Project will meet regulatory requirements for the protection of fish resources and aquatic habitat and will subsequently mitigate against effects on surface water quality.
- Surface water run-off from the plant site will be directed to a storm water runoff pond constructed in accordance with relevant regulations. All surface runoff will be collected in the storm water runoff pond and returned to the CPF for use as plant makeup water. It is anticipated that occasionally, depending upon site and operating conditions, the surface runoff collected in the storm water runoff pond may be released to the surrounding watershed if it meets the quality requirements outlined in the operating approval.
- All storage tanks, except boiler feed water and source water tanks, will be equipped with secondary containment and leak detection equipment to minimize the occurrence of product leaks, hence under normal operating conditions, surface run-off from the plant to the storm water runoff pond is not anticipated to contain any process related chemicals.

- The storm water runoff pond will function as a sedimentation pond and will settle particulates to reduce levels of any sediment-associated chemicals, such as metals, nutrients and organics. To mitigate against potential adverse impacts to surrounding watercourses, runoff pond water will always be tested prior to discharge and will only be released in accordance with the terms and conditions of the operating approval. Based on the anticipated management of runoff waters and the controlled rate of water releases from the storm water runoff pond, the release of runoff waters on nearby surface waters is predicted to have a negligible effect on water quality.
- The facilities or locations where potentially contaminating materials are handled, transferred or stored include the well pad during drilling of production wells and the CPF.
- Management and disposal of all drilling waste will be in accordance with all regulations and will be implemented under the Project's waste management plan. The oil content in the drilling fluids after drilling the bitumen sections is expected to be too high for onsite or offsite disposal. The rig will be equipped with centrifuges and linear motion shakers. The oil contaminated cuttings will be mixed with wood fibre and stored in steel containers on site, and then hauled to a certified Class II Landfill. The oil contaminated liquid mud will be hauled to certified Class II Salt Cavern for disposal.
- All storage tanks, except boiler feed water and source water tanks, will be equipped with secondary containment and leak detection equipment to mitigate against product leaks. Additionally, an Integrated Environmental Health and Safety Management Plan will be prepared for the Project. This Plan will include an Emergency Response Plan; a Substance Release Control and Monitoring Plan and a Loss Control and Environmental Compliance Program which will describe the contingency plans for responses to accidental releases. Collectively, the secondary containment and leak detection measures, along with management and response plans will minimize the risk of substance release into watercourses and waterbodies and resultant negative impacts to aquatic resources.
- Diverting runoff from disturbed areas into the natural environment, away from the existing stream networks and phasing reclamation activities such that they commence before the entire Project is developed.
- Water requirements for the Project will be met through an existing approved source on the North Saskatchewan River. There is a license to withdraw up to 8,000 m^3/day from the North Saskatchewan River, which is sufficient to meet demands for the Project at its full capacity.
- No planned discharges of Project-affected waters will take place from the Project. Occasional releases may take place from the storm water runoff pond to the environment. Such releases will be undertaken at a controlled rate, in strict accordance with the terms and conditions of the operating approval, in order to mitigate against adverse impacts to surface water flow rates.
- Pengrowth will work closely with ESRD to ensure the fisheries resources in the study area, particularly the lakes, do not become over-exploited as a result of increased sportfishing. Possible initiatives include:

a) raising awareness among the Project workers of the existing ESRD regulations for the species found in the study area lakes;
b) educating the Project workforce on the benefits of the practice of catch-and-release angling; and
c) discouraging fishing by Project employees within the LSA.

A series of mitigation measure are described in the Air Quality Assessment Report (CR #1) that will minimize acidifying emissions related to Project activities.

D.2.4.2 Monitoring

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

- ensure that contractors submit environmental management plans as part of construction agreements that will outline proposed methods for each activity as well as for the post-construction period;
- conduct routine audits and associated surface aquatic resources monitoring during construction periods, specifically targeting suspended sediments for all instream works occurring in flowing water; and
- conduct effects monitoring at specific locations in specific drainages to assess how surface aquatic resources (water quality, fish, and fish habitat) are changing with the Project implementation and to ensure environmental quality guidelines are being met. Monitoring requirements will be carried out in accordance with the terms and conditions of all approvals.

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.2.5-1.

Table D.2.5-1 Summary of Impact Rating on Residual Effects for Aquatic Resources VECs

VEC	Nature of Potential Effect	Mitigation/ Protection Plan	Type of Effect	Geographical Extent of Effect[1]	Duration of Effect[2]	Frequency of Effect[3]	Ability for Recovery from Effect[4]	Magnitude of Effect[5]	Project Contribution[6]	Confidence Rating[7]	Probability of Effect Occurrence[8]	Significance[9]
NOTE: VEC 1: Water Quality; VEC 2: Fish Resources												
VEC 1 and VEC 2	Changes to aquatic habitat and resources from surface disturbance during construction, operation and reclamation activities	1) Implement sediment and erosion control plan and sediment control measures in line with the *Alberta Code of Practice for Watercourse Crossings*; 2) Observe timing windows and maintain appropriate buffers where possible; 3) Manage surface water runoff from disturbed areas; 4) Adopt slope stabilization techniques and progressive reclamation techniques where needed; and 5) Apart from watercourse crossings, avoid construction activities within 100 m of fish bearing streams.	Application and Planned Development	Local	Long	Occasional	Reversible in short term	Low	Negative	High	High	Low Impact

Table D.2.5-1 Summary of Impact Rating on Residual Effects for Aquatic Resources VECs

VEC	Nature of Potential Effect	Mitigation/ Protection Plan	Type of Effect	Geographical Extent of Effect[1]	Duration of Effect[2]	Frequency of Effect[3]	Ability for Recovery from Effect[4]	Magnitude of Effect[5]	Project Contribution[6]	Confidence Rating[7]	Probability of Effect Occurrence[8]	Significance[9]
VEC 2	Changes to fish and fish habitat due to instream construction activities.	1) Watercourse crossings to comply with *Alberta Code of Practice for Watercourse Crossings*; 2) Comply with Alberta Transportation's Fish Habitat Manual; and 3) Observe restricted activity period.	Application and Planned Development	Local	Long	Occasional	Reversible in short term	Low	Negative	High	High	Low Impact
VEC 1	Changes to fish and fish habitat due to changes in surface water quality.	1) Surface water runoff from the plant site will returned to the CPF for use as plant makeup water. If site and operating conditions warrant, the surface runoff from the pond may be released to the surrounding watershed if it meets the quality requirements outlined in the operating approval; 2) Handle and dispose of drilling waste and chemicals in accordance. with management plans; and	Application and Planned Development	Local	Long	Occasional to accidental	Reversible in short term	Low to Moderate	Negative	High	Medium	Low Impact

Table D.2.5-1 Summary of Impact Rating on Residual Effects for Aquatic Resources VECs

VEC	Nature of Potential Effect	Mitigation/ Protection Plan	Type of Effect	Geographical Extent of Effect[1]	Duration of Effect[2]	Frequency of Effect[3]	Ability for Recovery from Effect[4]	Magnitude of Effect[5]	Project Contribution[6]	Confidence Rating[7]	Probability of Effect Occurrence[8]	Significance[9]
		3) Comply with integrated Environmental Health and Safety Management Plan and contingency plans for responses to accidental releases.										

D.3 HISTORICAL RESOURCES

D.3.1 INTRODUCTION AND TERMS OF REFERENCE

Pengrowth Energy Corporation conducted a Historical Resources Impact Assessment (HRIA) for the proposed Project. The following section is a summary of the Historical Resource Impact Assessment (HRIA) that was prepared by Lifeways of Canada Limited and is included as Consultant Report #3 (CR #3). For full details of the assessment, please refer to CR #3.

ESRD issued the final ToR for the Project on December 13, 2013. The specific requirements for the historical resource component are provided in Section 4, and are as follows:

4 HISTORIC RESOURCES

4.1 Baseline Information

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

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

a) site type and assigned Historic Resources Values; and

b) existing site specific Historical Resources Act requirements.

[C]. Provide an overview of previous Historical Resources Impact Assessments that have been conducted within the Project Area, including:

a) a description of the spatial extent of previous assessment 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.

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

4.2 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 magnitude 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 palaeontological records.

Historical Resources, as defined by the Alberta Historical Resources Act, include natural or cultural works that are of value for archaeological, palaeontological, historic, scientific, or aesthetic interest. Archaeological resources are objects, structures, or groups of objects created by people. Archaeological resources are usually divided into two major descriptive chronological categories; Precontact, being material of Aboriginal manufacture dating to a time before the arrival of Europeans in Alberta, and Post-Contact, being any material dating to the more recent past (*i.e.*, after the arrival of Europeans in Alberta). Archaeological sites may also

be: multicomponent, containing materials representing different time or cultural periods; or single component, resulting from one single occupation. Palaeontological resources are works of nature consisting of, or containing evidence of, extinct plants and animals.

The study area for the HRIA portion of the Lindbergh SAGD Expansion Project is presented in CR #3, Figure 2.1 and consisted of the following legal descriptions:

a) Sections 5-8, 17-20 and 29-32 of T58-R4-W4M;
b) Sections 1-3, 10-15, 22-27 and 34-36 of T58-R5-W4M;
c) Sections 1-36 of T59-R4-W4M; and
d) Sections 1, 2, 11, 12 and parts of Sections 13 and 14 of T59-R4-W4M.

Unlike many EIA level assessments, the Lindbergh site encompasses existing infrastructure and includes projected development plans consisting of "Initial" and "Future" development. These plans are provisional in nature and may be subject to considerable change. The "Initial" development, which is relatively modest in scope and largely limited to the area around the existing Pengrowth facilities. The "Future" phase includes extensive developments to the south, west, east and northeast of the existing facilities.

D.3.2 BASELINE CONDITIONS

D.3.2.1 Overview

The project is on the very northern limits of the agricultural "White Area" in Alberta, and is on the northern limits of the Central Parkland Subregion of the Parkland Region, just south of the Central Mixedwood Subregion of the Boreal Forest Region (Natural Regions Committee 2006). There are several lakes and streams throughout the study area which have been found to have been places where past peoples would have characteristically travelled to, congregate at, and travel through as part of their daily lives. North and South Garnier Lakes, are near the south limits of the project area, and Muriel Lake on the northwest. Rieta lake straddles the northeast margin of the study area. A major glacial meltwater channel also runs from the northwest to the southeast through the center of the study area.

D.3.2.2 Previous HRIAs

Several HRIAs have been previously carried out within the Project area. Most of the study area is undisturbed, and previous HRIA investigations have been limited in scope and are generally localized within overlapping areas. Only two larger scale area-based studies had been carried out in the study area, both associated with the Lindbergh property. The known Precontact sites are associated with elevated landforms in close proximity to lakes and streams, and with the margins and bottoms of the relict glacial spillway while the recorded Historic sites and structures show a different distributional pattern. The Historic sites are closely associated with developed road allowances and cultivated lands in relatively flat and well-drained context. It appears that there are several historic trails passing through the study area, indicating areas of usage during the early historic period.

D.3.2.3 Existing Sites

The selection of original target areas in the study area was based partly on previous archaeological investigations and partly on terrain analysis. Throughout much of the region, the prevailing pattern of archaeological site distribution is one based on landscape variables. While relatively few time diagnostic artifacts have been recovered, comparative studies of Precontact sites indicate that the majority of the sites are Middle or Late Precontact in age, a period when environments were broadly similar to those of today. A summary of known site environmental locational characteristics is presented in CR#3, Table 4.1.

Twenty-four sites had been previously recorded within the study area. The Precontact sites ranged from isolated finds (n=5), to small artifact scatters (n=5), to campsites (n=8). Previously recorded Historic sites consisted of a trail (n=1), cemetery (n=1), and early homestead/farmsteads (n=4). Of these 24 sites, 12 were revisited during the 2013 HRIA.

D.3.3 PREDICTED CONDITIONS

D.3.3.1 Site Assessment

During the 2013 HRIA field work, 24 target areas or landforms were subjected to visual surveys in the study area, in which a total of 743 shovel tests were excavated (CR #3, Figure 5.1). Field investigations were carried out over a period of 13 days in mid-October 2013.

Nineteen previously unreported archaeological sites, including 16 Precontact Aboriginal sites and three Historic period sites, were discovered and recorded in the vicinity of the Project. CR #3, Table 4.2 lists the newly recorded sites in the study area. Historic sites include a churchyard and foundation and two trails. Precontact sites include: four isolated finds, nine small scatters, and three campsites. Each of the 19 newly recorded sites are described in detail.

D.3.3.2 Historical Resources Potential

The topographic and drainage complexity of the study area would have been attractive for past use, and has considerable potential for preserving intact historic resource sites. In fact, the major meltwater channel running through North and South Garnier Lakes north to Muriel Lakes is a deep, broad valley, and has well defined margins and relatively steep valley walls. The channel's valley is occupied by the under-fit drainage of Muriel Creek, and a number of small unnamed streams.

The number of archaeological sites identified during the most recent studies in the area clearly indicates a relatively high density of sites in the area, contrary to the results predicted based upon previous linear development HRIAs that traverse the area. Nineteen previously unreported archaeological sites have been discovered and recorded in the project study area, including 16 Precontact Aboriginal sites and three Historic Period sites. Only two of these 19 sites (FlOp-56 and GaOp-25) will be impacted by the Project.

D.3.4 POTENTIAL IMPACTS

Development in the immediate areas in which archaeological sites are located would result in negative and high impacts to the condition of the sites themselves, although the impacts to archaeological knowledge not necessarily so. Impacts are mitigated during Project design by the use of constraints mapping so as to avoid development at site locations. The evaluation of impacts is closely related to the assessment of site significance, based on interpretation.

The construction of Project components located on, or immediately adjacent to any of the archaeological sites recorded, would disturb or impact those sites. The removal of vegetation will result in subsurface disturbance of sediments, which results in the modification of the internal structure of archaeological sites. Any disturbance to the original context of artifacts within a site causes information about the manufacture and use of those artifacts to be lost or compromised. That being the case, the seriousness of the loss of information on any individual site correlates with the significance of that site with respect to the regional understanding of past human settlement.

D.3.4.1 Impact of Project Upsets on Historic Resources

Historic sites identified in the study area are very localized in extent. Because of this, there would be no impact upon historic resources unless upsets occur in the immediate area of a historic resource site. Spills and leaks are the most likely type of upset condition to occur as a result of Project construction and operation.

If a spill or leak is confined to areas that have been previously disturbed by development (*e.g.,* on well pads or pipeline right-of-ways), historic resources will not be a concern, as they will have been mitigated previous to development. If the spill is more widespread and contacts historic resource sites listed as moderate potential, the impact of the spill itself will be minimal, although materials hazardous to human health could require modification of excavation methods and could damage the site.

D.3.5 MITIGATION AND MONITORING

D.3.5.1 Mitigation

Eighteen sites within the study area have been deemed significant enough to warrant mitigative measures should avoidance not be possible (see CR #3, Tables 4.1 and 4.2). These sites are all relatively small and localized; although each has characteristics which suggests it may contain more significant data upon further examination.

Further archaeological examination of these sites is recommended if they cannot be permanently avoided during the construction and operation of the Project. The number of archaeological sites identified during the most recent studies in the area indicates a relatively high density of sites in the area, contrary to the results predicted based upon previous linear development HRIAs that traverse the area.

Given the above noted density of archaeological sites, and the preliminary nature of impact assessment activities in much of the study area, additional examinations in relatively undisturbed high potential lands that have not been subject to previous examination are recommended. These lands are indicated in CR #3, Figure 6.1. HRIA level examination in these lands should precede any ground-disturbing construction activities.

D.3.5.2 Monitoring

No monitoring or follow-up program is planned.

D.3.6 SUMMARY

The objectives of this HRIA were the identification and assessment of historical resources. These were achieved through baseline research centred on the collection of archaeological site data for the study area and a literature review of sedimentary and geomorphological information. The location and field assessment of new sites was achieved through the examination of exposed surface sediments and subsurface excavations in the form of shovel tests in target areas at regular intervals.

The study area is large, and a reasonably high number of significant archaeological sites are known from previous studies or were recorded during this HRIA. Twenty-four sites had been previously recorded within the study area. Nineteen archaeological sites, including 16 Precontact Aboriginal sites and three Historic sites, were newly recorded.

The Lindbergh SAGD Expansion Project will avoid most of the identified significant historic sites; therefore, impacts to historical resources are expected to be low. Impacts to individual sites will be reviewed by Alberta Culture upon receipt of final development plans, and appropriate site mitigation requirements will be issued. No cumulative effects are anticipated.

D.4 HUMAN HEALTH

D.4.1 INTRODUCTION AND TERMS OF REFERENCE

Pengrowth Energy Corporation (Pengrowth) conducted a human health risk assessment for the proposed Project. The following section is a summary of the Human Health Risk Assessment (HHRA) that was prepared by Millennium EMS Solutions Ltd. and included as Consultant Report #4 (CR #4). For full details of the assessment please refer to CR #4.

MEMS also conducted a Screening Level Wildlife Health Risk Assessment (SLWRA) for the proposed project. The following summary also includes select information from the wildlife health risk assessment is detailed in CR #4, Appendix D.

ESRD issued the Terms of Reference for the project on December 13, 2013. The specific requirements for the human health component are provided in Section 6.0 of the Terms of Reference.

6 PUBLIC HEALTH AND SAFETY

6.1 Public Health

[A]. Describe 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. 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.

6.2 Public Safety

[A]. Describe aspects of the Project that may have implications for public safety. Specifically:

a) describe the 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.

The Human Health Risk Assessment (HHRA) describes the nature and significance of potential health risks to the local human population, associated with exposure to chemicals that could be released to the environment from the proposed Lindbergh SAGD Expansion Project (the Project). The HHRA also assessed the potential health risks associated with existing conditions, prior to development of the Project, as well as future conditions related to the Project in combination with other planned developments in the region. A wildlife health risk assessment was also conducted, using the same models and air concentrations as the human health risk assessment (CR #4, Appendix D).

Pengrowth has conducted consultations with community stakeholders including residents of communities in the region and other organizations representing local interests and concerns, as well as with First Nations communities in the vicinity of the Project. No specific health-related concerns raised by community stakeholders or local First Nations.

The LSA is a 40 km by 40 km area centred on the Central Processing Facility. It was selected to include key local receptors but also to exclude most regional emissions sources in order to differentiate Project impacts from the effects of regional projects.

The RSA is a 200 km by 200 km area, centred near the northern boundary of the LSA, and extending north beyond Primrose Lake, south to Vermilion, west beyond Whitefish Lake and an equidistance east beyond the Saskatchewan border. The RSA was selected to include all oil sands and conventional emissions in the Cold Lake area.

The LSA and RSA are shown in CR#4, Figure 1. The HHRA assessed potential health risks at over 130 locations within the LSA and RSA.

Even though the life of the Project is shorter than the lifetime of a typical individual, chronic exposures in this assessment were assumed to extend over a period of 80 years, the assumed human lifetime duration recommended by Health Canada (2009).

D.4.2 ASSESSMENT APPROACH

The human health risk assessment was conducted using standard methods endorsed by regulatory agencies. Specifically, the risk assessment followed the Alberta Health and Wellness (2011) Guidance on Human Health Risk Assessment for Environmental Impact Assessment in Alberta. Additional guidance published by Health Canada (2010), the Canadian Council of Ministers of the Environment (CCME, 2008), and United States Environmental Protection Agency (US EPA, 2005) was also consulted. The risk assessment used reasonable worst-case assumptions to ensure that risk estimates would be conservative.

The risk assessment included four main stages:

- problem formulation, where chemicals of potential concern (COPCs), potential receptors and operative exposure pathways are identified. Determination of which COPCs could accumulate in other media (soil, water, food) was also conducted at this stage;

- exposure assessment, including evaluation of concentrations of volatile COPCs in air to which receptors could be exposed; and estimation of exposure through secondary exposure to other media;
- toxicity assessment, where potential adverse effects of COPCs are identified and relationships between exposure and potential toxic effects established; and
- risk characterization, where the results of the exposure and toxicity assessments are used to determine the potential for adverse effects.

D.4.2.1 Problem Formulation

Chemical Inventory

COPCs were identified through an inventory of expected Project air emissions, as described in the Air Quality Assessment (CR #1, Section 3.1). As the Project will not release any chemicals into potential domestic use aquifers or surface water under normal operating conditions, the COPCs were based on air emissions only.

COPCs identified for the Project included:

- criteria air contaminants (CACs);
- SO_2, NO_2, CO, fine particulate matter ($PM_{2.5}$);
- polycyclic aromatic hydrocarbons (PAHs);
- petroleum hydrocarbons (PHC);
- sulphur compounds; and
- volatile organic compounds (VOCs).

Metals were not included as COPCs since the Air Quality Assessment (CR #1) determined that they would not be emitted from the Project in significant quantities.

The HHRA evaluated both acute and chronic inhalation health risks for all of the identified COPCs for which adequate toxicological data was available. A list of the chemicals included in the HHRA is presented in CR #4, Table 3.

A multimedia exposure assessment, which included exposure through secondary oral and dermal contact pathways, was only completed for a subset of the identified COPCs. Chemical properties used to screen chemicals for the multimedia assessment are summarized in CR #4, Table 4.

Identification and Characterization of Receptors

Local residents, communities, and any people spending time near the Project could be exposed to COPCs.

Human Receptor Locations and Groups

The evaluation considered the entire LSA and RSA, and was based on locations with maximum chemical concentrations predicted by the air quality assessment. To ensure that locations of any sensitive receptors or where people would likely spend the most time were captured, specific

locations evaluated within the LSA and RSA also included communities, First Nations, known residences, and recreational areas (CR #4, Table 4 and Figure 1).

Receptors were divided into general groups:

- First Nations;
- agricultural;
- other area residents;
- workers; and
- visitors.

Receptor Characteristics

Inhalation exposures are evaluated using predicted air concentrations and no other characteristics of receptors are required. For multimedia exposures, the amount of exposure is dependent on characteristics such as diet and the intake rates of media. Receptor characteristics were based on recommendations from Health Canada (2009). Dietary composition was based on data on Aboriginal food consumption patterns (Wein *et al.*, 1990) as well as local consultation. Receptor characteristics are summarized in CR #4, Table 6.

Exposure Pathway Identification

Direct inhalation of air was assumed to be the primary exposure pathway and several secondary pathways were also identified:

- COPCs in air can be deposited onto soil in the surrounding area. Receptors may then be exposed by direct contact with soil, inadvertent ingestion of soil, and inhalation of dust;
- COPCs could accumulate in local vegetation, through direct deposition from air or uptake from affected soils. Receptors may then be exposed by ingestion of local vegetation;
- COPCs in soil, plants, and water can be ingested by local wildlife. Receptors may then be exposed by ingestion of local wild game; and
- The Project is not expected to have any effect on water quality (CR #2). Exposure through ingestion of surface water, contact with surface water while swimming, and ingestion of fish were considered in order to properly evaluate total exposure.

A summary of the applicable exposure pathways for each receptor group is presented in CR #4, Table 7.

D.4.2.2 Exposure Assessment

The exposure assessment involves the estimation of the amount of each COPC that receptors could potentially be exposed to, based on reasonable worst-case assumptions.

Inhalation

Inhalation exposure is evaluated using the results of air dispersion modelling conducted as part of the air quality assessment (CR #1). Concentrations were predicted both over a grid covering

the LSA and RSA and at specific receptor locations as described above. Concentrations were evaluated separately for the Baseline, the Application Case, and the PDC. Concentrations included both emissions associated with the Project and the emissions from other sources.

For purposes of estimating exposure, it was assumed that humans would be continuously exposed for the averaging periods being evaluated.

Multimedia Exposure

The multimedia exposure assessment evaluated secondary exposure through oral and dermal routes. The processes involved are only relevant for chemicals that can potentially accumulate in media other than air; many of the COPC associated with Project emissions are too volatile to be present in soil, water or food. The results of the screening are summarized in CR #4, Table 8.

The multimedia assessment included consideration of background/ambient concentrations of COPC, combined with predictive modelling based on air concentrations.

Complete details on soil and vegetation sampling are provided in CR #9 and CR #10, respectively. A total of 49 soil samples collected from the terrestrial local study area were analyzed for polycyclic aromatic hydrocarbons (PAH). Concentrations were generally below analytical detection limits and therefore the multimedia assessment used modelled concentrations in soil.

A multimedia exposure model was used to predict concentrations of COPCs in potential exposure media, based on the maximum ground-level concentrations in air predicted from the air quality assessment. Details of the model and an example calculation are provided in CR #4, Appendix A.

D.4.2.3 Toxicity Assessment

The toxicity assessment involves establishing the relationship between the amount of a chemical that a person is exposed to over a specified duration and the potential for adverse effects. Chemicals are typically divided into two categories for the purposes of human health risk assessment: threshold and non-threshold chemicals.

Threshold chemicals, which are generally non-carcinogens, are chemicals for which it is believed a certain minimum dose (the “threshold”) must be exceeded before adverse effects are expected to occur. Non-threshold chemicals, which are generally genotoxic and mutagenic carcinogens, are not believed to have a threshold below which no effects would occur. Instead, toxicity is expressed based on the risk of developing cancer for a particular level of exposure. Non-threshold effects are evaluated over a lifetime since the risk of developing cancer is generally assumed to be related to the lifetime cumulative exposure.

For both threshold and non-threshold effects, toxicity is expressed herein as an exposure limit (TC or RSC for inhalation; TDI or RSD for oral exposure).

Chemical Screening

Chemicals potentially emitted from the Project were identified as COPCs. Some of these chemicals were grouped prior to conducting the toxicity assessment. Specifically:

- aliphatic and aromatic petroleum hydrocarbons were assigned to sub-fractions specified by CCME (2008) to reflect the combined toxicity of these defined mixtures; and
- where insufficient toxicity data were identified for particular chemicals, they were grouped with other similar chemicals and assigned surrogates believed to conservatively represent the group.

Toxicity reference values (TRVs) were identified for both acute and chronic inhalation exposures. For those chemicals evaluated under the multimedia assessment, chronic oral TRVs were also identified. The basis for each available TRV was evaluated to select the most appropriate value, giving consideration to consistency with Alberta approaches, scientific defensibility, incorporation of the most current information, and conservatism.

Selected TRVs are summarized in CR #4, Tables 9 through 11. The detailed toxicity assessments for all COPCs are provided in CR #4, Appendix B.

Mixtures

Receptors are potentially exposed to mixtures of chemicals, and in these mixtures there is the potential for chemical interactions to affect toxicity. Consistent with Health Canada (2009) recommendations, where chemicals have similar effects on the same target organs, they were assumed to have additive toxicity (*i.e.*, the toxic effects are combined).

As part of the toxicity evaluations (CR #4, Appendix B), chemicals were assigned to toxicity groups based on critical effects and target organs (CR #4, Table 2). All COPCs within a toxicity group were assumed to have additive toxicity. Additionally, chemical components of the aliphatic and aromatic hydrocarbon sub-fractions are implicitly evaluated as mixtures, either based on toxicity studies of actual mixtures or by using a chemical surrogate and assuming all chemicals within the sub-fraction have equivalent and additive toxicity.

D.4.2.4 Risk Characterization

Risk characterization is the stage where the results of the exposure and toxicity assessments are combined to evaluate potential risks to human receptors.

Risks are characterized using risk quotients, which are the ratio of the predicted exposure to the appropriate exposure limit. For threshold chemicals, a risk quotient less than 1 indicates that predicted exposures are less than the TC or TDI and that therefore adverse effects are not predicted for any receptors. For non-threshold chemicals, the risk quotient is the estimated incremental lifetime cancer risk per 100,000 population; a risk quotient less than 1 indicates that the predicted incremental lifetime cancer risk is less than the “essentially negligible” target of 1 in 100,000.

D.4.3 PREDICTED CONDITIONS

D.4.3.1 Acute Inhalation

Risk quotients for acute inhalation have been calculated for exposures less than 24 hours and are independent of the receptor group since they are evaluated based on concentrations only and the toxicity limits are the same for all age groups and receptor types (CR #4, Table 13). CR #4, Table 14 presents acute risk quotients for toxicity groups (eye irritation, nasal irritation, respiratory irritation, neurological and reproductive/developmental).

All risk quotients are less than one, with the exception of 10-minute average SO_2 concentrations which have a risk quotient of less than 1 in the LSA but slightly above 1 in the RSA. The maximum concentrations and risk quotients were identical for the baseline, application and PDC scenarios, indicating that the predicted concentrations do not arise from the Project, but rather from industrial sources in the vicinity of the MPOI for the RSA.

Therefore, acute effects on humans from the Project are not expected at any location.

D.4.3.2 Chronic Inhalation

Risk quotients for chronic inhalation are based on long-term exposures. Both carcinogenic and non-carcinogenic effects have been evaluated; the calculation of risk quotients is identical for both. Conservative risk quotients based on the assumption that humans would spend extended periods of time at the locations with the maximum concentrations (MPOI) are presented in CR #4, Table 15; chronic risk quotients for toxicity groups (eye irritation, nasal irritation, kidney, liver, neurological, nasal tumours, leukemia) are presented in CR #4, Table 16. Results at specific receptor locations are provided in CR #4, Appendix C. Exposures and risk quotients are not affected by characteristics of the receptor for this pathway, only by location.

Strictly speaking, for non-threshold (carcinogenic) substances, the target is for the contribution from the Project itself to result in a cancer risk less than 1 in 100,000 (*i.e.*, the "Project only" risk quotient should be less than 1). Since the proposed Project is an expansion of an existing facility, emissions from the current facility are already incorporated into baseline exposures, making it difficult to clearly establish the incremental contribution of the facility. To ensure conservatism, total risks (baseline plus Project) are evaluated against the incremental risk targets.

All predicted risk quotients are less than one. Since it is considered unlikely that receptors would actually be chronically exposed at the MPOI, these estimates are believed to be conservative and no significant adverse inhalation effects are predicted from the Project.

D.4.3.3 Chronic Multimedia Exposure

Long-term (chronic) risks from the multimedia exposure assessment were evaluated for COPCs emitted to air which could potentially accumulate in the environment. This assessment focuses on secondary exposure to these COPCs through oral and dermal exposure pathways.

Risk quotients were calculated based on Aboriginal receptors, since this is the most sensitive receptor group based on their assumed lifetime exposure in the LSA and RSA, and their higher ingestion of country foods. Risks were evaluated based on the MPOI as well as specific receptor locations.

As for the chronic inhalation assessment above, risks for non-threshold substances should be assessed based on the incremental contribution of the Project. Due to the difficulty in separating out the contribution of the existing facility from the baseline exposures, the assessment was conservative based on the cumulative exposure from baseline and the Project.

All risk quotients are less than one, indicating that adverse effects resulting from the Project are not predicted (CR #4, Table 17 and Table 18). Risk quotients for the application case are generally identical to the baseline risk quotients, suggesting that the Project emissions will not significantly increase secondary exposure.

D.5.4.4 Upset Scenarios

As described in the Air Quality Assessment (CR #1), three separate Upset Cases were evaluated.

In Upset Case 1, the maximum 1-hour SO_2 concentration in the LSA increased to 146 µg/m^3. No other air quality changes are reported and concentrations in the RSA are unaffected. This value is well below the acute exposure limit and therefore no adverse effects are expected.

For Upset Case 2, the 1-hour NO_2 concentration in the LSA is 176 µg/m^3. No other adverse air quality changes are reported and concentrations in the RSA are unaffected. This value is below the acute exposure limit of 188 µg/m^3 and therefore no adverse effects are expected.

For Upset Case 3, the maximum 1-hour NO_2 concentration at the CPF Boundary increases to 204 µg/m^3. No other adverse air quality changes are reported and concentrations in the RSA are unaffected. This value slightly exceeds the 1-hour exposure limit of 188 µg/m^3, based on respiratory irritation. Under this scenario the potential for respiratory irritation to occur may exist if humans are present at the CPF Boundary during this upset condition. These effects would be expected to be temporary and reversible. This maximum concentration is still well below the 1-hour Alberta Ambient Air Quality Objective of 300 µg/m^3.

D.4.4 MITIGATION AND MONITORING

The results of the human health risk assessment do not suggest a need for further mitigation of emissions based on potential human health risks.

D.4.5 SUMMARY

The emissions from the Project are not predicted to cause significant adverse effects to human health.

- **Acute Inhalation** – Acute inhalation risks were evaluated by comparing maximum predicted short-term concentrations in air to appropriate toxicity limits. The 10-minute

average SO_2 concentration resulted in a risk quotient approximately equal to 1 in the RSA but less than 1 in the LSA. This concentration was the same in the baseline scenario as the application and PDC scenarios and therefore is not associated with the proposed Project. All other risk quotients were less than 1. The Project is not expected to result in human health risks from short-term inhalation exposure.

- **Chronic Inhalation** – Chronic inhalation risks were evaluated by comparing maximum predicted annual average concentrations in air to toxicity limits. All risk quotients were less than 1, indicating that the Project is not expected to result in human health risks from chronic inhalation exposure.
- **Chronic Multimedia Exposure** – Chronic risks from secondary exposure through oral and dermal pathways were evaluated using maximum predicted annual average concentrations in air and a multimedia exposure model. The risk quotient for naphthalene exceeded 1 in the RSA but not the LSA. Further evaluation indicated that the risk quotient was the same for the baseline scenario as the application and PDC scenarios and therefore is not associated with the proposed Project. All other risk quotients were less than 1. The Project is not expected to result in human health risks from chronic oral and dermal exposure.

The wildlife health risk assessment (CR #4, Appendix D) demonstrated that the risks to wildlife health from COPCs under the Project and PDC did not differ from the baseline scenario.

D.5 HYDROGEOLOGY

D.5.1 INTRODUCTION AND TERMS OF REFERENCE

Pengrowth Energy Corporation (Pengrowth) conducted a hydrogeological assessment for the proposed Project. The following section is a summary of the Hydrogeological Environmental Assessment that was prepared by Millennium EMS Solutions Ltd. and included as Consultant Report #5 (CR #5). For full details of the assessment please refer to CR #5.

ESRD issued the Terms of Reference for the Project on December 13, 2013. The specific requirements for the hydrogeology component are provided in Section 3.2 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 groundwater and surface water quantity and quality;

b) implications for terrestrial or riparian vegetation, wildlife and aquatic resources including wetlands;

c) changes in groundwater quality, 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.

The hydrogeology local study area (HLSA) was defined as a 1.6 km buffer around the EIA Project Area and the hydrogeology regional study area (HRSA) was defined as an 8 km buffer around the HLSA (CR #5, Figure 1). The HRSA was selected to satisfy the requirements presented in Section 7.3 of Draft Directive 023 (AER, 2013). It is expected that the HLSA will include the extent of all groundwater impacts related to the Project and that any residual effects with the potential to cumulatively interact with the residual effects of other projects will be within the HRSA.

Components of the Project that have the potential to impact groundwater resources include the operation of surface facilities; and steaming and production.

The valued environmental components (VECs) focused on for this assessment included non-saline aquifers, surface water bodies and wetland areas.

D.5.2 BASELINE CONDITIONS

The Project is located within the Eastern Alberta Plains physiographic region, and is situated over a surface water divide between the Beaver River basin and the North Saskatchewan River basin (Parks *et al.*, 2005). The area is characterized by relatively high relief, with ridged to hummocky rolling terrain. The Project is located on Crown and private land, with both anthropogenic and natural cover (Pengrowth, 2010).

The ground surface in the vicinity of the Project varies between 570 and 720 m above sea level (asl) (CR #5, Figure 2). Over the HLSA, the topography generally slopes towards topographical lows such as lakes and creeks. Several unnamed surface water bodies lie within the HLSA in addition to two larger named lakes: Garnier and Bluet. Portions of Muriel Lake and Reita Lake and the majority of Cushing Lake are within the HLSA boundary (CR #5, Figure 1).

Environment Canada (EC) provides long-term climate data, where mean monthly temperatures are typically below zero from November to March with mean annual precipitation of 442 mm.

The project is underlain by Quaternary, Cretaceous, Devonian and Cambrian deposits (CR #5, Figure 3). The stratigraphy and hydrostratigraphy, adapted from Bachu *et al.*, (1993) is

illustrated in CR #5, Figure 3 and cross sections illustrating the Quaternary geology within the HLSA and the corresponding line of section map are included as CR #5, Figures 4, 5 and 6. Aquifers within the Quaternary deposits in the HLSA are identified within the Sand River equivalent, Ethel Lake, Bonnyville, Muriel Lake, and Empress formations. Groundwater from bedrock aquifers is expected to be saline.

D.5.2.1 Cambrian

In the HRSA, the Cambrian deposits are the lowermost deposits of interest for the purposes of this study. The Cambrian deposits lie beneath Devonian deposits and unconformably overlie the Precambrian basement (CR #5, Figure 3). The top of the Cambrian is expected to be approximately -750 m asl and can be up to 200 m thick (Hitchon *et al.*, 1989; Hitchon *et al.*, 1996). Pengrowth plans to utilize two existing disposal wells (ERCB Approval No. 12088A), which are both completed within the Cambrian (Basal Sandstone Formation) as part of their expansion operations.

D.5.2.2 Devonian

Devonian deposits overlie the Cambrian units and include the Elk Point, Beaverhill Lake and Woodbend groups. The Elk Point Group consists of depositional sequences, with an elevation of approximately -300 m asl and can be up to 200 m thick (Hitchon *et al.*,1996).

The Devonian Elk Point Group includes formations that are characterized as aquifers, aquicludes and aquitards. The stratigraphy and hydrostratigraphy of the Elk Point Group is summarized in CR #5, Figure 3. The salinity of the groundwater in the Contact Rapids-Winnipegosis aquifer system can be up to 100,000 mg/L and the general groundwater flow direction is to the northwest (Bachu *et al.*, 1993).

D.5.2.3 Cretaceous

The Cretaceous Mannville Group overlies the Devonian deposits in the HRSA, is expected to be up to 200 m thick and includes the McMurray, Clearwater and Grand Rapids formations. The Lloydminster Sand of the lower Grand Rapids Formation is the focus of Pengrowth's SAGD development.

The Colorado Group overlies the Mannville Group and includes the Lea Park Formation, the 2nd White Specks Sandstone, the LaBiche Formation, the Viking Formation and the Joli Fou Formation (CR #5, Figure 3). Across the HRSA, the upper bedrock is the Lea Park Formation, with thickness expected to be greater than 125 m in the HRSA (Andriashek and Fenton, 1989).

Regional mapping of bedrock topography indicates that the Holyoke Channel is present within the HRSA (CR #5, Figure 7) and is estimated to be between one and two kilometres wide and 115 to 120 m deep. The regionally-mapped Bronson Lake channel is also present at the northeastern edge of the HRSA (CR #5, Figure 7) and is estimated to be 1.5 to 3 km wide and 30 to 40 m deep.

In the HRSA, the Cretaceous McMurray aquifer system includes the McMurray Formation is likely hydraulically connected to the underlying Beaverhill Lake – Cooking Lake aquifer system.

Overlying the McMurray aquifer system is the Clearwater Aquitard and the Grand Rapids aquifer system; both are part of the Mannville Group. The Lloydminster Sand is the lowermost unit within the Grand Rapids Formation and is the target for bitumen production for the Project.

Initial findings indicate that the quality of groundwater from the Grand Rapids Formation may be acceptable for use by Pengrowth. The quantity of groundwater that the Formation can supply may not be sufficient to develop.

There are four monitoring wells completed in the Lea Park Formation of the Colorado Group within the HLSA. Of the four monitoring wells, only two appear to have reached static water levels following drilling in June 2013. An interpretation of groundwater flow rate and direction within the Lea Park Formation is unable to be determined at this time (CR #5, Figure 18).

The groundwater from the Lea Park Formation is sodium bicarbonate type water or calcium type water with no dominant cation (CR #5, Figure 19) and the TDS concentration primarily ranges between 900 and 1,900 mg/L (CR #5, Table 4). The Alberta Energy Regulator reports that the top of the Lea Park Formation represents the base of groundwater protection in the HRSA (CR #5, Figure 16) and although the chemical analyses indicate that the groundwater from the upper Lea Park Formation is non-saline, given the thickness of the Lea Park Formation, it is expected that the groundwater becomes saline within the Formation.

D.5.2.4 Quaternary

Empress Formation

The Empress Formation is divided into three units. Unit 1 is described as pre-glacial sands and gravels. The overlying Unit 2 is of glacial origin and is primarily composed of clay and silt, and Unit 3 is a glacial unit composed of sand, gravel, silt and clay. Typically, Unit 3 contains fine to coarse grains and the deposits are described as soft and loose. The Unit is expected to be up to 20 m thick within the Channels (Andriashek and Fenton, 1989).

Within the HRSA, only Unit 3 of the Empress Formation is expected to be present and its extent is restricted to the Bronson Lake Channel and the southeastern portion of the Holyoke Channel (CR #5, Figure 8). It is typically characterized as an aquifer as it is primarily composed of stratified sand and gravel (Andriashek and Fenton, 1989).

Bronson Lake Formation

The Bronson Lake Formation is present within the Holyoke and Bronson Lake channels and overlies the Empress Formation Unit 3 (CR #5, Figure 9). It is described as a relatively clast free clay till unit with an average thickness of less than 10 m (Andriashek and Fenton, 1989). It is typically characterized as an aquitard as it is primarily a glacial till unit.

Muriel Lake Formation

The Muriel Lake Formation overlies the Bronson Lake Formation and is present within and in close proximity to the Holyoke and Bronson Lake channels in the HRSA (CR #5, Figure 9). The

Muriel Lake Formation consists of silt, sand, and sand and gravel deposits, with minor occurrences of silt and clay beds (Andriashek and Fenton, 1989).

It is characterized as an aquifer (Alberta Government, 2013) and is expected to be between 5 to 10 m thick within the HRSA, but locally it can be up to 20 m thick. Only one monitoring well encountered the Muriel Lake Formation within the HLSA (MW13-27-90) and its water level measured was 596.2 m asl. CR #5, Figure 19 and Table 4 show water analysis from MW 13-27-90.

Bonnyville Formation

The Bonnyville Formation is sub-divided into two units, Unit 1 and Unit 2, both believed to consist of glacial deposits from the Fort Kent Glaciation (Andriashek and Fenton, 1989). Unit 1 is located at the bottom of the Formation and is primarily composed of clay till, and the overlying Unit 2 is characterized as a sandy glacial till.

In the southeast of the HRSA, in the vicinity of the Holyoke Channel trace, it is expected that the Bonnyville Formation Unit 1 sands and gravels will be present (CR #5, Figure 11). The Bonnyville Formation Unit 2 is present throughout the HRSA (CR #5, Figure 12). This unit is approximately 10 m thick over most of the HRSA but can be up to 30 m in the east.

Both units of the Bonnyville Formation were encountered during hydrogeological drilling activities within the HLSA. Bonnyville Formation Unit 1 sand and gravel deposits are discontinuous over the HLSA and only one monitoring well (MW13-19-82) was completed within the Unit. The Bonnyville Formation was found to be up to 30 m thick, and the sands observed were described as fine to coarse grained and generally increasing in coarseness with depth.

The Bonnyville Formation is characterized as an aquifer-aquitard due to a discontinuous sand and gravel aquifer between the Units. Since there is only one monitoring well completed within the Bonnyville Formation Unit 1 sands, the hydraulic gradient and groundwater flow direction and velocity are unable to be determined.

Ethel Lake Formation

The Ethel Lake Formation consists of stratified silt and clay, with some sand and gravel (Alberta Government, 2013). CR #5, Figure 13 shows the distribution of the Ethel Lake Formation in the HRSA and the elevation of the top of the Formation based on regional data. The regional surface is approximately 10 m higher than the top of the Formation based on drilling data within the HLSA. The Ethel Lake Formation is approximately 10 m thick and is considered to be widespread but not continuous (Andriashek and Fenton, 1989).

This formation is interpreted as a glacially-derived aquifer that could supply water for domestic use (Alberta Government, 2013). Six groundwater monitoring wells are completed within the Ethel Lake Formation that were drilled and completed in 2011 and 2013 (CR #5, Table 3).

Regional groundwater flow in the Ethel Lake Formation is expected to be to the north within the Beaver River basin (Parks *et al.*, 2005). Since there is only one monitoring well completed within the Ethel Lake Formation in the Beaver River basin, no further groundwater flow characteristics can be determined; additional drilling will be completed to determine the groundwater flow.

Three monitoring wells were drilled near the Pilot Project SAGD well pad to establish background groundwater chemistry for the Ethel Lake Formation before steaming began. Chemical analysis results from the Ethel Lake Formation have been compared to the *targets* and *thresholds* in 2011 and 2012. No increasing trends in concentrations and therefore, no impacts related to the Pilot project have been observed over the two years of operational monitoring (MEMS, 2013).

Marie Creek Formation

The Marie Creek Formation is a glacial till unit with local occurrences of very coarse sand rich in carbonate fragments deposited during the Ardmore Glaciation (Andriashek and Fenton, 1989). This formation is subdivided into two units: Unit 1 and Unit 2. Unit 1 is absent over most of the HRSA and is only regionally mapped near the eastern boundary whereas Unit 2 is present throughout; both Units are described as sandy diamictons (Andriashek and Fenton, 1989).

The Marie Creek Formation is present throughout the HLSA (CR #5, Figure 14) and was typically described during hydrogeological drilling as a dark grey, gravelly clay deposit. Characterized as an aquitard, the Marie Creek Formation is expected to be between 30 and 40 m thick (CR #5, Figures 5 and 6). One monitoring well is completed within the Marie Creek Formation (P02-5). The average water level measured in P02-5 is 650 m asl.

Sand River Formation Equivalent

Regional mapping indicates that the Sand River Formation is present inside the northern boundary of the HRSA but is absent beneath the HLSA. A facies of similar geological characteristics and stratigraphic position was reported present during drilling in the vicinity of the Pilot Project footprint (MEMS, 2011b). The Sand River Formation is composed of stratified sand and gravelly sand, with some silt and clay and the sand is described as well sorted and is classified as fine to medium-grained (Andriashek and Fenton, 1989). It is expected to be up to 15 m thick and considered an aquifer as it primarily consists of sand and silt. There are 23 monitoring wells completed in the formation.

Grand Centre Formation

The Grand Centre Formation is primarily composed of glacial till with sandy-clay texture deposited during the Cold Lake Glaciation (Andriashek and Fenton, 1989). The Formation is subdivided into four glacial till members, is widespread and expected to be present throughout the HRSA (CR #5, Figure 15). The very coarse-grained sand content is typically high in igneous and metamorphic material which differentiates the Formation from the other till formations in the HRSA (Andriashek and Fenton, 1989).

The Grand Centre Formation encountered during drilling within the HLSA was typically 15 to 25 m thick depending on the topography, and were primarily a silty clay with some gravels and local occurrences of sand and gravel seams. It is interpreted as an aquitard. One groundwater monitoring well is completed in the Grand Centre Formation (P10-12A), which has an average water level of 649.2 m asl and a hydraulic conductivity of 8.5 x 10^{-7} m/s.

D.5.2.5 Groundwater Flow System

Groundwater flow within Quaternary deposits is expected to be driven by physiography, with recharge in upland areas and flow towards topographic lows. Regional groundwater flow within the Beaver River basin is north from the HLSA towards Beaver River (Parks *et al.*, 2005). Based on limited datasets, groundwater flow within the North Saskatchewan River basin appears to be generally to the south as demonstrated by the groundwater levels in the Pengrowth monitoring wells (CR #5, Figures 20 and 21). Only one spring which is located near the east shore of Muriel Lake was identified and sampled during a field verified survey conducted in October 2013. The spring represents an area of groundwater discharge.

Within the North Saskatchewan River basin, there is an overall upward hydraulic gradient observed in nested wells completed within the upper bedrock and Quaternary deposits to the west of Garnier Lake in sections 12 and 13-058-05 W4M (CR #5, Figure 5). The nested wells in 01-20-059-04 W4M in the Beaver River basin show an overall downward hydraulic gradient within the Quaternary deposits (CR #5, Figure 5).

Since it is expected that the shallow surficial deposits over most of the HLSA are the clay tills of the Grand Centre Formation, the recharge potential is expected to be relatively low as precipitation will not be able to penetrate the low permeability materials as easily as they would infiltrate higher permeability materials such as sand and gravel. The recharge potential to Quaternary and bedrock aquifers will be particularly low in areas where the Sand River Formation equivalent is absent within the HLSA.

Over one thousand vertical metres of material separate the Cambrian Basal Sandstone Formation from the Quaternary aquifers including several aquitards and the Clearwater aquitard system which effectively separate the proposed disposal zone from non-saline aquifers (CR #5, Figure 3).

D.5.2.6 Groundwater Surface Water Interactions

Under natural conditions, groundwater flows into Muriel Lake (Alberta Government, 2013). Muriel Lake is expected to be up to 10 m deep and is in contact with the Ethel Lake and Bonnyville formations (Alberta Environment, 2008b; University of Alberta, 1990; Parks *et al.*, 2005). The hydrology of Muriel Lake was reviewed by Millennium EMS Solutions Ltd. and Northwest Hydraulic Consultants Ltd. in 2012 (MEMS and NHC, 2012). The review determined that Muriel Lake received groundwater from the Grand Centre, Marie Creek and Ethel Lake formations and groundwater from the Bonnyville and Muriel Lake formations is moving downwards and northwards. Hydrogeological drilling in 01-20-059-04 W4M indicates that there also may be upward flow from the Bonnyville Formation and the Muriel Lake Formation towards Muriel Lake (CR #5, Figure 5 and Table 3).

Garnier Lake and Bluet Lake are south of Muriel Lake and are situated within a deep valley. Surface water flows from southeast to northwest along the valley towards Muriel Lake. The lake level measured in Garnier Lake in 2004 was 602.84 m asl, which is lower than the water levels measured in nearby monitoring wells completed in the Ethel Lake, Bonnyville and Lea Park formations. An upward hydraulic gradient is also observed in nested monitoring wells adjacent to the valley within the HLSA suggesting that groundwater is contributing to the lakes in the valley bottom. The maximum depth of Garnier Lake is 9.5 m and the maximum depth of Bluet Lake is over 6.5 m (Alberta Lake Management Society, 2005a and 2005b) suggesting that the lakes are likely receiving groundwater from the Ethel Lake Formation.

Reita Lake and Cushing Lake are at higher elevations than Muriel, Garnier and Bluet lakes. Reita and Cushing lakes are also expected to be shallower than the lakes situated in the valley. Nested water wells in 01-20-059-04 W4M indicate a downward hydraulic gradient and along with the limited lake depths it is expected that the primary source of water for Reita and Cushing Lakes is precipitation. If groundwater contributes to these lakes at all, it is expected that it would be from the shallow Grand Centre Formation and the contribution would be minor.

Groundwater is expected to be recharged by precipitation over most of the HLSA, except in the areas of Muriel Lake and the valley containing Garnier and Bluet lakes where groundwater is expected to discharge into the surface water system.

D.5.2.7 Groundwater and Surface Water Use

Water well records in the ESRD Water Well Information Database were reviewed within the HLSA (ESRD, 2013c). One hundred forty-one records were identified within the search radius (65 domestic use, 12 domestic and stock use, six stock watering use, 38 industrial use, three monitoring or observation use, 16 unknown use, and one record for an “old well”). Sixteen records indicate that the feature is abandoned or was a dry hole. The nearest domestic water well record located downgradient of the Project CPF is approximately four kilometres southwest in 04-15-058-05 W4M (Well ID 289206).

A map showing the location of the water well records and a summary of the well details are included in CR #5, Appendix C, Figure C-1 and Table C1.

During the 2012 and 2013 field surveys, 162 residences were visited. Of the 162 residences, MEMS confirmed 39 water sources (12 for domestic, 11 for stock, nine for domestic and stock, one for landscape maintenance and two used for unknown purposes and four that are not in use). During the field survey, 26 groundwater samples and 13 surface water samples were collected. A map and table summarizing the field survey are included in CR #5, Appendix D, Figure D-1and Table D-1.

D.5.2.8 Licenced Groundwater and Surface Water Use

There are two licenced and six registered groundwater users within the HLSA. Based on the depths drilled and area water well lithologies, both of the licenced water wells are likely completed within Quaternary deposits. No information associated with the licences or any corresponding water well records are available to confirm this interpretation.

There are 179 registered surface water diversions within the HLSA, and 159 of the applicants are listed as “Public Land Management”.

In CR #5, Appendix C Figure C-2 and Table C-2 summarize the licenced water well and surface water locations records.

D.5.3 PREDICTED CONDITIONS

Quaternary non-saline aquifers, surface water bodies and wetland areas have been identified as VECs related to the Project (CR #5, Section 2.5). Potential impacts to VECs include the effects of operating surface facilities as well as production and injection wells on the quality of water resources in the area.

D.5.3.1 Potential Effects of the Surface Facilities on Groundwater Quality

As a result of the best management practices and the material handling methods, there should be a low possibility of potential effects to shallow groundwater quality, except through upset conditions, (*i.e.*, accidental spills or leaks). The impact to groundwater quality will depend on the volume and type of fluids released, the characteristics of the surface materials at the release location, and the underlying groundwater conditions. Fluids handled at the Project CPF include produced emulsion, produced vapours, diluent, dil-bit, produced water and small volumes of various process related organic chemicals such as glycol or lubricants (Section B.5).

No impacts to surface water receptors, terrestrial or riparian vegetation, wildlife or aquatic resources including wetlands are expected. The potential impact to groundwater from surface facilities, will be local in extent, can occur during the operation of the facilities, may occur occasionally, will diminish over time and may exceed background concentrations but will likely be within threshold limits. The overall impact rating is determined to be low.

D.5.3.2 Potential Effects on Production/Injection Wells on Groundwater Quality

The main areas of concern with respect to the SAGD production/injection wells include:

- the potential for casing failure to allow well bore fluids to be introduced into non-saline aquifers; and
- thermal effects adjacent to the well bore of the injection wells that could cause mobilization of metals within groundwater.

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. The design features and operational factors that Pengrowth has committed to are expected to ensure that the production and injection wells will not have any effect on the chemical quality of the groundwater in non-saline aquifers or surface water bodies due to failure of the well casing integrity.

The lifetime of each well pair is anticipated to be seven years, following which, temperature conditions would return to baseline. During the operational life of the well pairs, there is potential for elevated arsenic concentrations to occur within non-saline aquifers underlying the Project

There are five main named lakes within the HLSA, three of which are likely receiving groundwater from the Ethel Lake Formation. Groundwater is likely discharging into Muriel Lake from the Grand Centre, Marie Creek and Ethel Lake formations. It is not expected that Muriel Lake will be negatively impacted by the Project. Groundwater discharging into Garnier Lake could be altered by the development of thermal plumes. Other processes and factors such as adsorption and mineral precipitation will reduce the possibility that undesirable concentrations of dissolved arsenic will actually discharge into the lake (Stollenwerk, 2003). It is unlikely that groundwater is discharging into Reita Lake or Cushing Lake.

Records indicate that water wells may be located in close proximity to proposed well pads in the southwest and the northeast areas of the HLSA. Water wells were field verified in the southwest and groundwater monitoring will be proposed to ensure the protection of the groundwater resource in that area. No water wells were field verified in the northeast due to restricted access.

The groundwater response plan will be effective at avoiding undesirable effects to groundwater. No impacts to surface water receptors, terrestrial or riparian vegetation, wildlife or aquatic resources including wetlands are expected.

The potential impact to groundwater due to steaming activities will diminish over time and may exceed background concentrations, but will be well within established limits. The overall impact rating is determined to be low.

D.5.4 CUMULATIVE EFFECTS

Groundwater effects associated with surface facilities and injection and production wells have low impact ratings and are local in extent. Oil sands facilities are located north of the HRSA in the vicinity of Cold Lake, approximately 60 km from the Project. The nearest industrial facility to the Project is the Canadian Salt Company Lindbergh Facility located 16 km south.

There will be no cumulative effects due to planned projects in the HRSA related to groundwater associated with the Project.

D.5.5 MITIGATION AND MONITORING

D.5.5.1 Mitigation

Surface Facilities

Mitigation measures for minimizing or preventing adverse impacts on shallow groundwater quality due to spills or leaks include industry-standard operating practices, preparedness for upset conditions and the appropriate management of upset conditions. Industry best practices employed by Pengrowth include double walled storage tanks, secondary protection, leak

detection and good housekeeping practices that will minimize the occurrence of product leaks from tanks and prevent any significant impacts to groundwater resources.

Production/Injection Wells

Design features, operational factors, operational monitoring and industry best practices are expected to ensure that the production and injection wells will not have any effect on the chemical quality of the groundwater in non-saline aquifers due to well casing failure.

D.5.5.2 Monitoring

Surface Facilities

A groundwater monitoring program will be implemented to detect any impacts on the shallow groundwater quality resulting from spills or leaks from surface facilities. In the event that an impact on groundwater quality is detected, a groundwater response plan will be implemented. The response plan would include determining the magnitude of the impact and the mitigation measures required.

Production/Injection Wells

Ongoing groundwater monitoring of the Quaternary deposits is being conducted for the Pilot Project, which will determine the propensity of minerals to mobilize from the soils into the groundwater under the changing thermal regime. Detailed monitoring of the Pilot SAGD well pad is ongoing. Based on continued groundwater monitoring results, additional groundwater wells may be drilled in areas downgradient of the proposed well pads so that sufficient monitoring of the Quaternary deposits can be accomplished.

Groundwater Monitoring Program

The groundwater monitoring program developed for the Project will have the following main purposes:

- to detect any impacts on the shallow groundwater quality resulting from spills or leaks from surface facilities at the plant site; and
- to identify any changes in groundwater chemistry in the non-saline groundwater zones associated with steam injection.

Areas that will be monitored will include the Project CPF, downgradient of well pads and upgradient of VECs such as domestic and stock water wells, Muriel Lake, Garnier Lake and Reita Lake.

Groundwater monitoring wells for the Project will target aquifer units that have the potential to transmit groundwater to receptors. Monitoring near the Project CPF will be focused on the shallowest aquifer unit or water table if no aquifer is within the upper 15 m whereas monitoring of the Project area away from the Project CPF will target all permeable units present. High-permeability Quaternary formations will be targeted. A detailed description is included in CR #5, Appendix D.

The monitoring program will include biannual sampling with more frequent sampling during the baseline data collection period. Water-measurements in monitoring wells not planned for operational monitoring will continue to be collected following the baseline data collection period. Annual reporting will be submitted to the AER.

D.5.6 SUMMARY OF VEC

A summary of possible residual impacts to Groundwater VECs by the project is summarized in Table D.5.6-1.

Table D.5.6-1 Summary of Impact Rating on Residual Effects for Hydrogeology VECs

Valued Environmental Component	Nature of Potential Impact or Effect	Mitigation	Geographic Extent[1]	Duration[2]	Frequency[3]	Reversibility[4]	Magnitude[5]	Project Contribution[6]	Confidence Rating[7]	Probability of Occurrence[8]	Impact Rating[9]
Groundwater Quality											
Aquifers in Quaternary Deposits	Surface Facilities	Groundwater Monitoring, Industry Standard Operating Practices, Preparedness for Upset Conditions, Spill and Groundwater Response Plans	Local	Long-term	Occasional	Reversible – long term	Moderate	Negative	Moderate	Medium	Low Impact
Surface Water Bodies and Wetlands[10]			N/A	N/A	N/A	N/A	N/A	N/A	Moderate	N/A	No Impact
Aquifers in Quaternary Deposits	Production and Steaming	Groundwater and Operational Monitoring, Well Design Measures	Local	Long-term	Isolated	Reversible – long term	Low	Negative	Moderate	Medium	Low Impact
Surface Water Bodies and Wetlands[10]			N/A	N/A	N/A	N/A	N/A	N/A	Moderate	N/A	No Impact

1. Local, Regional, Provincial, National, Global; **2.** Short, Long, Extended, Residual; **3.** Continuous, Isolated, Periodic, Occasional; **4.** Reversible in short term, Reversible in long term, Irreversible; **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; **10.** Based on the current understanding of cause-effect relationships, groundwater will not provide a pathway for potential contaminants to reach surface water bodies or wetlands at detectable concentrations.

D.6 HYDROLOGY

D.6.1 INTRODUCTION AND TERMS OF REFERENCE

Pengrowth conducted an assessment of hydrology for the proposed 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 the Project on December 13, 2013. 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, and:

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.

The Project lies in a small zone of Central Mixedwood Boreal Forest situated within a larger region of Dry Mixedwood Boreal Forest. The Project is drained by tributaries of Mooswa Creek, by Garnier Creek (the creek connecting Garnier Lakes to Muriel Lake), Reita Lake, Muriel Lake and Borden Lake.

The Hydrology LSA is defined as the Project Footprint and surrounding areas which would be directly affected by runoff from the Project and is 485.4 km^2 in area (CR #6, Figure 3). The Hydrology RSA is defined as the area in which flows and water levels could be directly or indirectly affected by the Project (CR #6, Figure 2) and is 756.4 km^2 in area. The RSA consists of drainage areas of Mooswa Creek to Mitchell Lake, Garnier Creek to Muriel Lake, Reita Creek

to Reita Lake and Middle Creek to Borden Lake. The LSA and RSA were selected because potential impacts to waterbodies downstream of these drainage basins are anticipated to have either no impacts or be negligible.

The Project 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

D.6.2.1 Surface Disturbances

Existing and approved developments within the LSA include access corridors, borrow pits, camps (construction operator and supervisor), well pads, disposal wells and the CPF.

Table D.6.2-1 summarizes the extent of the existing spatial disturbances within the individual drainage watersheds. The total disturbed in the LSA is 174.3 ha, which is 0.22% of the total area of the LSA. The most disturbed watershed is G7, with 8.3% of the area disturbed, largely because the watershed is quite small, only 191 ha.

Table D.6.2-1 Summary of Existing and Approved Disturbance Areas within LSA

Watershed	Access Corridors (ha)	Borrow Pits (ha)	Camps (ha)	CPF (ha)	Soil Storage (ha)	Disposal Wells (ha)	Well Pads (ha)	Total Disturbed area (ha)	Total Watershed Area(ha)	Percentage of Watershed Disturbed
M2	49.4	24.7	13.2	34.0	14.0	1.6	12.3	149.2	2881	5.18%
M3	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.3	1966	0.02%
Mitchell Lake Total	49.4	25.0	13.2	34.0	14.0	1.6	12.3	149.6	14946	1.00%
Mooswa Creek Total	49.4	25.0	13.2	34.0	14.0	1.6	12.3	149.6	16528	0.90%
Bluet Lake	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1223	0.00%
G7	1.8	4.5	0.0	3.6	1.2	0.0	4.9	16.0	191	8.34%
G8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	178	0.00%
G9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	253	0.00%
Garnier Lake Total	5.4	4.5	0.0	3.6	4.2	0.0	7.1	24.7	2838	0.87%
G2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2437	0.00%
G4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4553	0.00%
G5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	412	0.00%
Garnier Creek Total	5.4	4.5	0.0	3.6	4.2	0.0	7.1	24.7	12195	0.20%

Table D.6.2-1 Summary of Existing and Approved Disturbance Areas within LSA

Watershed	Access Corridors (ha)	Borrow Pits (ha)	Camps (ha)	CPF (ha)	Soil Storage (ha)	Disposal Wells (ha)	Well Pads (ha)	Total Disturbed area (ha)	Total Watershed Area(ha)	Percentage of Watershed Disturbed
ML5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2575	0.00%
Muriel Lake Total	5.4	4.5	0.0	3.6	4.2	0.0	7.1	24.7	45598	0.05%
Reita Lake Total	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7397	0.00%
Middle Creek Total	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6116	0.00%
Grand Total[1]	**54.8**	**29.5**	**13.2**	**37.5**	**18.2**	**1.6**	**19.4**	**174.3**	**75639**	**0.23%**

[1] The Total may not equal the sum of areas in all watersheds due to rounding.

D.6.2.2 Stream Disturbances

The footprint of the existing and approved components of the Project does not cross streams with defined channels or mapped drainages. The existing public road network crosses a number of streams and drainages. The drainage at these crossings is typically maintained with culverts but there are a few small bridges over the larger creeks such as Garnier Creek and Mooswa Creek.

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. 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. Changes in runoff volumes were estimated assuming a worst case condition represented by estimated runoff coefficients for each disturbance type applied for all runoff events (Table D.6.2-2).

There are no significant changes in the surface drainage patterns due to existing and approved disturbances. Drainage patterns are maintained by providing culverts at appropriate locations.

The greatest change in runoff volume occurs in Watershed M2, which is estimated to have an increase in runoff volume of about 10.6% due to the development in the watershed. The least change in runoff volume in Mooswa Creek is about 1.8% while in Muriel Lake it is only 0.1%. There is no change in runoff volume expected in the Reita Lake or Middle Creek watersheds.

A Hydrologic Simulation Program – FORTRAN (HSPF) was used to perform a more detailed process-based assessment of the hydrologic effects of existing and approved disturbances. The HSPF model was modified to represent watershed alterations due to these disturbances. For most types of disturbances, the HSPF runoff parameters were adjusted to reflect the effects of clearing and soil compaction. HSPF simulations were carried out for all local watersheds and

changes to runoff volumes, peak flows and minimum flows were assessed. The results of these assessments are summarized in Table D.6.2-2.

The effects on runoff volumes were greatest for Watershed M2 with an overall average increase of 5.4%. The change in magnitude in 2-year peak flow was also greatest in Watershed M2, with a predicted increase of 6.2%. There were no perceptible changes in the timing of peak flows. Changes in magnitude of summer minimum flow rates ranged between -1.6% and +1.2%.

Table D.6.2-2 Summary of Baseline Changes in Runoff Volumes Due to Existing and Approved Surface Disturbances from Lindbergh Project

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 (%)
M2	2,881	149.2	10.6%	5.4%	6.19%	-1.60%
M3	1,966	0.3	0.0%	0.0%	0.00%	-0.98%
Mitchell Lake Total	14,946	149.6	2.0%	1.0%	1.15%	-0.56%
Mooswa Creek Total	16,528	149.6	1.8%	1.0%	1.41%	0.99%
Bluet Lake	1,223	0.0	0.0%	0.0%	-0.02%	-0.06%
G7	191	16.0	3.7%	4.4%	4.20%	0.00%
G8	178	0.0	0.0%	0.0%	0.00%	0.00%
G9	253	0.0	0.0%	0.0%	0.00%	0.79%
Garnier Lake Total	2,838	24.7	1.2%	1.8%	0.00%	0.00%
G2	2,437	0.0	0.0%	0.0%	0.00%	-1.23%
G4	4,553	0.0	0.0%	0.0%	0.00%	0.00%
G5	412	0.0	0.0%	0.0%	0.00%	1.17%
Garnier Creek Total	12,195	24.7	0.3%	0.1%	0.02%	0.65%
ML5	2,575	0.0	0.0%	0.0%	0.00%	-0.27%
Muriel Lake Total	45,598	24.7	0.1%	-0.2%	-0.11%	0.00%
Reita Lake Total	7,397	0.0	0.0%	0.0%	0.00%	0.01%
Middle Creek Total	6,116	0.0	0.0%	0.0%	0.00%	-0.27%

D.6.2.4 Water Levels and Surface Areas

Annual peak water levels and surface areas in the streams are not anticipated to be affected by existing and approved disturbances since changes to snowmelt-dominated annual peak flows are expected to be small. Stream minimum water levels and surface areas may be slightly higher due to increased minimum flows. Zero flows will still occur in most of these small watersheds.

The water levels in the permanent lakes in the LSA are expected to increase slightly due to the increased runoff volumes into these water bodies. The average annual increases in water level in the five major lakes in the LSA are summarized in CR #6, Table 16.

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 existing and approved disturbances 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 as a result of the Project.

The cumulative impact of projects in the hydrology RSA was also considered. As there are no other activities planned in the hydrology RSA, the impact rating is low.

D.6.3.1 Surface Disturbances

The Project will produce surface disturbances of approximately 792.3 ha in addition to the 174.3 ha of the existing and approved phases for a total disturbance area of 966.6 ha (Table D.6.3-1).

Surface disturbances for the Project are similar to the disturbances associated with the Pilot and Phase 1. These disturbances include the areas presented in CR #6, Table 14 for the existing and approved disturbances. The greatest percentage area of disturbance due to the Project will be 27.9% in Watershed G7. The percentage disturbance is large because the watershed is quite small. CR #6, Figure 19 shows the layout of the Project.

Table D.6.3-1 Summary of Surface Disturbances of the Proposed Project by Watershed

Watershed	Access Corridors (ha)	Borrow Pits (ha)	Camps (ha)	CPF (ha)	Soil Storage (ha)	Disposal Wells (ha)	Well Pads (ha)	Total Disturbed area (ha)	Total Watershed Area (ha)	Percentage of Watershed Disturbed
M2	95.2	64.9	13.2	31.8	38.4	1.6	45.9	290.9	2,881	10.10%
M3	64.2	7.8	0.0	0.0	26.7	0.0	61.8	160.5	1,966	8.16%
Mitchell Lake Total	161.5	78.0	13.2	31.8	73.5	1.6	120.0	479.5	14,946	3.21%
Mooswa Creek Total	161.5	78.0	13.2	31.8	73.5	1.6	120.0	479.5	16,528	2.90%
Bluet Lake	15.3	0.0	0.0	0.0	0.0	0.0	0.0	15.3	1,223	1.25%
G7	17.8	3.8	0.0	3.6	7.6	0.0	20.6	53.4	191	27.90%
G8	4.2	0.8	0.0	0.0	3.0	0.0	8.5	16.6	178	9.32%

Table D.6.3-1 Summary of Surface Disturbances of the Proposed Project by Watershed

Watershed	Access Corridors (ha)	Borrow Pits (ha)	Camps (ha)	CPF (ha)	Soil Storage (ha)	Disposal Wells (ha)	Well Pads (ha)	Total Disturbed area (ha)	Total Watershed Area (ha)	Percentage of Watershed Disturbed
G9	4.8	0.0	0.0	0.0	0.0	0.0	0.0	4.8	253	1.89%
Garnier Lake Total	55.4	4.6	0.0	3.6	15.2	0.0	37.3	116.1	2,838	4.09%
G2	28.0	9.1	0.0	0.0	10.1	0.0	12.9	60.0	2,437	2.46%
G4	43.7	18.4	0.0	0.0	14.3	0.0	6.7	83.1	4,553	1.83%
G5	10.1	2.3	0.0	0.0	7.6	0.0	2.7	22.8	412	5.52%
Garnier Creek Total	161.3	38.4	0.0	3.6	57.6	0.0	69.3	330.1	12,195	2.71%
ML5	23.2	0.0	0.0	0.0	13.0	0.0	26.6	62.7	2,575	2.44%
Muriel Lake	194.3	44.8	0.0	3.6	74.5	0.0	107.4	424.6	45,598	0.93%
Reita Lake	16.6	9.1	0.0	0.0	10.7	0.0	19.9	56.3	7,397	0.76%
Middle Creek	6.2	0.0	0.0	0.0	0.0	0.0	0.0	6.2	6,116	0.10%
Grand Total	378.6	131.9	13.2	35.4	158.7	1.6	247.3	966.6	75,639	1.28%

D.6.3.2 Stream Disturbances

In general, the Project footprint was developed with the following setbacks from streams and drainages:

- waterbodies with fish habitat – 100 m;
- defined channels with no fish habitat – 50 m; and
- drainages without defined channels – 0 m.

The Project footprint will cross mapped channels and drainages at 19 locations. All but one of the crossing locations are for access corridors.

The crossings were inspected by low-level aerial reconnaissance and on the ground. Most of these locations are crossing mapped drainages as compared to defined channels. There are six locations where the footprint crosses ephemeral channels and one location where it crosses a small permanent channel. The drainage pathways at all of these locations can be maintained with adequately sized culverts. These crossings are not navigable. The locations of these crossings are shown in CR #6, Figure 20 and summarized in CR #6, Table 18.

D.6.3.3 Water Supply

Water from the North Saskatchewan River will be used to supply water for the Project. This water will be obtained from an existing intake and supply pipeline under an existing water licence. The Project will be designed to recycle water so there will only be a small increase in

water use relative to current usage. The existing water licence allows a maximum rate of 4,404 m^3/day to be diverted from the North Saskatchewan River.

D.6.3.4 Runoff Volumes and Streamflows

There will be no significant changes in the surface drainage patterns due to the Project. Existing drainage paths will be maintained. The effect of the Project on runoff volumes in each individual watershed depends on the proportions of the watershed area that are used for the CPF, borrow pits, soil storage, access corridors and well pads. The borrow pits will reduce runoff volumes and flood peaks because water will not be released from these areas. Soil storage and access corridors will increase both runoff volumes and flood peaks due to the reduction in vegetation and the addition of less permeable surfaces. The CPF and well pads will tend to reduce the flood peaks because of the detention of runoff.

Changes in runoff volumes when the Project is fully developed were estimated assuming a worst case condition that the estimated runoff coefficients for each disturbance type are applicable for all runoff events. These changes are summarized in Table D.6.3-2. The development of the Project would generally result in increased runoff volumes. The greatest change in runoff volume will occur in Watershed G7 with estimated increases of 47%. The smallest increase for the major basins would be about 5% or less.

Simulations were carried out for all local watersheds using HSPF modeling. Changes to runoff volumes, peak flows and minimum flows are summarized in CR #6, Table 20. The effects for the Application Case on runoff volumes are greatest for Watershed M2. The largest increase for the major basins would be less than 2%. The largest increase in magnitude in 2-year peak flow due to the Application Case is 7.1% in Watershed M2. There are no perceptible changes in the timing of peak flows, based on the simulation results. Changes in magnitude of summer minimum flow rates ranged between -2.9% and +9.4%.

Table D.6.3-2 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 (%)
M2	2,881	290.9	18.4%	6.1%	7.06%	-0.96%
M3	1,966	160.5	16.7%	3.0%	1.22%	0.00%
Mitchell Lake Total	14,946	479.5	6.0%	1.6%	1.77%	1.20%
Mooswa Creek Total	16,528	479.5	5.4%	1.5%	2.19%	2.29%
Bluet Lake	1,223	15.3	4.1%	5.8%	0.00%	0.00%
G7	191	53.4	47.3%	5.6%	2.67%	0.00%
G8	178	16.6	15.4%	1.4%	0.83%	1.87%
G9	253	4.8	6.2%	2.4%	2.59%	8.09%
Garnier Lake Total	2,838	116.1	8.8%	4.9%	0.00%	0.00%
G2	2,437	60.0	5.4%	1.2%	1.41%	3.07%
G4	4,553	83.1	4.2%	1.4%	1.92%	7.69%
G5	412	22.8	16.2%	4.4%	4.59%	-2.86%
Garnier Creek Total	12,195	330.1	6.3%	1.7%	1.97%	9.43%
ML5	2,575	62.7	5.3%	1.4%	1.09%	0.00%
Muriel Lake Total	45,598	424.6	2.1%	0.5%	0.58%	0.00%
Reita Lake Total	7,397	56.3	1.3%	0.1%	0.00%	1.13%
Middle Creek Total	6,116	6.2	0.3%	0.1%	0.14%	-0.27%

D.6.3.5 Water Levels and Surface Areas

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. 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 water levels in the permanent lakes in the LSA are expected to increase slightly due to the increased runoff volumes into these water bodies. The average annual increases in water level in the five major lakes in the LSA are summarized in CR #6, Table 21.

D.6.3.6 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 most of the streams in the LSA are not expected to increase due to changes in the surface runoff characteristics because, in most cases, the runoff increase is not significant. Some small watersheds such as M2 and G7, may have increases in runoff volumes and peak flows of greater than 5% on average due to the Project disturbances and these increases have the potential to cause erosion and increased sediment concentrations in the channels downstream of the disturbances.

D.6.4 MITIGATION AND MONITORING

D.6.4.1 Mitigation

The following practices and procedures will be carried out to reduce the effects of the development on the surface water hydrology:

- water will not be transferred from one watershed to another;
- appropriate drainage culverts will be provided at crossings of any identifiable drainage courses to maintain existing drainage patterns;
- runoff from well pads will not be discharged directly to drainages;
- run-on from upstream of well pads and plant site will be directed around the disturbances and back into their original pathways;
- surface disturbances will be reclaimed after they are no longer required;
- disturbances will be kept away from streams with defined channels;
- sediment control will be utilized for construction activity where runoff may potentially flow directly into drainages; and
- erosion control measures will be implemented at locations where channel erosion is observed to occur due to increased stream flows. Implementation of erosion control measures in anticipation of potential erosion is not recommended because it is more likely that the channels will remain stable.

D.6.4.2 Monitoring

Impacts on runoff volumes and streamflows will be difficult to distinguish from natural variability, so direct monitoring of streamflows is not necessary. However, the following monitoring should be carried out to ensure that the impacts on the surface water hydrology are low:

- routine visual inspections should be carried out to ensure that the access road drainage culverts are working as intended to maintain the natural surface drainage patterns;
- downstream channels should be inspected annually for new areas of channel erosion;
- water volumes pumped from the CPF stormwater ponds into the natural environment should be recorded; and

- the volume of any runoff water used for the Project should be recorded.

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.6.5-1.

Table D.6.5-1 Summary of Impact Rating on Residual Effects for Hydrology VECs

VEC	Nature of Potential Impact or Effect	Mitigation/ Protection Plan	Type of Impact or Effect	Geographical Extent	Duration	Frequency	Reversibility	Magnitude	Project Contribution	Confidence Rating	Probability of Occurrence	Impact Rating
1. Runoff Volumes and Streamflows												
	Changes to runoff volume, peak flows, and low flows	1) Maintain drainage around disturbed areas 2) Reclaim surface disturbances once no longer required 3) Discharge runoff into natural environment away from streams in accordance with EPEA Approval	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	1) Maintain drainage around disturbed areas 2) Reclaim surface disturbances once no longer required 3) Discharge runoff into natural environment away from streams in accordance with EPEA Approval	Application	Local	Long-term	Periodic	Reversible in long term	Low	Positive	High	High	Low
			Cumulative	Local	Long-term	Periodic	Reversible in long term	Low	Positive	High	High	Low
3. Channel Morphology and Sediment Concentration												
	Changes in channel shape and sediment concentration due to flow changes and crossing construction	1) Maintain drainage around disturbed areas 2) Reclaim surface disturbances once no longer required 3) Design and construct crossings to minimize impacts	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; [4.] Reversible - in short term, Reversible - in long term, Irreversible; [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

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

ESRD issued the Terms of Reference for the project on December 13, 2013. The specific requirements for the noise component are provided in Section 3.1.2, as follows:

> ***3.1.2 Impact Assessment***
>
> *[C]. Summarize the results of the noise assessment conducted for the AER, 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 AER's Directive 38: Noise Control.*

The purpose of the work was to conduct a site visit to measure the noise levels of current industrial noise sources within the area, to generate a computer noise model of the Project under Baseline Case, Application Case, and Planned Development Case conditions, and to compare the resultant sound levels to the Alberta Energy Regulator (AER) permissible sound level guidelines (Directive 038 on Noise Control) and to the Alberta Utilities Commission (AUC) Rule 012 on Noise Control.

There are numerous other industrial noise sources within approximately 5 km of the proposed Project. These include:

- various well-sites with small internal combustion engines and surface pumps operated by Canadian Natural Resources Ltd (CNRL) and Bonavista Energy Ltd.;
- two small compressor stations operated by Bonavista Energy Ltd. (with internal combustion engines);
- two small compressor stations operated by AltaGas (with internal combustion engines); and
- a compressor station operated by Inter Pipeline (with electrically driven pumps).

The full list of existing sites with LSDs and noise producing equipment is provided in CR #7, Appendix I.

The computer noise modeling was conducted using the CADNA/A (version 4.3.143) software package. CADNA/A allows for the modeling of various noise sources such as road, rail, and stationary sources. Topographical features such as land contours, vegetation, and bodies of water and meteorological conditions such as temperature, relative humidity, wind-speed and

wind-direction are considered in the assessment. The modeling methods utilized met or exceeded the requirements of the AER Directive 038 and AUC Rule 012.

Area roads include Secondary Highway 657 which runs north-south through the middle of the Project, and is considered heavily traveled during the night-time. All other roads have a lesser volume of traffic and are not considered significant contributors to background noise levels.

There are no residential receptors within 3,000 m of Pilot Plant or the Project CPF noise sources. There are several residential receptors within 1,500 m of the Project well pads and a total of 51 residential receptors within approximately 2,000 m of the Project boundary. All 51 residential receptors have been included in the assessment.

The computer noise modeling results were calculated in two ways. First, sound levels were calculated at the residential receptors within approximately 2,000 m of the Project boundary and at the theoretical 1,500 m receiver locations. Second, sound levels were calculated using a 50 m x 50 m receptor grid pattern within the entire study area. This provided color noise contours for easier visualization and evaluation of the results.

Topographically, the land surrounding the Pilot Plant and the Project has regions with small hills and lower lying areas with bodies of water. There is a change in elevation of approximately 170 m from the lowest to the highest point within a 1.5 km radius surrounding the Project boundary (CR#7, Figure 1). Topographical mapping information for the entire area was incorporated into the model. The land is generally covered in trees, bush, grain crops, and field grasses throughout. As such, the vegetative sound absorption is significant.

D.7.2 BASELINE CONDITIONS

D.7.2.1 Permissible Sound Levels

Environmental noise levels from industrial noise sources are commonly described in terms of equivalent sound levels, or L_{eq}. This is the level of a steady sound having the same acoustic energy, over a given time period, as the fluctuating sound. In addition, this energy averaged level is A–weighted to account for the reduced sensitivity of average human hearing to low frequency sounds. These L_{eq} in dBA, which are the most common environmental noise measure, are often given for day-time ([07:00 to 22:00] L_{eq}Day) and night-time ([22:00 to 07:00] L_{eq}Night), while other criteria use the entire 24-hour period as L_{eq}24. AER Directive 038 and AUC Rule 012 set the PSLs at the receiver locations based on population density and relative distances to heavily traveled road and rail.

D.7.2.2 Baseline Case Results

The results of the Baseline Case noise modeling are presented in CR #7, Tables 2a and 2b for the residential and theoretical 1,500 m receptors and illustrated in CR #7, Figure 2. The modeled noise levels at most of the residential and theoretical 1,500 m receptor locations are under the PSLs with the existing noise sources and the Pilot Plant and the approved Phase 1 combined with the ASLs. At four of the residential receptors (R-13, R-39, R-40, R-41) and at 1,500 m regions to the south, the noise levels are above the PSLs. These exceedances are related to existing, non-

Pengrowth noise sources. For all of the residents, the contribution from the Pengrowth Pilot Plant and Phase 1 is significantly less than from the other existing industrial noise sources. It is important to note that these exceedances are based on noise modeling results and have not been confirmed with a comprehensive sound level (CSL) survey because Phase 1 is not yet operational.

In general, both the dBA and dBC sound levels are modeled to be low and the dBA sound levels are all below the PSLs. Again, the contribution from the Pengrowth Pilot Plant and Phase 1 is significantly less than from the other existing industrial noise sources.

D.7.3 PREDICTED CONDITIONS

D.7.3.1 Application Case Results

The results of the Application Case noise modeling are presented in CR #7, Tables 3a and 3b for the residential and theoretical 1,500 m receptors, respectively, and are illustrated in CR #7, Figure 3. The modeled noise levels at the residential and theoretical 1,500 m receptor locations are under the PSLs with the Project noise combined with the ASLs. In addition, the Project-only noise levels (*i.e.*, no average ambient sound level) are more than 5 dBA below the PSLs at all of the residential and theoretical 1,500 m receptors, providing for a large margin of safety for the noise modeling results.

In general, both the dBA and dBC sound levels are modeled to be low and the dBA sound levels are all well below the PSLs. The equipment at the well pads does not contain significant low frequency noise and the distances between the Project CPFs and the receptors are several kilometers. As such, the likelihood of a low frequency noise complaint related to Project operations is minimal.

D.7.3.2 Planned Development Case Results

The results of the Planned Development Case noise modeling are presented in CR #7, Tables 4a and 4b for the residential and theoretical 1,500 m receptors, respectively, and illustrated in CR #7, Figure 4. As with the Baseline Case, the modeled noise levels at most of the residential and theoretical 1,500 m receptor locations are under the PSLs with the existing noise sources and the Project combined with the ASLs. At the same four residential receptors (R-13, R-39, R-40, R-41) and at 1,500 m regions to the south, the noise levels are above the PSLs. These exceedances are related to existing, non-Pengrowth noise sources. The contributions from Pengrowth noise sources are significantly less than from the other existing industrial noise sources. This is clearly indicated in the order-ranked noise source contribution from the existing and Pengrowth noise sources at the four residential, presented in CR #7, Appendix VI. In addition, the increase in noise levels at these four residential receptors and the theoretical 1,500 m regions to the south, relative to the Baseline Case, ranges from +0.0 to +0.1 dBA which is completely insignificant and will not be subjectively discernible.

In general, both the dBA and dBC sound levels are modeled to be low. Again, the contributions from the Pengrowth noise sources are significantly less than from the other existing industrial

noise sources. The equipment at the well pads does not contain significant low frequency content and the distances between the Project CPFs and the receptors are several kilometres. As such, the likelihood of a low frequency noise complaint related to Project operations is minimal.

D.7.4 MITIGATION MONITORING

D.7.4.1 Mitigation

The results of the noise modeling indicated that no specific additional noise mitigation measures are required for the Project equipment.

Although there are no specific construction noise level limits detailed by AER Directive 038 and AUC Rule 012, there are general recommendations for construction noise mitigation. This includes all activities associated with construction of the facility, well pads (including drilling), borrow pits, *etc*. Pengrowth will follow these general recommendations for construction noise mitigation.

D.7.4.2 Monitoring

No monitoring or follow-up program will be implemented unless a noise complaint is filed with the AER or Pengrowth. In the case that a complaint is filed, Pengrowth will conduct a comprehensive sound level survey in accordance with the requirements of AER Directive 038 and AUC Rule 012.

D.7.5 SUMMARY OF VEC

The results of the noise modeling indicated Baseline Case noise levels associated with the Pilot and the approved Phase 1 and the existing area noise sources (with the average ambient sound levels [ASLs] included) are below the AER Directive 038 and AUC Rule 012 PSLs at most of the area residential and theoretical 1,500 m receptors. For the four receptors with modeled Baseline Case noise levels in exceedance of the PSLs, the noise levels related to existing, non-Pengrowth, noise sources and were not confirmed with a comprehensive sound level (CSL) survey since Phase 1 is not yet operational.

The Application Case noise levels associated with the Project (with the ASLs included) will also be below the AER Directive 038 and AUC Rule 012 PSLs for all surrounding residential and theoretical 1,500 m receptors. The Project-only noise levels (*i.e.*, no ASL) are projected to be more than 5 dBA below the PSL at all of the receptors.

As with the Baseline Case, the Planned Development Case noise levels associated with the existing noise sources and the Project noise sources (with the ASLs included) will be below the AER Directive 038 and AUC Rule 012 PSLs at most of the area residential and theoretical 1,500 m receptors. These exceedances are related to existing, non-Pengrowth, noise sources and the contributions from Pengrowth noise sources are significantly less than from the other existing industrial noise sources.

The modeling results at some of the residential and theoretical 1,500 m receptor locations indicated C-weighted (dBC) sound levels will be less than 20 dB above the dBA sound level, while others have dBC - dBA sound levels greater than 20 dB. The reason for this is the large distances between the existing noise sources and the receptors. The contributions from the Pengrowth noise sources are significantly less than from the other existing industrial noise sources, demonstrating that the likelihood of a low frequency noise complaint related to Project operations is minimal.

D.8 SOCIO-ECONOMIC ASSESSMENT

D.8.1 INTRODUCTION AND TERMS OF REFERENCE

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

Alberta Environment issued the ToR for the Project on December 13, 2013. The specific requirements for the SEIA are provided in Section 7.0 of the ToR and are as follows:

7.1 Baseline Information

[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 all stages of the Project, including a description of when peak activity periods will occur;

c) planned accommodations for the workforce for all stages of the Project. Discuss the rationale for their selection;

d) the Proponent's policies and programs regarding the use of local, 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 new or existing camp(s) 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;

e) describe the services that will be provided in the camp (e.g., security, recreation and leisure, medical services), including a description of the impacts on Municipal or other external services; and

f) outline the emergency services and evacuation plan that will be in place.

[C]. Describe the need for additional Crown land.

[D]. Discuss opportunities 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.

The Socio-Economic Impact Assessment (SEIA) evaluates the impacts of the construction and operations of the Project on the communities of the region. The potential socio-economic impacts of the construction and operation of the Project include economic and fiscal benefits as well as pressures on social systems. The SEIA draws on and refers to ongoing consultation by Pengrowth in the context of the Project and other initiatives.

The key socio-economic issues to be considered in this SEIA analysis fall into the following categories:

- employment effects;
- regional and provincial economic benefits, including:
  - personal and business income;
  - government tax and royalty income;
- population effects;
- effects on regional infrastructure and services, including:
  - housing, including worker housing;
  - policing and emergency services;
  - health services;
  - social services;
  - education services;
  - recreation activities;
  - municipal infrastructure and services;
  - transportation effects; and
  - traditional land use effects.

The SEIA covers the Project life from construction through to the end of operations. It will concentrate on the time between 2013 and 2018, reflecting that:

- on-site construction of the Project is expected to take place between Q4 2015 and Q1 2017; and
- the Project is expected to begin in early Q2 2017.

The Regional Study Area (RSA) for the SEIA (CR #8, Figure 2.1) is comprised of the Municipal District (M.D.) of Bonnyville; the County of St. Paul and including the Elizabeth and Fishing Lake Métis communities and reserve lands for six First Nations.

D.8.2 BASELINE CONDITIONS

D.8.2.1 Economic and Fiscal Assessment

Resource extraction has played a prominent role in the regional economy for a number of years. Historically, agricultural production formed much of the economic base in the RSA and movements by agricultural producers away from conventional cattle and grain towards specialized livestock, greenhouses, and niche crops suggests that agriculture will remain a part of the local economy for years to come. In recent years, the economic driver of the M.D. of Bonnyville has been the development of conventional heavy oil and oil sands resources.

The educational attainment of the workforce in the RSA is generally reflective of the importance of the oil and gas and agricultural industries to the regional economy. For example, the proportion of workers holding a trade or apprenticeship certification in the RSA is 16%, well above the provincial average of 11% (NHS 2011). The population of the region as a whole has a higher proportion (27%) of individuals who have not completed high school.

The unemployment rate of the labour force in the RSA (4.5%) is on par with the provincial average (4.3%). There are some differences in the unemployment rate across specific communities within the RSA but this variation is minimal and is generally within 1% of the RSA average. The corresponding rate for the Aboriginal communities in the RSA is 17%, well above the general provincial rate of 4.3% (Statistics Canada 2006).

The participation rate (*i.e.*, the number of people working or looking for work as a percentage of the total population over 15 years of age) in the RSA is 73%, slightly below the provincial average of 74%. The corresponding rate for the Aboriginal communities in the RSA is 53%.

The wide range of incomes across communities and family types throughout the RSA is shown in Table D.8.2-1.

Table D.8.2-1 Median Family Income

Community	All Families	Couple Families	Male Lone-Parent Families	Female Lone-Parent Families
	Family Income ($ 2005)			
Town of Bonnyville	$77,903	$85,328	$92,407	$32,697
M.D. of Bonnyville	$91,678	$98,506	$44,122	$27,908
Town of St. Paul	$68,545	$73,485	-	$39,586
St. Paul County	$71,682	$72,631	$62,502	$54,655
Town of Elk Point	$63,276	$67,534	-	$36,590
Kehewin IR	$30,664	$38,247	$20,109	$18,421
Alberta	$95,524	$103,145	$69,765	$44,922

The total direct employment effect of the operations phase includes the regular operations work force, the ongoing maintenance work force and ongoing drilling activities. The total estimated direct operations employment effect of the Project is approximately 65 full-time equivalent positions. The total direct, indirect and induced employment is estimated to be 245 person years annually.

D.8.2.2 Population

In 2011, the RSA was home to nearly 36,200 people distributed throughout the Towns of Bonnyville, St. Paul and Elk Point, the M.D. of Bonnyville, County of St. Paul, and several First Nations and Métis communities (Statistics Canada 2011). The closest population centre to the Project (35 km) is the Town of Elk Point, which was home to 1,412 people in 2011. Other urban service centres in close proximity to the Project include the Town of St. Paul (55 km) and the Town of Bonnyville (38 km), with populations of 5,400 and 6,216 residents, respectively (CR #8, Table 4.1).

The non-resident population of the County of St. Paul and the Towns of St. Paul and Elk Point is estimated to be 1,100 workers or approximately 10% of the permanent population. This number fluctuates over time due to the seasonal nature of oil and gas projects, pipeline and related infrastructure projects as well as the phased nature of large scale industrial construction.

Any estimate of the future population of the RSA is subject to uncertainty and is linked to the future industrial development scenarios (including oil sands), the workforce housing model employed, and the availability of housing and services in the RSA. Based on industry's growth plans in late 2013, the resident population in the RSA is expected to grow by approximately 1.3% annually, reaching 39,410 by 2018, an increase of 2,470 people.

D.8.2.3 Housing

The RSA has a well-developed housing stock, estimated to be 12,778 private dwellings in 2011, an increase of 743 (6%) dwellings since 2006 (Statistics Canada 2006, 2011). The housing stock has increased at an average annual rate of 1.1% in the region in the past five years, roughly on par with the 0.9% average growth rate of the population (Statistics Canada 2011, 2006). Compared to the provincial average, the RSA shows slightly higher ownership tenure than the province as a whole (80% versus 73%) (Statistics Canada 2011, 2006).

In 2012/2013, the average home price in each of the three municipalities within the RSA for which data are available was below the provincial average of $381,308 (CR #8, Table 5.1). There is a reported shortage of both affordable and senior's housing units in all of the municipalities within the RSA with above average rental costs in the Town of Bonnyville (Poole 2013; Power 2013; Fedoretz 2013; Goyan 2013; Boisvert 2013, pers. Comm).

The housing needed to accommodate Baseline Case population growth in the RSA is estimated at 700 units (140/year) for the period between 2013 and 2018 (CR #8, Table 5.3). The expected demand for housing under the Baseline Case assumption is higher than the previous rate of growth in supply for the RSA as a whole.

D.8.2.4 Municipal Infrastructure

Each of the municipalities within the RSA is responsible for the planning, construction, operations, and maintenance of municipal infrastructure within its boundaries. The demand for certain municipal infrastructure and services in the Towns of Bonnyville, St. Paul and Elk Point is driven not only by their respective residents, but also by the needs of individuals living nearby.

Generally speaking, municipal governments are responsible for costs associated with the construction and maintenance of infrastructure such as water and sewer systems. As shown in Table D.8.2-2, many of the municipalities in the RSA show signs of healthy financial positions.

Table D.8.2-2 2011 Municipal Financial Indicators

Community	Per Capita Debt	Average Per Capita Debt for Municipality Type	Per Capita Assessment	Average Per Capita Assessment for Municipality Type
County of St. Paul	$50	$754	$213,725	$398,723
Town of St. Paul	$656	$1,052	$105,478	$110,346
Town of Elk Point	$191	$1,052	$81,025	$110,346
M.D. of Bonnyville	$220	$754	$469,313	$378,723
Town of Bonnyville	$1,560	$1,052	$127,703	$110,346

The Baseline Case population growth rates for RSA municipalities, ranging between 0% to 2.3%, fall within the growth rates being used for municipal planning purposes (SP 2010, TOB 2005, MDB 2007). Even so, some municipal infrastructure and services outlined above – such as the water treatment facility in the Town of Bonnyville – is either reaching or at capacity. Plans for addressing these capacity issues will need to be developed and carried out in a timely manner in order to meet future growth demands.

D.8.2.5 Social Infrastructure

All residents of the region rely on social infrastructure as a means of maintaining and improving quality of life. Social infrastructure includes a diverse range of human services and infrastructure, including health, education, social, recreation, policing and emergency services.

The Project will have an effect on social infrastructure in the RSA primarily via its population effect. According to an FCSS representative with the County of St. Paul, the presence of temporary workers in the region has driven increased demand for some services (*e.g.*, demand for mom and tot services by partners of temporary workers living in campgrounds). Social service providers in the region have indicated a difficulty in recruiting staff due to local labour market conditions (Boone 2013, pers. comm.). Social service organizations operating in the Bonnyville region are currently at or near capacity and are unable to increase services under current staffing levels.

Population growth under Baseline Case, Application Case and PDC assumptions will require additional social infrastructure in the RSA as demand for social infrastructure is expected to

increase largely in line with population effects. The increase in demand for social infrastructure will require additional facilities, programming, and staffing. The social infrastructure requirements identified in the table are for the RSA as a whole, but will largely fall on the Town and M.D. of Bonnyville where the majority of population effects are expected to occur.

D.8.2.6 Transportation

The RSA has a well-developed road network, consisting of a number of primary and secondary highways. Major highways in the region include (CR #8, Figure 2.1):

- Hwy 41, providing north-south travel through the region and connecting the Town of Bonnyville to Hwy 16 (the Yellowhead Hwy); and
- Hwy 29, which connects St. Paul to Hwy 411 to the east and Lamont to the west.
- Secondary highways within the RSA that are of relevance to the Project include:
- Hwy 646, which connects Hwy 41 near Elk Point to Lindbergh; and
- Hwy 657, which connects north from the Project to both Hwy 659 near Bonnyville, as well as Hwy 41.

Project access is via Range Road (RR) 50 (also known as the Murphy Road) which connects Hwy 646 near Lindbergh to Hwy 657 by Muriel Lake (CR #8, Figure 2.1).

Traffic volumes in the RSA are increasing due to a number of factors, including existing heavy conventional oil and gas and oil sands projects commencing and expanding, pipeline construction and as a result of general economic activity. Average annual growth rates in traffic volumes, ranging between 1% and 4% are reflective of the region's level of economic activity. Growth rates on the segments identified for analysis within the RSA are in-line with, and in some cases, higher than the Provincial average for rural highways, which typically range between 2% to 2.5% per annum.

Although volumes have seen substantial relative increases throughout this period, the daily vehicle movements in the region are still relatively low, with levels well below the carrying capacity of these highway classifications. Under Baseline Case assumptions, traffic volumes on regional highways are expected to increase between 2012 and 2018. CR #8, Table 8.3 presents volume estimates for the relevant RSA roadways under Baseline Case assumptions

According to the County of St. Paul, potential upgrades to road infrastructure in the RSA include:

- a new pavement overlay for RR 50; and
- potential upgrade to the Hwy 41 / 29 intersection.

The County has applied to Alberta Transportation for support in paying for the new overlay to RR 50, a project which is estimated to cost $7 million. According to the County, the Hwy 41 /

29 intersection has been the subject of a number of studies by Alberta Transportation over the years. As of November 2013, the potential for either of these projects proceeding remains uncertain (deMoissac 2013, pers. comm.).

Collision frequencies on area highways during the 2007 to 2011 period have consistently exceeded provincial averages. In 2011, the most recent year for which data are available, the collision rate was 9% to 96% higher, depending on the segment under analysis, than the provincial average for comparable highways. The frequency and severity of collisions vary across the RSA roadways. CR #8, Table 8.2 provides a summary of the collision rates on RSA road segments over the past five years.

D.8.2.7 Traditional Land and Culture

Aboriginal peoples have lived in the region for thousands of years, engaging in traditional activities such as hunting, fishing, and gathering. While traditional land use remains essential to Aboriginal culture, it has changed. The traditional land use and culture of Aboriginal groups in the RSA has been and will continue to be affected by a number of external influences, including:

- increased use of traditional lands for non-traditional purposes, whether it be resource development or increased agricultural development and encroaching urbanization;
- government actions (e.g., policies, programs, funding) in a number of areas including governance, land use, education and training and the development and delivery of infrastructure and services; and
- increased access to influences of other cultures through advancements in technology (e.g., television, internet, cell phones).

The relative magnitude of these external influences is not equal and the experience of individual Aboriginal community members might vary.

D.8.3 PREDICTED CONDITIONS

D.8.3.1 Economic and Fiscal Assessment

Income Effects

Construction

Total initial capital expenditure for the Project is estimated at $770 million. 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. Capital outlays will likely begin before the construction period for items such as engineering and purchases of long lead-time equipment.

CR #8, Table 3.2 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 Pengrowth, and the past experiences of similar projects in the province (ABFIN 2011). The table indicates that an estimated 48% of the total expenditure will accrue to the RSA and the rest of Alberta. An additional 26% will accrue to the rest of Canada, and the

balance to foreign suppliers. The expenditure accruing to foreign suppliers is related primarily to the purchase of machinery and equipment.

Sustaining capital and ongoing drilling expenditures will total approximately $1.1 billion (real $2013) over the life of the Project, averaging approximately $44 million (real $2013) per year. This is in addition to the initial capital expenditure needed to bring the Project on-stream. Approximately 73% of the average annual sustaining capital and ongoing drilling expenditures will accrue to Alberta, including the RSA. Approximately $5 million of the expenditures in Alberta will accrue to the RSA, primarily as drilling and maintenance wages. CR #8, Table 3.3 provides a breakdown of the average annual sustaining capital and ongoing drilling costs by region, based on published supply ratios (ABFIN 2011).

Operations

Once fully constructed, the annual operations expenditure of the Project, including fuel and utilities, will total $1.5 billion ($44 million per year, real $2013). These costs are in addition to the sustaining capital and ongoing drilling expenditures of approximately $1.1 billion. CR #8, Table 3.4 provides a breakdown, by region, of the annual operations expenditure based on the published supply ratios by industry (ABFIN 2011).

An estimated $3 million of the operations expenditure is expected to accrue to local area workers and contractors. Some of the contractor spending is likely to accrue to out-of-region workers in the early years of operations in view of the relatively small size of the RSA labour force.

Total Income Effects

Based on published statistics, the Project's direct, indirect and induced impact in terms of Gross Domestic Product (GDP), and household income is approximately $600 million and $300 million respectively (ABFIN 2011). The total (direct, indirect and induced) GDP impact of operating, ongoing drilling, and sustaining capital expenditures are estimated at $90 million. The total labour income effect of the Project's operating, sustaining capital, and ongoing drilling expenditures is estimated at $40 million. The estimates represent averaged annual impact over the life of the Project and are based on published multipliers (ABFIN 2011).

Project Fiscal Effects

The Project contributes property taxes to the affected municipalities, oil sands royalties to the provincial government, and corporate taxes to the provincial and federal governments. 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 the Project will pay 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 Project's municipal tax payment during 2017, its first full year of operations, is $3.8 million. This estimate assumes the prevailing municipal tax rates remain in effect. The use of an on-site camp will limit the impact of the Project on municipal expenditures. The Project and associated on-site camp will not be tied directly into the water and sewer system

of the County. Pengrowth will purchase potable water from the County and haul out sewage to the Bonnyville and Cold Lake Municipal lagoons. The municipal tax payments are expected to be an order-of-magnitude higher than the municipal costs, making the Project a net contributor to the municipal fiscal health of the County.

Once fully operational, the Project will pay royalties 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. Under these assumptions, the Project is expected to pay, on average, $58 million (REAL 2013) in royalties per year. Over the 25 year operational life, royalty payments are expected to have a net present value (2013) of $400 million.

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 the Project. CLOSA CRISP outlines the requirement of provincially funded infrastructure in the Cold Lake Oil Sands area, which includes the RSA, as bitumen production increases. These costs notwithstanding, oil sands are a net contributor to the fiscal position of Alberta

Project Employment Effects

Construction of the Project is expected to require 1,200 person years of labour during the 2015 to 2017 period, of which approximately 540 are expected to be on-site, with the balance in construction yards and fabrication shops outside the RSA. In addition to the 540 person years for the construction of the on-site facilities, there will be initial drilling and completions activity which is expected to generate an additional 75 person years of on-site employment between 2015 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 615 person years of on-site employment over the 18 month construction period (including site preparation and commissioning), with a peak of nearly 600 in late 2016, as shown in CR #8, Figure 3.2. Total off-site construction is estimated to be 435 person years during the 2015 to 2017 period.

In addition to on- and off-site construction employment, the Project is expected to create an estimated 145 person years of employment for engineering contractors, the majority of which will accrue engineering firms outside of the RSA in Edmonton and Calgary.

Once the Project is fully operational, it is expected to employ 37 people on-site, including contractors. Off-site employment is expected to average between 5 and 10 person years of employment annually over the life of the Project. CR #8, Table 3.6 provides an approximate breakdown of the operations workforce by type.

The total direct employment effect of the operations phase includes the regular operations work force, the ongoing maintenance work force and ongoing drilling activities. The total estimated direct operations employment effect of the Project is approximately 65 full-time equivalent positions. The total direct, indirect and induced employment is estimated to be 245 person years annually

D.8.3.2 Population

Application Case

Under the Application Case assumptions, the permanent population effect of the Project is expected to be 61 people. The population increase will be distributed primarily across the Towns of St. Paul, Bonnyville and Elk Point as well as the residential communities within the M.D. of Bonnyville and the County of St. Paul (CR #8, Table 4.3).

The levels of growth forecast in the Application Case are below the 2% annual growth level currently being planned for by the Towns of Bonnyville and St. Paul, and roughly in line with the 2.5% annual growth being planned for by the M.D. of Bonnyville (MDB 2007; TOB 2005; TOSP 2010).

Planned Development Case

Under the PDC assumptions, the population is expected to increase by 423 people above the Application Case during the by 2018 period. The anticipated distribution of future population growth is shown in CR#8, Table 4.4.

All of the growth in the PDC incremental to the Application case is expected to accrue to the Town and M.D. of Bonnyville due to the physical location of the projects included in the PDC. The levels of growth forecast under the PDC are within the 2% annual level of growth currently being planned for by the Towns of Bonnyville and St. Paul and slightly above the 2.5% annual growth being planned for by the M.D. of Bonnyville (MDB 2007; TOB 2005; TOSP 2010). Communities in the RSA may experience population growth rates that differ from those presented, as individuals react to changes in the availability and affordability of housing throughout the region.

D.8.3.3 Housing

Application Case

The permanent housing need associated with the long-term population effect of the Project is estimated to be approximately 25 units by 2018. Including the growth in the Baseline Case, demand is estimated at approximately 730 units (146/year) by 2018. Similarly to the Baseline Case, the recent rate of growth in the housing stock in the M.D. and the Town of Bonnyville will not be sufficient to meet the demand for housing in the Application Case. Discussions with municipal officials indicate that the pace of residential development is increasing in the Town of Bonnyville and the M.D. of Bonnyville is capable of bringing up to 100 units of housing on-line per year (Poole 2013; Power 2013, pers. comm.). They also indicate that sufficient land is available to meet the demand for new housing under the Application Case (Poole 2013; Power 2013, pers. comm.).

Planned Development Case

The permanent population forecast for the PDC is estimated to generate housing demand for 880 units (180/year), by 2018 (150 units above the Application Case).

D.8.3.4 Municipal Infrastructure and Services

Application Case

The additional population growth and hence municipal infrastructure requirements under the Application Case are marginal. The municipal infrastructure currently in place and planned is expected to be sufficient to service the anticipated Project-related population effect of approximately 60 people.

The Project itself will require potable water and have need for the disposal of waste and sewage water during both construction and operations. For potable water, Pengrowth may use well water or have water trucked to site, or use a combination thereof.

Planned Development Case

Population effects under PDC assumptions are estimated to be 488 new residents in the RSA above Baseline Case estimates in 2018. For most RSA municipalities, the PDC population growth rate falls within the growth rate being used for municipal planning purposes, with the exception of the M.D. of Bonnyville where the growth rate is slightly above (2.8%) the upper range of 2.5% being used by the municipality. The municipal infrastructure currently in place combined with planned upgrades and expansions might not be sufficient to service the anticipated population under the PDC assumptions and therefore development plans should be monitored and plans adjusted as required in order to ensure full services should the PDC materialize.

With respect to future infrastructure needs, the provincial government has developed a Comprehensive Regional Infrastructure Sustainability Plan (CRISP) for the Cold Lake Oil Sands Area (CLOSA) – a larger region that includes the RSA (GOA 2012c). The CLOSA CRISP links oil sands industry expansion to population growth and requirements for provincially funded infrastructure, including water and wastewater facilities.

D.8.3.5 Social Infrastructure

Application Case

Population growth under Baseline Case, Application Case and PDC assumptions will require additional social infrastructure in the RSA as demand for social infrastructure is expected to increase largely in line with population effects. The long-term Project effects on social infrastructure, in line with population effects, are expected to be negligible.

CR#8, Table 7.4. shows that the Project and PDC-induced population growth will require additional services (*i.e.*, over and above social infrastructure required under the Baseline Case assumptions). The social infrastructure requirements identified in the table are for the RSA as a whole, but will largely fall on the Town and M.D. of Bonnyville where the majority of population effects are expected to occur.

Construction of the Project will increase the mobile workforce in the region, placing temporary additional demands on regional social infrastructure, such as health and social services, and

policing and emergency response services. These effects will mostly occur in or near RSA communities that are in closer proximity to the Project.

The operating phase of the project will contribute well-paying employment that will attract permanent residents to the region who are less likely to draw on social supports or certain social services (*e.g.*, affordable housing, income support) but will create additional demands on other social infrastructure, such as health and education services. It will also draw operations workers from outside the region who will bring spouses and family members with them, increasing the labour pool and volunteer base on which local service providers can draw. Due to more activity, there will also be an increase in the potential for traffic accidents, which could in turn place demands on policing, emergency response and health services in the region

For Aboriginal communities in the RSA industrial development both limits opportunities for traditional pursuits, and makes available income and employment opportunities to people with the requisite skills. Many Métis and First Nations community members currently need, and may continue to need, support in managing the changes brought on by development.

Planned Development Case

With respect to the PDC, a number of service providers indicated that they are well positioned to plan for and address most future growth forecasted under PDC assumptions. The one exception is FCSS in the Town of Bonnyville, who report that they are currently operating at, or very near, capacity. In general, service providers will likely face some challenges in meeting increased demands.

D.8.3.6 Transportation

Application Case

Project-related traffic, as measured at the access road on RR 50, is expected to average 100 AADT during the construction period, peaking at 150 AADT in Q3 2016. Operations related traffic is expected to be 300 AADT once full production is achieved. Project traffic beyond the site is expected to be dispersed throughout the RSA highway network. CR #8, Table 8.4 presents estimated volumes associated with Project traffic during peak construction in 2016 and operations related traffic in 2018.

Pengrowth intends to connect its Lindbergh facility, via a dedicated pipeline, to the wider regional network by 2023 (5 years into the operations phase of the Project). Upon completion of this pipeline, which is outside the scope of this regulatory application, Pengrowth would ship diluent to and diluted bitumen from the central processing facility via the pipeline. As a result, overall traffic volumes at the Lindbergh facility (including Phase one) could decrease by up to 80%, or in the order of 400 AADT, depending on the split used between trucking and pipeline shipments.

Assuming the full use of the pipeline for shipping, the effect of the Project and the entire Lindbergh facility on traffic volumes in the RSA would be reduced by roughly the same

order-of-magnitude. The effects presented in this analysis represent a conservative (high) assessment, relative to when the volumes expected if pipeline connectivity is achieved.

Planned Development Case

The projects included in the PDC assessment (CR #8, Section 2.1.3) are all located in the north-east portion of the RSA, and have limited to no effect on the highway segments around the Project location.

D.8.3.7 Traditional Land and Culture

As of late fall 2013, traditional land use (TLU) studies with respect to Project activities have not yet been carried out. Pengrowth remains engaged in consultations with local Aboriginal groups and working on the development of these studies. The Project is part of cumulative development in the study area and as such will contribute to cumulative pressures on traditional land use and culture. The results of additional TLU assessment work to be carried out will further inform the discussion and assessment of Project-related TLU effects.

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. 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.8.4 MITIGATION AND MONITORING

D.8.4.1 Mitigation

Housing

With a view to these realities, Pengrowth has adopted construction and operations strategies that make use of on-site camps to house both construction and a portion of operations workers. Housing workers in on-site camps will minimize the direct Project effects on the demand for housing, both temporary and permanent, in the RSA.

Municipal Infrastructure

Pengrowth is committed to communicating regularly with municipalities in the region to keep them informed of its development plans so that affected municipalities can make informed decisions regarding any potential Project-related changes in the demand for services.

Social Infrastructure

Pengrowth will implement a number of additional initiatives to both mitigate the social infrastructure effects of the Project and to support its role as a good corporate citizen in the region. Specifically, Pengrowth will:

- put in place Project-related measures to mitigate effects on regional social infrastructure, including:

- developing and implementing an emergency response plan. This will include putting in place fire and emergency services such as an on-site first aid facility with trained medical personnel, emergency transportation vehicle and fire-fighting equipment. Pengrowth's personnel and contractors will also have the appropriate Health and Safety Training;
- employing on-site security services and procedures, including controlled gates, check-in procedures, and camp-based security officers on duty 24 hours. Pengrowth will also offer in-house security services to assist the RCMP within, and sometimes outside, the Project lease boundaries (*e.g.*, securing accident scenes, assisting with highway closures);
- maintaining explicit and enforced workplace policies with regards to the use of alcohol, drugs, and illegal activities;
- offering shift schedules that provide workers with sufficient time off to enjoy leisure activities in their home communities;
- providing operations-related 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; and
- establishing on-site recreation facilities for camp workers, including a TV room, a games rooms, a library, and an exercise room.

- 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 (e.g., health, social, education), government, and other industrial operators in the region to assist in addressing effects of the Project and resource 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.

Transportation

Traffic effects related to the Project are expected to be reduced in part by mitigation measures proposed by Pengrowth:

- the portion of the on-site construction workforce that is not resident in the RSA will be housed in the on-site camp, thus limiting the majority of workforce-related vehicle movements to once per week on shift-turnarounds;
- scheduling construction deliveries during off-peak hours; and
- engage employees and contractors in an active education and enforcement program to ensure truck trips related to its operations in the region are undertaken in a safe and respectful manner.

The company intends to construct a pipeline within 5 years of achieving full production, which will substantially reduce the amount of truck-based traffic generated by its operations.

Traditional Land Use Effects

The proponent will carry out the following actions to enhance positive and minimize adverse effects of its Project:

- undertake progressive reclamation, giving consideration to traditional land use, where possible;
- provide access to traditional users across the lease;
- compensate trappers directly affected by the Project, according to industry standards;
- promote cultural diversity awareness to Pengrowth employees and contractors regarding respect for traditional resource users;
- support specific community projects, such as elder and youth programs, where appropriate;
- continue working 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; and
- make use of on-site camps to house both construction and a portion of operations workers. Housing workers in on-site camps will minimize the direct Project effects on the demand for housing, both temporary and permanent, in the RSA.

D.8.4.2 Monitoring

Pengrowth anticipates that it will gather selected socio-economic information on its Project and report it as part of its ongoing engagement with stakeholders. The nature and extent of this monitoring will be established in discussion with stakeholders. It is anticipated that reporting of monitoring results will occur through a number of means, including:

- presentations at functions and meetings;
- newsletters; and
- summary reports.

Over time, the reporting content and frequency may be adjusted depending on feedback received from stakeholders.

D.9 SOILS RESOURCES

D.9.1 INTRODUCTION AND TERMS OF REFERENCE

Pengrowth conducted an assessment of soil resources for the proposed 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 the Project on December 13, 2012. 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 to exceed Potential Acid Input 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 (e.g., pads, pipelines, access roads), aggregate and borrow sites, camps, drilling waste disposal and other infrastructure-related construction and operational 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.

10 Monitoring

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

a) how the monitoring programs will assess any project impacts and measure the effectiveness of mitigation plans. Discuss how the Proponent will address any Project impacts identified through the monitoring program;

b) how the Proponent will contribute to current and proposed regional monitoring programs;

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

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

e) regional monitoring that will be undertaken to assist in managing environmental effects and improve environmental protection strategies;

f) how monitoring data will be disseminated to the public, Aboriginal communities or other interested parties; and

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

The local study area (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 the Project (CR #9, Figure 3). Soils were investigated within the LSA boundary, an area of approximately 18,853.3 hectares (ha).

The regional study area (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 Project in combination with adjacent existing, approved and future planned oil sands operations. The RSA covers approximately 198,092 ha and extends north-south from Township 56-61 and east-west from Range 2-7, West of the 4th Meridian (CR #9, Figure 3). It included consideration of the following terrestrial requirements: average size of two female moose home ranges (30 km^2); ecosite phase classification boundaries; and unique changes in surficial geology and terrain. The majority of LSA (84%) and RSA (53%) lie within Soil Correlation Area (SCA) 21 – the Gray Soil Zone of Northeast, Central Alberta (CR #9, Figure 3).

The following VECs were identified for the Project:

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

D.9.2 BASELINE CONDITIONS

Soil interpretations detailed in CR #9, Section 4.1 to 4.5 describe the current baseline conditions (Baseline Case) of the soil resource and terrain. Portions of the LSA include privately owned land (CR #9, Figure 4A). Permission to access for environmental baseline work was not granted on all private land.

Local Study Area

Sufficient soil inspection data was obtained to achieve a survey intensity level (SIL) 2 as defined in the FTOR for the Project.

A total of 1,188 soil inspection sites have been recorded in the LSA and 76 soil profiles were sampled. The survey intensity achieved was one inspection per 15.9 ha of land. CR #9, Figure 4A and 4B) displays the site inspections collected within the LSA.

Site characteristics recorded at each inspection site included:

- surficial (parent) material type and grouping as per Agricultural Region of Alberta Soil Inventory Database, Version 3.0 (AGRASID 3.0) (ASIC, 2001);
- surface expression and landscape form based on AGRASID methods for terrain classification (ASIC, 2001);
- slope gradient, aspect, and position;
- soil drainage and depth to apparent water table;
- vegetation including main tree and understory species and distribution as well as an ecosite phase call; and
- information related to existing disturbances.

Soil horizons at 76 locations within the LSA were sampled and analyzed. This number of samples provided good representation of most Organic, Luvisolic, Brunisolic and Gleysolic soils found in the LSA.

Eighteen terrain types (CR #9, Table 6 and Figure 5) were recognized as being large enough to map at the 1:15,000-production scale. Within the LSA, hummocky moderate and low relief (H1m and H1l) landforms are predominant (4,187.6 ha or 22.2%, and 4,150.9 ha or 22.0%, respectively). Slopes for these units range from 2 to 15%. Undulating high and low relief landforms (U1h and U1l) are of significant extent within the LSA (2,503.2 ha or 13.3%, and 966.1 ha or 5.1%, respectively) with slopes ranging from 0.5 to 5%

Regional Study Area

The baseline soil map for the RSA was developed through the use of the following information sources:

- Agricultural Region of Alberta Soil Inventory Database (AGRASID) (ASIC, 2001; Bock *et al.*, 2006); and
- ecosite phase and ground cover class shapefile data for the vegetation RSA (CR #10).

AGRASID provides the only soil data available which covers the entire RSA. Existing disturbance data were extracted from the Alberta Ground Cover Classification (AGCC) map of the region to update the disturbance layer for the regional Soils map (Sleep, 2003, current to 2007).

D.9.2.1 Thickness of Soil Layers

Estimating average topsoil, surface peat (where applicable) and subsoil depths assists in determining suitable soil salvage and stockpiling requirements for reclamation purposes. For the purpose of volume calculations the litter material, topsoil, surface peat and subsoil layers were defined based on *The Canadian System of Soil Classification – Third Edition* (SCWG, 1998). Surface litter, deep organics, topsoil, and upper subsoil layers were defined as follows:

- surface litter/shallow organics – under forested vegetation the surface litter is commonly comprised of L, F, and H layers (L – forest litter; F – fibric; and H – humic) of various thicknesses and shallow organic layers (peaty overlays) are organic layers (Of, Om, and Oh) <40 cm thick. Shallow organic layers are considered to constitute mainly transitional landscapes. Organic material thicknesses >40 cm typically occur in organic landscapes (termed deep organics). In instances where the dominant organic material is fibric the total thickness to qualify as a deep organic is >60 cm;
- deep Organics – organic material profiles differentiated by degree of decomposition (Of, Om, and Oh) layers that have a total thickness of >40 cm. If the dominant organic material is fibric a total thickness of >60 cm is required to qualify as a deep organic;
- topsoil (TS) – Ae, Ahe and AB horizons, including gleyed (g) and weakly gleyed (gj) versions of these horizons; and
- upper subsoil (US) – all types of B horizons (Bm, Bt, BA), plus gleyed (g) and weakly gleyed (gj) versions of these (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.9.2-1 and shown in CR #9, Figure 8.

Table D.9.2-1 Soil Layer Thicknesses by SLM

Map Unit (SLM)	Thickness (cm)			
	Litter/Peat	Topsoil	Topsoil Lift Thickness[1]	Upper Subsoil
ABAM2/U1h	5	10	15	40
ABC2/H1h	10	15	25	30
ABC2/H1l	5	20	25	30
ABC2/H1m	5	20	25	30
ABC2/HR2h	10	15	25	40
ABC2/I3h	5	20	25	25
ABC2/I3m	5	20	25	35
ABC2/U1h	5	20	25	35
ABC6/I3h	5	15	20	30
ABC6/I3m	5	15	20	40
ABC9/H1l	5	20	25	30
ABC9/H1m	5	15	20	35
ABC9/HR2m	5	20	25	40
ABC9/I3h	5	25	30	25
ABC9/I3l	5	15	20	35
ABC9/I3m	10	20	30	30

Table D.9.2-1 Soil Layer Thicknesses by SLM

Map Unit (SLM)	Thickness (cm)			
	Litter/Peat	Topsoil	Topsoil Lift Thickness[1]	Upper Subsoil
ABC9/U1h	5	15	20	40
ABMH2/HR2m	5	20	25	35
ABMH2/U1h	10	10	20	46
ABOW9/U1h	10	15	25	20
ABSL1/H1l	25	15	40	25
ABSL1/H1m	25	20	45	30
AMK18/H1l	5	15	20	60
AMK18/H1m	5	15	20	40
AMK18/U1h	5	15	20	60
AMK2/U1l	0	15	15	60
AMLA5/SC4	5	15	20	35
ARV21/U1l	25	0	25	0
BLBQ21/FP3	10	15	25	5
BLBQ21/SC1	10	10	20	30
CTW1c/O1	70	0	70	0
CTW1c/O2	75	0	75	0
CTW1c/O3	65	0	65	0
CTW1c-G/O2	45	0	45	0
CTW1c-G/O3	35	0	35	0
CTW1m/O1	70	0	70	0
CTW1m/O2	65	0	65	0
CTW1m/O3	65	0	65	0
CTW1m-G/O1	45	0	45	0
CTW1m-G/O2	45	0	45	0
CTW1m-G/O3	40	0	40	0
CTW1m-G/O5	55	0	55	0
CTW2/O1	130	0	130	0
CTW2/O2	200	0	200	0
CTW2/O3	160	0	160	0
CTW2c/O1	105	0	105	0
CTW2c/O2	130	0	130	0
CTW2m/O1	170	0	170	0

Table D.9.2-1 Soil Layer Thicknesses by SLM

Map Unit (SLM)	Thickness (cm)			
	Litter/Peat	Topsoil	Topsoil Lift Thickness[1]	Upper Subsoil
CTW2m/O2	150	0	150	0
CTW2m/O3	165	0	165	0
LCNI2/I1l	5	15	20	45
LCNI2/U1h	5	5	10	40
LCY1/I3h	5	20	25	35
LCY2/H1l	5	20	25	35
LCY2/U1h	5	20	25	35
LCY9/HR2m	10	10	20	45
LCY9/I3m	10	10	20	45
LCY9/U1h	5	15	20	40
LCY9/U1l	10	20	30	40
MMW21/SC1	10	15	25	10
NWB20/U1h	20	10	30	45
NWB20/U1l	10	10	20	35
NWB21/U1l	10	10	20	35
PIAM18/H1l	5	15	20	55
SDLC2/U1l	5	25	30	35
ZDL	0	0	0	0
ZWA	0	0	0	0

[1] Topsoil Lift Thickness includes the mineral A horizon plus the litter/surface organic layer.

D.9.2.2 Forest Soil Capability Classification

Baseline Ratings

Land capability for the LSA has been catalogued by rating the Soil Models (SMs) according to the *Land Capability Classification System for Forest Ecosystems in the Oil Sands* (LCCS) (CEMA, 2006). This classification system evaluates a soil profile based on its soil moisture regime index (SMR) and soil nutrient regime index (SNR). Forest soil capabilities were determined for SMs (*i.e.*, ABC9) through amalgamation of individual soil series ratings of dominant (>50%), co-dominant (>30%) and significant soils (10-30%) estimated to occur in each SM.

Within the LSA, capability ratings ranged from Class 2 to Class 5. The main limitations to soils within the LSA include poor or very poor drainage (typically in the SMs dominated by Organics or peaty Gleysols (subclass W)), very dry mixture regime (typically in the SMs dominated by

coarse textured soils (subclass X)) and massive subsoil structure and firm consistence (subclass D).

The baseline forested land capabilities for SMs of the LSA are listed in CR #9, Table 13. Distribution of final land capability classes within the LSA and Project footprint are provided in Table D.9.2-2 and are shown on CR #9, Figure 9.

Table D.9.2-2 Extent of Forested Soil Capability in the LSA and Project Footprint

LCCS Ratings Classes	LSA		Project Footprint	
	Area (ha)	% of LSA	Area (ha)	% of Footprint
Class 2	599.0	3.2	35.9	4.4
Class 3	13,328.2	70.7	584.1	71.9
Class 4	800.8	4.2	47.3	5.8
Class 5	2,507.7	13.3	74.4	9.2
Not Rated (ZDL, ZWA)	1,617.6	8.6	70.9	8.7
TOTAL[1]	**18,853.3**	**100**	**812.7**	**100**

[1] Due to rounding of values, totals may not equal the sum of the individual values presented in the table.

Class 3 is the most extensive within the LSA, accounting for 70.7% of the area. Class 3 lands are also the most common within the Project footprint, covering 71.9%. Class 5 soils account for 9.2% of the Project footprint. Class 4 lands represent transitional landscapes and as a result have limited distribution within LSA and Project footprint and do not exceed 6% of the area. Class 2 land is the least extensive covering less than 5% of the area.

Reclaimed Ratings

The main goal for the reclamation program is to achieve forested land capability equivalent or higher than pre-disturbance conditions. The reclaimed LCCS ratings are estimated based on the composition of the reclaimed profile (*e.g.*, peat over mineral) and the projected soil physical and chemical characteristics created post reclamation.

Post-reclamation suitability was only evaluated for soil map units in the Project footprint that are expected to be disturbed over the life of the Project. CR #9, Table 15 displays the baseline and reclaimed LCCS ratings for soil map units located in the Project footprint. The summary output data for the reclaimed ratings and detailed assessment assumptions are provided in CR #9, Appendix E.

The reclaimed LCCS values were calculated using the physical and chemical characteristics of representative soil series and variants recorded in the baseline conditions of each map unit, amalgamated as appropriate, and based on the anticipated soil salvage, storage, planned recontouring (based on the location and type of Project component), and eventual replacement, and implementation of mitigative measures (*e.g.*, decompaction activities).

The majority of the SMs contained the same final capability ratings for pre and post disturbance. Details concerning soil handling, reclamation activities and post disturbance land use are detailed in the Conceptual C&R Plan provided in Part E of the Application (Pengrowth, 2013).

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 upper lift (UL) and lower lift (LL) 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).

Reclamation suitability ratings for the SM within the LSA are listed in Table D.9.2-3. CR #9, Figure 10 and Figure 11 display suitability ratings for upper lift and lower lift, respectively.

Table D.9.2-3 Reclamation Suitability Ratings for Soil Landscape Models in the LSA

Soil Model	Amalgamated Reclamation Suitability Ratings[1]		Comments
	UL[2]	LL[3]	
ABAM2	G-P	F-P	UL – Moderately coarse texture, coarse texture LL – Moderately fine texture, coarse texture *Note: UL lift rated as G-P due to the texture of ABC rated as good, and the texture of AMK rated as poor.*
ABC2	G	F	UL – No limitations LL – Moderately fine texture, low saturation %
ABC6	G	F	UL – No limitations LL – Moderately fine texture
ABC9	G	F	UL – No limitations LL – Moderately fine texture
ABMH2	G-F	F	UL – Low saturation %, slightly alkaline pH LL – Moderately fine texture
ABOW9	G	F	UL – No limitations LL – Moderately fine texture
ABSL1	G	F	UL – No limitations LL – Moderately fine texture *Note: Co-dominant organic soil (SLN) was not rated*
AMK18	P	P	UL – Coarse texture LL – Coarse texture
AMK2	P	P	UL – Coarse texture LL – Coarse texture
AMLA5	P	P	UL – Coarse texture LL – Coarse texture

Table D.9.2-3 Reclamation Suitability Ratings for Soil Landscape Models in the LSA

Soil Model	Amalgamated Reclamation Suitability Ratings[1]		Comments
	UL[2]	LL[3]	
ARV21	P	P	UL – Alkaline pH LL – Alkaline pH
BLBQ21	F-P	F-P	UL – High saturation %, alkaline pH LL - Moderately fine texture, coarse texture
CTW1c	NR	NR	UL – Organic LL – Organic
CTW1c-G	NR	NR	UL – Organic LL – Organic
CTW1m	NR	NR	UL – Organic LL – Organic
CTW1m-G	NR	NR	UL – Organic LL – Organic
CTW2	NR	NR	UL – Organic LL – Organic
CTW2c	NR	NR	UL – Organic LL – Organic
CTW2m	NR	NR	UL – Organic LL – Organic
LCNI2	G-P	F-P	UL – Moderately coarse texture , coarse texture LL – Moderately fine texture, coarse texture *Note: UL rated as G-P due to the texture of LCY rated as good, and the texture of NIT rated as poor.*
LCY1	G	F	UL – No limitations LL – Moderately fine texture
LCY2	G	F	UL – No limitations LL – Moderately fine texture
LCY9	G	F	UL – No limitations LL – Moderately fine texture
MMW21	F-P	F-P	UL – Alkaline pH LL – Alkaline pH, moderately fine texture, high saturation %
NWB20	G-F	F	UL – Alkaline pH, high saturation % LL – Moderately fine texture
NWB21	F	F	UL – Slightly alkaline pH LL – Moderately fine texture
PIAM18	P	P	UL – Coarse texture LL – Coarse texture

Table D.9.2-3 Reclamation Suitability Ratings for Soil Landscape Models in the LSA			
Soil Model	**Amalgamated Reclamation Suitability Ratings[1]**		**Comments**
	UL[2]	**LL[3]**	
SDLC2	G	F	UL – No limitations LL – Moderately fine texture
ZDL	NR	NR	Disturbed land
ZWA	NR	NR	Open water

[1] G – Good, F – Fair, P – Poor, O – Organic, NR – Not rated
[2] UL – upper lift (A horizons and perhaps a portion of the B horizon depending upon site specific conditions as define by SQCWG, 1987)
[3] LL – lower lift (material below the upper lift to a depth deemed appropriate relative to specific site conditions as define by SQCWG, 1987)

D.9.2.4 Erosion Risk Assessment

Soil erosion by wind or water can affect soil profiles and distribution of soils in the landscape. Soil erosion is dependent on soil texture, slope gradient, length of slope, vegetation type and cover. In areas where vegetation has been cleared and the soil surface disturbed, the risk of erosion generally increases. Bare soil has higher erosion potential than undisturbed profiles due to the lack of mechanisms that can reduce or minimize the erosive energy of wind or water.

Wind erosion risk ratings were modified from the *Wind Erosion Risk, Alberta* (Coote and Pettapiece, 1989). Wind erosion risk under current conditions is considered to be very low to negligible due to the vegetation cover in the LSA. The wind erosion ratings estimated for the SLMs (CR #9, Table 17) are based on the assumption that vegetation has been removed and bare soil is exposed.

Soil erosion via water was evaluated for the dominant and co-dominant soils of all soil map units in the LSA. The rate of water erosion was estimated using the *Revised Universal Soil Loss Equation for Application in Canada* (RUSLEFAC) (Wall *et al.*, 2002). Factors considered when estimating soil loss via water (A) include: rainfall and runoff (R), soil erodibility factor (K), slope factor (LS), crop / vegetation and management Factor (C), and support or management practices (P).

The risk of water erosion for baseline conditions is typically very low as the soil surface is currently well protected by tree and understory cover. Significant vegetation cover and an extensive litter/surface organic layer results in minimal exposure of surface soil material to water throughout the LSA. Water erosion risk for the majority of soils within LSA with vegetation removed and mineral soil exposed was rated as Very Low to Moderate.

D.9.2.5 Soil Sensitivity - Acidification

According to Alberta Acid Deposition Management Framework (AENV, 2008a), the critical, target and monitoring load for provincial scale applications are set to be:

- **Critical load** - the highest load that will not lead to long-term, harmful changes to a receptor;
- **Target load** - the level of deposition that consider the critical load and is practically and politically achievable; and
- **Monitoring load** – the level of deposition predicted or estimated by a dispersion model and deposition model that trigger monitoring and/or research.

Based on a review of the cumulative case PAI isopleths there are no PAI isopleths that contain values that trigger critical, target or monitoring load exceedances for the soils within the LSA or the RSA (CR #9, Figure 15). Predicted acid depositions level does not exceed the most conservative monitoring loads for sensitive soils.

The 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. The impact of the Project with respect to potential soil acidification is negligible at the local and regional scale for assessment cases and not considered to pose a potential impact to soils.

D.9.3 PREDICTED CONDITIONS

The impact assessment considered each of the three VECs and assessed the impacts for the Application (Project only) and the Planned Development Case (Cumulative Effects). With the exception of geographic extent, which varied between the LSA and RSA, the impact assessment for both cases was identical.

D.9.3.1 Soil Quality

Profile Disturbance

Application Case

Disturbance of the soil profile during construction, soils handling and stockpiling, and reclamation has the potential to impact soil quality. During Project construction, potential impacts to the soil resource will be limited to the proposed areas of disturbance (totalling 812.7 ha). Soil salvage, transport, storage (long term and short term) and replacement may have an environmental effect with respect to soil quality. Implementation of appropriate soil salvage techniques, in addition to field guidance by experienced professionals and pre-disturbance soil survey information will result in minimal soil losses due to conventional salvage and handling methods and minimize impacts to soil quality.

Topsoil lift material (mineral topsoil layer plus surface litter/shallow peat salvaged as one lift) will be salvaged within the Project disturbance limits. During site construction, soils with peat thicknesses greater than 40 cm will be left intact and padded over with fill material. Organic areas padded over will not have the soil profile physically removed, and admixing is expected to be minimal. All salvaged soil materials will be stockpiled for later use in reclamation.

Within the Project footprint, LCCS ratings and percentage of the proposed disturbance areas are as follows:

- Class 2 – pre-development 35.9 ha (4.4%); post reclamation 304.9 ha (37.5%);
- Class 3 – pre-development 584.1 ha (71.9%); post reclamation 305.0 ha (37.5%);
- Class 4 – pre-development 47.3 ha (5.8%); post reclamation 11.1 ha (1.4%);
- Class 5 – pre-development 74.4 ha (9.2%); post reclamation 71.7 ha (8.8%)
- Not Rated (ZDL) – pre-development 70.9 ha (8.7%); post reclamation 69.1 ha (8.5%); and
- Water – pre-development 0 ha; post reclamation 50.9 ha (6.3%).

The difference between pre- and post-reclamation areas is a result of the water bodies/shallow wetlands created through borrow pit development and converting padded organic landscapes to uplands. With proper soil salvage and handling, the effects on the soil resource for the Application Case are rated as low impact (CR #9, Table 17).

Planned Development Case

Within the RSA, an estimated 0.4% (812.7 ha) will be disturbed based on the Project. An estimated 3.8% (7,512.8 ha) is currently disturbed within the RSA.

It is expected that existing and potential future developments within the RSA that disturb (or have disturbed) the soil resource as a part of the development will be required to conserve topsoil and complete reclamation as per current regulatory and operating requirements. Compliance with regulatory requirements for planning, construction, and reclamation of developments will minimize any impacts to soil quality and quantity. With effective soil salvage and handling, and mitigation and monitoring, the impacts to the RSA as a result of development of the Project and existing current and future developments are expected to be low with respect to productivity (as related to LCCS).

Erosion

Application Case

The potential for impacts resulting from wind and water erosion on soil quality exists throughout the development and final reclamation of the Project. There is potential for loss of soil via erosion during soil salvage, soil storage, and after soil replacement. The risk of erosion to surface soils is greatest during the soil disturbance (salvage and storage) stages of Project construction, and during the soil replacement phase of the reclamation process. At these stages, Pengrowth will implement mitigation measures to minimize soil erosion. The resultant residual effects to the soil resource due to potential soil erosion for the LSA are anticipated to be low.

Planned Development Case

The resultant environmental effects pertaining to soil erosion for the PDC are anticipated to be equivalent to the Application Case. 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). The resultant residual effects to the soil resource due to potential soil erosion for the PDC (RSA) are anticipated to be low.

Accidental Releases

Application Case

Impacts to soil quality caused by accidental releases and operational incidents within the Project footprint have the potential to alter chemical and physical attributes of soils. This can include 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 in the LSA, accidental releases will result in a low effect 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. With the appropriate regional environmental management plans in place, accidental releases will likely result in a low effect on soil quality.

Soil Biodiversity

Application Case

The potential impact on soil biodiversity will be discussed in terms of the effects of the Project on the spatial distribution of soil patterns and potential changes in soil diversity and ecological integrity. The Project footprint will disturb approximately:

- 69.9 ha of organic soils, this equates to approximately 2.9% of the organic soils in the LSA and 1.0% of the estimated organic soils in the RSA;
- 631.1 ha of upland soils, this equates to approximately 4.4% of the upland soils in the LSA and 0.4% of the estimated upland soils in the RSA; and
- 40.8 ha of transitional mineral soils (Gleysols), this equates to approximately 9.0% of the transitional soils in the LSA and 1.0% of the estimated transitional soils in the RSA.

Common soils in the LSA and RSA include Luvisols, Brunisols and Chernozems 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 Project footprint that are not commonly found within the LSA and RSA. Reclamation of soil and landscape patterns to provide similar drainage and moisture regimes will allow for the eventual formation of a range 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 the Project is expected to have a low impact.

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. 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.

Cumulatively the impacts to soil biodiversity and ecological integrity for the PDC are the same as for the Application Case and are expected to be low.

D.9.3.3 Terrain

Application Case

Development of the Project will result in disturbances to the terrain types within the Project footprint. A total of 4.3% of the LSA will have terrain disturbances as a result of the Project development, including upland and organic terrain.

After reclamation, in some areas there will be a permanent loss of upland and organic terrain to water bodies/shallow wetlands due to the development of the borrow pits. In other areas, some organic landscapes converted to uplands. The alteration of terrain is expected to have a low impact on the soil resource.

Surface heave is expected to occur gradually through the operating period of each well pair. The area influenced by heave is expected to be localized. Minimal surface subsidence, if any, is expected to occur in the vicinity of the SAGD wells and surface subsidence below baseline elevation is not anticipated. Overall slope change and length of slope is not expected to exceed ranges of natural landscape mesorelief within the Project development area. Potential impact of changes in the ground surface during steaming and recovery operations will be low.

Planned Development Case

The landscape patterns within the RSA and LSA are similar. The expected impacts to terrain types disturbed by existing and future projects in the RSA are negligible. An estimated 4.2% will be disturbed based on the Project plus the existing disturbance within the RSA (8,325.5 ha).

It is expected that existing and potential future developments within the RSA that disturb soil and terrain as a part of the development will be required to complete reclamation as per all regulatory and operating requirements. This includes appropriate re-contouring to ensure reclaimed landscapes blend with adjacent undisturbed lands and provide appropriate surface drainage across the reclaimed landscapes. The alteration of terrain within the RSA as a result of the Project and current disturbances is expected to have a low impact on overall productivity (as related to LCCS).

D.9.4 MITIGATION AND MONITORING

D.9.4.1 Mitigation

Soil Quality

Impact management and mitigation objectives aim to reduce the extent and severity of surface disturbance during construction and operations. Recommended mitigation and monitoring measures are summarized below.

- upland soils will be salvaged using best management practices. Supervision of soil salvage operations and placement of soil materials during reclamation (direct placement) by a qualified individual is recommended;
- organic soils will be left in place and padded over with clay fill. Pad removal would occur at reclamation or they would be converted to uplands depending on site conditions;
- organic soil material can be salvaged in select areas for later use in reclamation;
- topsoil and subsoil will be salvaged and stored in separate stockpiles in a manner to minimize soil loss or degradation. Stockpiles will be located on higher ground to minimize potential for groundwater saturation whenever site conditions warrant;
- decompaction will be completed to reduce potential compaction as a result of soil replacement; and
- all reclaimed lands will be vegetated upon completion of soil placement to minimize soil loss via erosion (wind and water); vegetation establishment will occur through natural regeneration, re-seeding and re-planting.

Soil Biodiversity

Project reclamation will create soil landscape patterns similar to pre-disturbance conditions such that equivalent land capability is met. The landscape will be developed to meet desired end land uses, as well as establishment of ecosystem patterns similar to pre-disturbance conditions.

Application of Terrain

Impacts to terrain will be mitigated through appropriate recontouring of reclaimed landscapes to provide topography and surface forms that provide appropriate surface drainage, blend with the adjacent undisturbed terrain (*e.g.*, drainage, aspect) and remain stable. In instances where the reclaimed landscape is expected to differ from the original terrain type (*e.g.*, borrow pits), the landscape will be designed to ensure that end land use objectives are met.

D.9.4.2 Monitoring

Soil Quality

A monitoring program will be developed and implemented to assess the success of reclamation with respect to soil quality. Success will be measured as compared to applicable reclamation criteria and the requirements set by regulatory approvals. Monitoring activities will include the following:

- direct supervision of soil salvage and replacement activities by a qualified individual;
- assessment of landscape characteristics and features to ensure appropriate drainage;
- assessment of potential soil erosion issues of stockpiled or recently replaced soil material; and
- assessment of reclaimed areas for topsoil quality (*i.e.*, admixing) and quantity (depths).

Mitigation and monitoring measures are detailed in the Conceptual Conservation and Reclamation Plan provided in Part E to ensure soil quality is maintained throughout the life of the Project.

Soil Biodiversity

Post-reclamation monitoring will be completed to ensure appropriate site contouring, soil placement, vegetation establishment, ecosystem trajectory and productivity.

Application of Terrain

Monitoring of post reclamation landscapes for stability, drainage, and the interaction of the vegetation communities in the reclaimed landscapes will be completed after reclamation and revegetation. Areas of concern would be addressed as necessary to mitigate terrain conditions undesirable for end land use and reclaimed vegetation communities. Monitoring will allow for adaptive management of the re-contouring, soil placement and re-vegetation activities throughout the life of the Project.

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.9.5-1.

Table D.9.5-1 Summary of Impact Rating on Residual Effects for the Soil Resource VECs

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	Appropriate soil salvage, handling, storage, and reclamation	Application	Local	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	Soil salvage, handling, and reclamation as per regulatory requirements for Projects in the RSA	Cumulative Effects (related Infrastructure outside the LSA)	Regional	Extended	Continuous, diminish with time	Reversible – long term	Moderate	Initially – Negative; Over time - Neutral	Moderate	High	Low
Erosion											
Impact on soil quality	Appropriate erosion control measures throughout Project	Application	Local	Short	Occasional	Irreversible	Moderate to Low	Neutral	Moderate	High during salvage and replacement at reclamation decreasing to Low after veg. establishment	Low
Impact on soil quality	Appropriate erosion control measures as per regulatory requirements for all stages of Projects in the RSA	Cumulative Effects	Regional	Short	Occasional	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	Appropriate spill containment and spill response plan	Application	Local	Long	Occasional (unplanned)	Reversible – short term	Low	Neutral	High	Medium to Low	Low

Table D.9.5-1 Summary of Impact Rating on Residual Effects for the Soil Resource VECs

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]
Impact on soil quality	Appropriate spill containment and spill response plan; compliant with regulatory requirements for construction, operation, and reclamation of Projects in the RSA	Cumulative Effects	Regional	Extended	Occasional (unplanned)	Reversible – short term	Low	Neutral	Moderate	Medium to Low	Low
2. Soil Biodiversity											
Impact on soil diversity (distribution of soils) and ecological integrity	Appropriate soil salvage, site recontouring soil replacement and revegetation	Application	Local	Extended	Continuous	Reversible – long term	Low	Negative	High	High	Low
Impact on soil diversity (distribution of soils) and ecological integrity	Implementation of an appropriate C&R plan as per regulatory requirements for Projects in the RSA	Cumulative Effects	Regional	Extended	Continuous	Reversible – long term	Low	Negative	High	High	Low
3. Alteration of Terrain											
Impact on terrain types	Appropriate site construction practices and recontouring at reclamation to meet end land use objectives	Application	Local	Residual	Continuous	Irreversible	Low	Neutral	High	High	Low

Table D.9.5-1 Summary of Impact Rating on Residual Effects for the Soil Resource VECs

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]
Impact on terrain types	Implementation of a C&R plan as per regulatory requirements for expected Projects in the RSA	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
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

Pengrowth Energy Corporation (Pengrowth) conducted an assessment of vegetation and wetland resources for the proposed 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.

ESRD issued the ToR for Project on December 13, 2013. The specific requirements for the vegetation and biodiversity component are provided in Section 3.6 and Section 3.8 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 and identify any species that are:

- *a) listed as "at Risk, May be at Risk and Sensitive" in the General Status of Alberta Wild Species (Alberta Environment and 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) the potential for introduction and colonization of weeds and non-native invasive species;*
- *c) potential increased fragmentation and loss of upland, riparian and wetland habitats; and*
- *d) 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.

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. Discuss the rationale for their selection.

3.8.2 Impact Assessment

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

a). the biodiversity metrics, biotic and abiotic indicators selected;

b). the effects of fragmentation on biodiversity potential;

c). the contribution of the Project to any anticipated changes in regional biodiversity and the potential impact to local and regional ecosystems; and

d). effects during construction, operations and post-reclamation and the significance of these changes in a local and regional context.

The LSA was defined to include a 500 m buffer around the EIA Project Area and encompasses the Project footprint (CR #10, Figure 1-2). The physical extent of the LSA is sufficient in size to capture potential Project effects to VECs that will result from direct disturbance to vegetation and wetland resources inside the Project footprint and also changes to vegetation communities adjacent to the Project footprint as a result of alterations to physical components such as water quantity (wetlands) and quality, air emissions, and dust. Project (residual) and cumulative effects are measured within the LSA. The LSA is 22,331 ha in area and is shown on CR #10, Figure 1-1 and Figure 1-2.

The RSA consists of the LSA plus a 16 km buffer surrounding the LSA (CR #10, Figure 1-1). The RSA is 198,092 ha. The RSA incorporates the annual critical load of nitrogen deposition and potential acid input (PAI) that is protective of the most sensitive vegetation species.

The FTOR for the Project was used to determine the valued environmental components (VECs) for vegetation and wetland resources:

- terrestrial vegetation (CR #10, Section 5.1);
- wetlands (CR #10, Section 5.2);
- ecosite phases of limited distribution (CR #10, Section 5.3);
- rare plants (CR #10, Section 5.4);
- traditional use plants (CR #10, Section 5.5);
- old growth forests (CR #10, Section 5.6);
- non-native and invasive species (CR #10, Section 5.7);
- habitat fragmentation (CR #10, Section 5.8); and
- biodiversity (CR #10, Section 5.9).

Although not considered a VEC, noxious, non-native and invasive vegetation species are also assessed, given they affect biodiversity.

D.10.2 BASELINE CONDITIONS

D.10.2.1 Terrestrial Vegetation Resources

Six hundred and thirty three plant species were identified in the LSA during field surveys conducted between 2011 and 2013. The plants included vascular plants and non vascular plants (mosses, liverworts and lichens). Five of the vascular plants identified in the LSA are non-native and invasive species. A complete list of the flora identified in the study area is presented in CR #10, Appendix 3. The most prevalent tree species were aspen, white spruce, black spruce, jack pine and tamarack, with small amounts of balsam poplar, paper birch, and balsam fir.

A total of 321 vegetation plots were surveyed, and initial mapped polygons within the LSA were then refined using survey plot data. The final map resulted in 22,188 polygons. Twenty-three ecosite phases, open water features (streams/rivers, flooded areas, lakes, and ponds), non-forested habitats, and existing anthropogenic disturbance were mapped. Table D.10.2-1 shows the total area (ha) and the percentage occupied by each ecosite phase, non-forested habitats and water features within the LSA.

Table D.10.2-1 Distribution of Ecosite Phases in the LSA

Ecosite Phase	Total Area[1]	% of LSA
Natural Vegetation		
a1 – lichen/jack pine	5.9	<0.1
b1 – blueberry / jack pine – aspen	126.4	0.6
b2 – blueberry / aspen(white birch)	1.2	<0.1
b4 – blueberry / white spruce – jack pine	0.5	<0.1
c1 – Labrador tea-mesic / jack pine – black spruce	30.4	0.1
d1 – low bush cranberry / aspen	8,807.6	39.4
d2 – low bush cranberry / aspen – white spruce	1,141.1	5.1
d3 – low bush cranberry / white spruce	5.1	<0.1
e1 – dogwood / paper birch – aspen	2,743.9	12.3
e2 – dogwood / white birch – white spruce	420.5	1.9
e3 – dogwood white spruce	22.5	0.1
f1 – horsetail / balsam poplar – aspen	169.3	0.8
f2 – horsetail / paper birch – white spruce	102.6	0.5
f3 – horsetail / white spruce	35.7	0.2
g1 – Labrador tea-subhygric / black spruce – jack pine	92.7	0.4
h1 – Labrador tea-horsetail / white spruce – black spruce	107.0	0.5
i1 – treed bog	8.9	0.0
j1 – treed poor fen	374.1	1.7
j2 – shrubby poor fen	48.9	0.2
k1 – treed rich fen	242.3	1.1

Table D.10.2-1 Distribution of Ecosite Phases in the LSA		
Ecosite Phase	**Total Area[1]**	**% of LSA**
k2 – shrubby rich fen	1,289.5	5.8
k3 – graminoid rich fen	656.2	2.9
l1 – marsh	209.6	0.9
Sub-total	**16,641.9**	**74.5**
Non-forested Habitats		
HF – Herbaceous, forb dominated	0.8	<0.1
HG – Herbaceous, graminoid dominated	44.6	0.2
SC – Closed upland shrub	57.5	0.3
SO – Open upland shrub	59.3	0.3
Sub-total	**162.2**	**0.7**
Naturally Non-Vegetated Features		
NMS – Sand	72.7	0.3
Sub-total	72.7	0.3
Water Features		
NWF – Flooded	1.0	<0.1
NWL – Seasonally thaws, lakes, ponds	674.9	3.0
NWR – Rivers and streams	35.2	0.2
Sub-total	**711.1**	**3.2**
Existing Disturbance		
AIF – Farmsteads, related to agriculture	54.7	0.2
AIG – Gravel pits and borrow pits	34.9	0.2
AIH – Permanent right of way; roads, highways, railroads, dam sites, reservoirs	372.3	1.7
AII – Industrial non-linear (Plant sites, sewage lagoons)	77.9	0.3
CC – Clear-cut	122.5	0.5
CIP – Industrial linear (pipelines, transmission lines)	591.4	2.6
CIW – Geophysical and wellsites seeded to grass	318.5	1.4
CL – Clearing	613.6	2.7
CP – Perennial forage crops	2,205.5	9.9
CPR – Rough Pasture (>10% woody cover)	351.5	1.6
Sub-total	**4,742.8**	**21.3**
TOTAL	**22,330.7**	**100.0**

[1] Due to rounding of values, totals may not equal the sum of the individual values presented in the table.

The RSA encompasses an area of 198,092 ha located within the Central Mixedwood and Dry Mixedwood Subregions of Alberta. The majority of the study area lies within the Central Mixedwood subregion. Fourteen broad land cover classes were mapped, with five upland classes, six wetland cover classes, and three anthropogenic classes. Land cover classes within the RSA are listed in Table D.10.2-2 and shown on CR #10, Figure 4-2.

Table D.10.2-2 Distribution of Land Cover Classes in the RSA

Land Cover Class	Ecosite Phase	Area (ha)	% of the RSA
Upland Communities			
Closed coniferous	a1, b1, b4, c1, d3, e3, f3, g1, h1	2,142.1	1.1
Closed deciduous	b2, d1, e1, f1	91,121.0	46.0
Mixedwood	b1, b3, d2, e2, f2	52.2	<0.1
Riparian	e1, f1	321.3	0.2
Shrubland		1,343.4	0.7
Sub-Total		**94,979.9**	**47.9**
Wetland Communities			
Graminoid wetland	k3, l1	3,993.3	2.0
Sedge meadow	k3, l1	6.7	<0.1
Shrubby wetland	j2, k2	2,741.2	1.4
Treed wetland	i1, j1, k1, h1, g1	707.9	0.4
Water (Unspecified natural wetlands)	NWL, NWF, l1, k3	210.0	0.1
Water (Wetlands and Open water)	NWL, NWR, NWF, k3, l1	22,441.7	11.3
Sub-Total		**30,100.8**	**15.2**
Anthropogenic			
Agriculture (Pasture)		60,281.9	30.4
Non-linear disturbance	AIG, AII, CIW	2,924.8	1.5
Linear disturbance	AIH, CIP, CL	9,804.1	4.9
Sub-Total		**73,010.8**	**36.9**
Total		**19,8091.5**	**100.0**

Potential Acid Input (PAI) and Nitrogen Deposition

Acid deposition can negatively affect vegetation directly if sufficient amounts are absorbed by tissues from the air. The direct effects of PAI and nitrogen deposition on vegetation include discoloration, defoliation and reduced plant vigour and reproductive success.

The modelled baseline levels of PAI within the RSA range from 0.025 to 0.075 keq/ha/yr. Baseline levels of PAI within the LSA range from 0.04 to 0.06 keq/ha/yr.

Modelled baseline levels for nitrogen deposition within the RSA range from 3.0 to 4.0 kg/ha/yr. Baseline nitrogen deposition within the LSA ranges from 2.75 to 4.0 kg/ha/yr.

Forestry Resources

Forested land (all timber productivity classes) represents 58% of the LSA and have an estimated 67,129 m^3 of salvageable timber and 20,536 m^3 of unproductive timber (CR #10, Table 4-3). All the salvageable timber present within the LSA was found to have a timber productivity rating (TPR) of medium. Non-forested (no timber) land occupies the remainder of the LSA (42.2%) and is a combination of anthropogenic features, lakes, rivers, shrubby and graminoid wetlands, natural meadows and other clearings. The leading tree type within the LSA is aspen and the volume of timber in the LSA by leading species is presented in CR #10, Table 4-4.

D.10.2.2 Wetlands

CR #10, Figure 4-3 shows the location of dominant wetland classes within the LSA. Eight different wetland classes were identified within the LSA (CR #10, Table 4-5) covering 3,595.2 ha (16.1% of the LSA). They included bogs (8.9 ha), fens (2,516.3 ha), swamps (149.3 ha), marsh (209.6 ha) and open water (711.1 ha). Secondary wetland classes that are not continuous and found in scattered or isolated pockets are too small to map at the scale used. CR #10, Appendix 6 provides detailed descriptions of the wetland classes found in the LSA.

Wetlands of limited distribution in the LSA make up 1.6% (367.8 ha) of the LSA (CR #10, Table 4-6). They include wooded bogs with internal no lawns (BTNN), open graminoid-dominated marsh (MONG), open shrub dominated swamps (SONS), and wooded swamps (STNN). The marsh wetland class makes up less than 1% of the LSA.

CR #10, Table 4-7 provides a summary of wetland classes found in the RSA. Wetlands occupy 15.2% (30,100 ha) of the RSA. Open waterbodies are the most common wetland type and occupy 11.4% (22,441.7 ha) of the RSA (CR #10, Figure 4-4). Graminoid wetlands and shrubby wetlands constitute 2% and 1.4% of the RSA, respectively, while treed wetlands occupy 0.4% of the RSA. Approximately 0.1% of the RSA consists of undifferentiated wetland areas, and less than 0.01% of the RSA is sedge meadow.

D.10.2.3 Ecosite Phases of Limited Distribution

Ecosite phases of limited distribution were defined as those with a total area less than 1% of the LSA (based on their baseline distribution). Ecosite phases of limited distribution are considered more vulnerable to losing species and consequently species diversity if disturbed, since a greater proportion of the total area would be lost, even in small disturbances. Within the LSA, 12 upland ecosite phases (a1, b1, b2, b4, c1, d3, e3, f1, f2, f3, g1, and h1) and three wetland ecosite phases (i1, j2, and l1) are of limited distribution; they collectively occupy approximately 4.3% (966.6 ha) of the LSA (CR #10, Table 4-8 and Figure 4-5). Among the water features found in the LSA, rivers, streams and flooded areas are of limited distribution, occupying approximately 0.2% (36.2 ha) of the LSA. All non-forested habitats identified within the LSA are of limited distribution; they occupy approximately 162.2 ha (0.7%) of the total LSA.

Four land cover classes occupy less than 1% of the RSA at baseline and are of limited distribution (CR #10, Table 4-9).

D.10.2.4 Rare Plants, Rare Plant Potential and Rare Plant Communities

Rare Plants

Ecosite phases with very high rare plant potential include f1, f2, f3, g1, and h1 and comprise 2.3% of the LSA. Ecosite phases with high rare plant potential make up 0.6 % of the LSA and include ecosite phases a1, b1, and b2.

An ACIMS query of townships within the RSA yielded two previously reported rare plant species (CR #10, Appendix 10) and no rare or special plant communities in the area. Two vascular plants *Hedyotis longifolia* (UTM E530657.1, N5967139.1) and *Polygala paucifolia* (UTM E506893.7, N5974476 and E509560.5, N5978136.6) were reported within the RSA. Project surveys also found *Polygala paucifolia* at a single location within the LSA.

Twenty five species found on the Alberta Rare Plant Tracking and Watch Lists (ACIMS 2013) were found during the survey of the LSA (CR #10, Figure 4-6) with 119 occurrences. A summary of the species found, the habitat(s) in which they were found along with their rarity rankings within Alberta, and globally is given in Table D.10.2-3.

Public databases indicated that 38 plant species listed as “Sensitive” or “at Risk” in the General Status of Alberta Wild Species (ASRD 2010) (CR #10, Appendix 7). All the vascular plants, three bryophytes and seven lichens that appear on ACIMS list of tracked elements in the LSA are also listed on the General Status of Wild Species in Alberta list. No plant species that appear on the SARA and COSEWIC databases were found in the LSA.

Rare Plant Potential

Ecosite phases with very high rare plant potential include f1, f2, f3, g1, and h1 and comprise 2.3% of the LSA. Ecosite phases with high rare plant potential make up 0.6 % of the LSA and include ecosite phases a1, b1, and b2. The rare plant potential rankings in the LSA are shown on CR #10, Figure 4-7 and listed in CR #10, Table 4-11.

Rare Plant Communities

No rare plant communities were found in the LSA. A list of rare ecological communities that could potentially occur in the RSA was also compiled. Of the 40 communities listed on the ACIMS tracking list for the Central Mixedwood and Dry Mixedwood natural subregions (Allen 2012), none were identified in the LSA.

Table D.10.2-3 Rare Plant Species in the LSA and Project Footprint

Scientific Name	Common Name	# in LSA	# in Footprint	Plant Community	Alberta Rank	Global Rank
Vascular Plants						
Agrostis exarata	spike redtop	1	0	CIP	S2	G5
Arenaria longipedunculata	sandwort	2	0	k3.1, e1.3	S1	G3G4Q
Carex adusta	browned sedge	1	0	j1.1	S1	G5
Carex lacustris	lakeshore sedge	1	0	k2.2	S2	G5
Chrysosplenium iowense	golden saxifrage	17	1	Various	S3?	G3?
Polygala paucifolia	fringed milkwort	1	0	b1.3	S1	G5
Bryophytes						
Brachythecium calcareum	moss	1	0	d1.3	S1	G3G4
Conardia compacta	moss	1	0	j1.1	S2	G3G5
Dicranella cerviculata	red-necked fork moss	1	0	d1.3	S1	G5?
Dicranum majus	greater fork moss	1	0	d1.5	SH	G4G5
Lophozia heterocolpos	liverwort	1	0	g1.1	S2	G5
Scapania glaucocephala	liverwort	2	0	d2.3, g1.1	S2	G4G5
Sphagnum fallax	peat moss	1	0	k2.1	S2	G5
*Sphagnum subsecundum**	twisted bog moss	2	0	d1.3, k1.1	S3	G5
Splachnum luteum	yellow collar moss	2	0	d3.5, k2.1	S3	G4?
Lichens						
Cladonia bellidiflora	floral pixie	5	0	a1.1, d1.4, e1.2, g1.1, l1.1	S2S3	G5
Cladonia rei	wand lichen	1	0	d1.3	S2	G3G5
Cladonia stygia	reindeer lichen	2	0	g1.1, i1.1	S2	G5
Cornicularia normoerica	bootstrap lichen	2	0	d1.3, e1.1	S1	G3G5
Flavopunctelia soredica	powder-edged speckled greenshield lichen	4	0	b1.3, d1.6, d2.4, j1.1	S2	G3G5
Peltigera cinnamomea	cinnamon dog pelt lichen	1	0	k1.1	S2	GNR
Peltigera polydactyla	alternating dog-lichen	6	0	d1, d1.3, f1.1, j1.1, k1.1, l1.1	S2	G5?
Ramalina farinacea	dotted ramalina	3	0	e1.2, g1.1, l1.1	S3	G3G5

Table D.10.2-3 Rare Plant Species in the LSA and Project Footprint

Scientific Name	Common Name	# in LSA	# in Footprint	Plant Community	Alberta Rank	Global Rank
Xanthomendoza fulva	bare-bottomed sunburst lichen	1	0	e1.3	S1	G5
Xanthomendoza hasseana	polar sunburst lichen	59	7	Various	S1S2	G5

D.10.2.5 Traditional Ecological Knowledge Vegetation

A total of 112 TEK vegetation species were observed and documented during field sampling within the LSA (CR #10, Appendix 8). TEK vegetation used for food was found in all ecosite phases. Most plant species used for food included forbs and shrubs (berries) and lichen species. Willows and tree species are primarily used for medicinal and other uses (CR #10, Table 4-13).

The potential for ecosite phases to support TEK vegetation species is shown in CR #10, Table 4-14 and Figure 4-8 and summarized in CR #10, Table 4-15. TEK vegetation has a high potential to occur in ecosite phases i1 (poor fen), k2 (shrubby rich fen), k1 (graminoid rich fen) l1 (marsh); grass dominated meadows (HG); and open shrubby upland areas (SO). Most of the LSA has moderate potential to support TEK vegetation. This includes disturbances such as pastures, pipeline, access roads, and transmission line ROW's. All of the ecosite phases of limited distribution in the LSA support TEK vegetation. The RSA was not sampled for TEK vegetation.

D.10.2.6 Old Growth Forests and Old Growth Potential

The LSA contains no stands of old growth forest. The oldest tree cored was found to be approximately 117 years old (CR #10, Table 4-16). The forests within the LSA are considered to be in a young or mature seral stage which is characterized by tree ages of 30 to 140 years of age. CR #10, Figure 4-9 shows the stand age class distribution of forest stands in the LSA.

Old growth potential and the associated level of confidence in the prediction for old growth potential has been assigned the rankings of "Low", "Moderate", and "High". CR #10, Figure 4-10 and Table D.10.2-4 show the old growth potential rankings for ecosite phases in the LSA. Ecosite phases with high potential to develop into old growth forests include d1, e1, and f1 and occupy 52.5% of the LSA (CR #10, Table 4-18). Ecosite phases with moderate old-growth potential include j1 and k1 and occupy 2.8% of the LSA. Ecosite phases with low old growth potential include b4, c1, d3, f3, and bogs and occupy 6.0% of the LSA. Shrubby fens (j2 and k2) have very low old growth potential. Not Ranked areas occupy 29.3%.

The RSA was not mapped for old growth forest stands because both the AGCC dataset and the GeoEye imagery (used to refine recent disturbances) do not include attributes for stand origin. Based on the land cover types found within the RSA, an old growth potential ranking was developed for the RSA. CR #10, Table 4-19 and Figure 4-11 provide potential for each land

cover class to support old growth forests. Confidence in the ranking predictions is determined to be low to moderate because of the uncertainties around the actual grazing pressures in the region.

Table D.10.2-4 Old Growth Potential by Ecosite Phases in the LSA

Ecosite Phase / AVI code	Old Growth Potential	Confidence	Area in LSA (ha)	% of LSA
a1-lichen jack pine	Moderate	Moderate	5.9	<0.1
b1-blueberry Pj-Aw	Moderate	Moderate	126.4	0.6
b2 – blueberry / Aw (Bw)	Moderate	Low	1.2	<0.1
b4–blueberry Sw-Pj	Low	High	0.5	<0.1
c1-Labrador tea-mesic Pj-Sb	Low	High	30.4	0.1
d1-low-bush cranberry Aw	High	High	8,807.6	39.4
d2-low bush cranberry Aw-Sw	Moderate	Moderate	1,141.1	5.1
d3-low bush cranberry Sw	Low	High	5.1	<0.1
e1-dogwood Pb-Aw	High	High	2,743.9	12.3
e2-dogwood Pb-Sw	Moderate	Moderate	420.5	1.9
e3-dogwood/Sw	Low	Moderate	22.5	0.1
f1-horsetailPb=Aw	High	High	169.3	0.8
f2-horsetail Pb-Sw	Moderate	Low	102.6	0.5
f3-horsetail Sw	Low	High	35.7	0.2
g1-Labrador tea –subhygric Sb-Pj	Moderate	Low	92.7	0.4
h1-Labrador tea/horsetail Sw-Sb	Low	Low	107	0.5
i1-treed bog	Low	High	8.9	<0.1
j1-treed poor fen	Moderate	High	374.1	1.7
j2-shrubby poor fen	Very Low	High	48.9	0.2
k1-treed rich fen	Moderate	High	242.3	1.1
k2-shrubby rich fen	Very Low	High	1,289.5	5.8
k3-graminoid rich fen	Not Ranked[1]	-	656.2	2.9
l1-marsh	Not Ranked[1]	-	209.6	0.9
Water, Meadows	Not Ranked[1]	-	945.8	4.2
Existing disturbance	Not Ranked[1]	-	4,742.9	21.2

[1] Ecosite phase/AVI code is not forested.

D.10.2.7 Noxious and Invasive Species

Baseline field surveys identified four noxious species (Alberta Agriculture and Food, 2007)) within the LSA (CR #10, Table 4-20), including populations of *Cirsium arvense* (Canada thistle), *Sonchus arvensis* (perennial sow thistle), *Convolvulus arvensis* (field bindweed), and *Ranunculus*

acris (tall buttercup). Other non-native and invasive species were found in a variety of habitats across the LSA (CR #10, Appendix 9).

D.10.2.8 Habitat Fragmentation

The Baseline Case for the LSA is highly fragmented by both linear and nonlinear (primarily agricultural) disturbances. Linear clearings including roads, cutlines, pipelines, and seismic lines account for approximately 2.6% of the LSA. Table D.10.2-5 presents the baseline landscape level fragmentation results for the LSA. Mean patch area is 0.8 ha, mean nearest neighbour distance is 29.7 m, and the patch density per 100^2 ha is 119.4 which suggests that, at baseline, the area is highly fragmented.

Table D.10.2-5 Baseline Landscape Level Fragmentation in the LSA

# of Patches	Patch Density	Patch Area Mean (ha)	Perimeter to Area Ratio	Mean Nearest Neighbor Distance (m)	Distribution (IJI)	Shannon Diversity Index	Shannon Evenness Index
26,672	119.4	0.8	4,836.2	29.7	54.2	2.3	0.6

Linear and nonlinear disturbances resulting from existing well sites, roads, seismic lines, cutlines, pipeline corridors, and other industrial activities account for approximately 6.4% of the RSA (CR #10, Table 4-23).

D.10.2.9 Biodiversity

The biodiversity VEC was assessed at three levels, including species biodiversity, community biodiversity, and landscape biodiversity.

Species biodiversity was assessed to address the effect of removing plant species from the LSA. Species level biodiversity was measured in terms of species richness, diversity, and evenness. A total of 633 plant species (vascular, bryophytes, terrestrial lichens, and epiphytic lichens) were identified within the LSA. A total of 413 vascular (trees, shrubs, forbs, and graminoids) and 220 non-vascular (mosses, liverworts, ground lichens, and epiphytic lichens) plant species were identified in the LSA (CR #10, Appendix 4). The number of sites sampled in each ecosite phase and the mean and standard deviation for diversity parameters (richness, Shannon diversity index, and evenness) are provided in Table D.10.2-6.

Community biodiversity was assessed to address the effect of removing ecosite phases or biodiversity potential (based on ecosite phases) from the LSA. The community level assessment focused on number of ecosite phases within the LSA and the biodiversity potential of each ecosite phase. The final biodiversity potential ranking of ecosite phases for the LSA is given in Table D.10.2-7 and mapped in CR #10, Figure 4-12.

Table D.10.2-6 Species Level Diversity of Ecosite Phases in the LSA

Ecosite Phase	Number of Species		Shannon's Diversity Index		Shannon Evenness Index	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
a1-lichen-pj	40.0	na	2.7	na	0.73	na
b1-blueberry Pj-Aw	35.8	6.2	3.6	0.7	0.99	0.17
b2-blueberry Aw(Bw)	30.0	1.0	3.3	0.2	0.97	0.07
b4-blueberry Sw-Pj	24.9	8.5	2.5	0.7	0.77	0.14
c1-Labrador tea-mesic Pj-Sb	28.3	8.4	2.8	0.5	0.86	0.14
d1-low-bush cranberry Aw	32.9	7.1	3.1	0.6	0.89	0.14
d2-low bush cranberry Aw-Sw	35.5	7.5	3.5	0.5	0.97	0.10
d3-low bush cranberry Sw	23.5	0.5	2.4	0.1	0.75	0.03
e1-dogwood Pb-Aw	36.1	7.0	3.3	0.5	0.91	0.13
e2-dogwood Pb-Sw	38.0	9.6	3.7	0.4	1.00	0.07
e3-dogwood Sw	45.1	1.6	3.0	0.2	0.78	0.04
f1-Pb-Aw	27.1	5.8	2.7	0.6	0.82	0.15
f2-horsetail Pb-Sw	44.3	11.8	3.6	0.8	0.96	0.15
f3-horsetail Sw	63.0	na	4.2	na	1.01	na
g1-Labrador tea-subhygric Sb-Pj	28.5	11.9	2.7	0.6	0.83	0.11
h1-Labrador tea-horsetail Sw-Sb	39.0	21.1	2.9	0.7	0.82	0.16
i1-treed bog	17.1	3.7	2.8	0.9	0.98	0.25
j1-treed poor fen	30.8	7.8	3.4	0.7	1.00	0.14
j2-shrubby poor fen	16.1	1.0	2.2	<0.1	0.79	0.03
k1-treed rich fen	28.4	7.8	2.8	0.4	0.86	0.09
k2-shrubby rich fen	28.8	11.9	2.6	0.5	0.80	0.12
k3-graminoid rich fen	25.4	13.7	2.4	1.0	0.76	0.19
l1-marsh	20.0	6.8	2.1	0.6	0.72	0.15
HG-Graminoid dominated	18.0	na	2.1	na	0.74	na
NMS- sandbars	14.0	na	2.2	na	0.83	na
SC- closed shrub dominated	21.0	na	2.5	na	0.83	na
SO-open shrub dominated	18.5	2.8	2.5	0.1	0.85	0.01
Regeneration Improved Pasture	15.0	na	1.7	na	0.62	na
Regeneration Rough pasture	29.2	8.1	3.1	0.3	0.94	0.01
Regeneration Industrial	19.1	9.8	2.2	0.7	0.78	0.16
Undifferentiated clearcuts	24.0	na	2.8	na	0.88	na

Table D.10.2-7 Biodiversity Potential Rankings by Ecosite Phase in the LSA

Ecosite Phase[1,2]	Biodiversity Potential	Confidence	Area in LSA (ha)
a1-lichen Pj	High	Moderate	5.9
b1-blueberry Pj-Aw	Very High	Moderate	126.4
b2-blueberry Aw(Bw)	High	Low	1.2
b4-blueberry Sw-Pj	Moderate	Low	0.5
c1-Labrador tea-mesic Pj-Sb	Moderate	High	30.4
d1-low-bush cranberry Aw	High	Moderate	8,807.6
d2-low bush cranberry Aw-Sw	High	Moderate	1,141.1
d3-low bush cranberry Sw	Moderate	Low	5.1
e1-dogwood Pb-Aw	High	Moderate	2,743.9
e2-dogwood Pb-Sw	High	Moderate	420.5
e3-dogwood Sw	High	Moderate	22.5
f1-horsetail Pb-Aw	High	Moderate	169.3
f2-horsetail Pb-Sw	Very High	High	102.6
f3-horsetail Sw	Very High	High	35.7
g1-Labrador tea-subhygric Sb-Pj	Very High	Moderate	92.7
h1-Labrador tea-horsetail Sw-Sb	Moderate	Moderate	107.0
i1-treed bog	Moderate	High	8.9
j1-treed poor fen	Very High	High	374.1
j2-shrubby poor fen	Moderate	High	48.9
k1-treed rich fen	Moderate	High	242.3
k2-shrubby rich fen	High	Moderate	1,289.5
k3-graminoid rich fen	Moderate	Moderate	656.2
l1-marsh	Moderate	Moderate	209.6
HF-Non forested-forb dominated	Very low	High	0.8
HG-Non forested-graminoid dominated	Low	Moderate	44.6
SC-Non forested closed shrub	Low	Moderate	57.5
SO- Non forested- open shrub	Low	Moderate	59.3
NMS- Sand	Low	Low	72.7
CP- improved pasture	Low	Moderate	2,205.5
CPR- rough pasture	Low	High	351.5
CIW, AIG- well sites, borrow pits (existing)	Low	High	353.4
CC- Undifferentiated Clearcuts	Low	Low	122.5
AIF- Residential (agricultural related)	Very Low	Low	54.7
AII- Industrial (includes plant sites, sewage lagoons)	Very Low	High	77.9

Table D.10.2-7 Biodiversity Potential Rankings by Ecosite Phase in the LSA

Ecosite Phase[1,2]	Biodiversity Potential	Confidence	Area in LSA (ha)
NWL, NWF- water	Not ranked	n/a	711.1
All other existing disturbances	Very Low	High	1,577.3

- Based on sampled ecosite phases only and refers to data from 10 by 10 plots, existing data and information and professional judgement
- Includes commonly used AVI codes

To determine biodiversity at the landscape level, the number and type of ecosite phases in the LSA and land cover classes in the RSA as well as the level of habitat fragmentation were used. The Baseline Case for the LSA is highly fragmented by both linear and non-linear (primarily agricultural) disturbances. Linear clearings including roads, cutlines, pipelines, and seismic lines account for approximately 2.6% of the LSA. From a vegetation perspective, the width of seismic lines do not significantly affect the functioning of plant communities but the existing linear features have contributed to further reduction in mean patch size of some ecosite phases. Results of the fragmentation analysis are provided in Table D.10.2-8.

Table D.10.2-8 Baseline Fragmentation Metrics for Ecosite Phases in the LSA[1]

Ecosite	Total Area (ha)	Mean Patch Area (ha)	# of Patches	Patch Density (#/100^2 ha)	Perimeter (m)	Perimeter to Area Ratio	Mean Nearest Neighbor Distance (m)	Distribution (IJI Index)
a1	7.4	2.5	3	0.0	3,140.0	881.7	5.6	29.1
b1	92.5	2.7	34	0.2	25,770.0	3,822.4	150.7	54.0
b2	1.2	0.3	4	0.0	1,660.0	6,009.2	5.6	35.5
b4	0.5	0.5	1	0.0	605.0	1,249.0	N/A	21.8
c1	22.4	2.5	9	0.0	7,990.0	949.0	5.8	47.0
d1	9,093.0	1.7	5375	24.1	4,106,220.0	3,862.0	9.1	49.9
d2	1,263.4	2.9	430	1.9	339,005.0	2,906.6	25.2	61.6
d3	1.0	0.3	3	0.0	1,165.0	6,312.5	2,511.1	24.2
e1	2,641.2	0.4	7,363	33.0	3,316,240.0	4,999.0	11.4	41.7
e2	322.4	0.3	1,191	5.3	305,840.0	5,484.7	45.3	56.9
e3	17.7	0.1	128	0.6	30,230.0	7,536.4	26.7	51.0
f1	154.5	0.7	215	1.0	86,412.5	4,381.7	24.6	59.2
f2	99.6	0.4	246	1.1	115,217.5	7,724.2	55.7	54.9
f3	36.4	0.3	136	0.6	57,760.0	3,389.6	59.8	50.2
g1	93.2	1.4	66	0.3	39,265.0	2,154.3	31.1	54.5
h1	116.5	0.3	385	1.7	98,590.0	7,122.9	44.6	63.1
i1	7.6	1.3	6	0.0	3,830.0	2,618.1	5.0	27.7
j1	387.9	0.4	960	4.3	404,155.0	6,246.5	34.4	55.5
j2	42.7	0.3	158	0.7	54,115.0	6,800.6	68.4	47.2
k1	226.1	1.0	227	1.0	115,515.0	3,604.7	28.5	62.6
k2	1,202.3	0.2	4,927	22.1	1,437,647.5	4,863.3	21.0	59.2
k3	617.4	0.4	1,490	6.7	414,982.5	5,394.5	41.7	61.0
l1	198.3	0.4	471	2.1	206,182.5	6,017.4	88.9	53.9

Table D.10.2-8 Baseline Fragmentation Metrics for Ecosite Phases in the LSA[1]

Ecosite	Total Area (ha)	Mean Patch Area (ha)	# of Patches	Patch Density (#/100^2 ha)	Perimeter (m)	Perimeter to Area Ratio	Mean Nearest Neighbor Distance (m)	Distribution (IJI Index)
AIF	54.7	0.9	59	0.3	36,890.0	1,243.6	295.3	52.8
AIG	34.9	1.7	21	0.1	9,165.0	962.6	733.1	57.7
AIH	372.0	4.3	87	0.4	523,302.5	3,380.1	113.4	59.9
AII	70.9	6.4	11	<0.1	12,590.0	392.7	243.5	48.8
CC	122.7	0.8	159	0.7	86,317.5	2,278.5	179.1	55.7
CIP	591.7	2.1	285	1.3	504,820.0	4,148.1	44.3	60.9
CIW	318.5	1.2	262	1.2	129,380.0	573.5	336.2	59.4
CL	613.0	0.9	711	3.2	2,049,925.0	6,872.0	38.1	56.0
CP	2,212.1	3.8	584	2.6	499,657.5	5,258.1	14.1	59.1
CPR	351.6	2.2	160	0.7	111,392.5	5,677.0	11.8	60.2
HG, HF	48.8	0.4	112	0.5	45,657.5	2,387.7	101.6	43.4
NMS	80.1	26.7	3	<0.1	15,040.0	404.7	3,273.5	38.7
NWL, NWR, NWF	716.5	2.3	318	1.4	133,410.0	6,715.5	105.1	56.2
SC	38.3	1.0	37	0.2	20,780.0	3,243.4	47.5	56.9
SO	59.5	1.7	35	0.2	21,470.0	2,596.7	153.2	64.3
Total	**22,330.7**		**26,672**					

[1] Vegetation data were converted from vector to raster format for use in FRAGSTATS, resulting in changes to the number of patches and area of ecosite phases. Results were used for fragmentation assessment only.

D.10.3 PREDICTED CONDITIONS

The environmental assessment for this Project includes an assessment of both the Application and the Planned Development Cases (PDC). As there are no other projects disclosed or planned for the RSA at this time, the Planned Development and Application Cases are essentially the same.

D.10.3.1 Terrestrial Vegetation Resources

The Project will remove all existing vegetation from the Project footprint during construction and operation. The area of ecosite phases that will be removed from the LSA are provided in CR #10, Table 5-1 and Figure 5-1.

Construction and operation of the Project will result in the removal of vegetation of approximately 2.7% (595.8 ha) of the LSA. As well, 9.7 ha of water features including flooded areas, ponds, and reservoirs will be removed by the Project. The remaining 207.2 ha of the footprint utilizes existing disturbance. Upland ecosites will be reduced by 3.7% (511.5 ha) and lowland ecosite phases will be reduced by 3% (84.3 ha) as a result of Project development. The d1 ecosite phase, which is the most abundant in the LSA, will be reduced by 3.9% (339.1 ha). The e3 ecosite phase, which is of limited distribution in the LSA as well as in the Boreal Mixedwood ecological region, will be reduced by 4% (0.9 ha). All but one of the wetland ecosites (j2 shrubby fen), will be reduced in area by 0.5 to 10% of baseline conditions. The k1 (treed rich fen) ecosite phase will be reduced by almost 10% (24.0 ha) from baseline conditions. Open water features (streams/rivers, flooded areas, lakes and ponds) will decrease in area by 1.5 ha from baseline conditions.

Approximately 0.3% of the vegetation resources including existing disturbance will be affected by the Project. Land cover classes that will be most affected by the Project include closed deciduous (571.4 ha) in upland areas, shrubby wetlands, and treed wetlands (CR #10, Table 5-2 and Figure 5-2).

CR #10, Table 6-1 provides a summary of impact assessment for assessed indicators in the LSA and RSA. Project-specific effects on terrestrial vegetation are expected to be low to moderate with mitigation. Residual 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 moderate, the probability of the effect is high, and the impact rating is no impact for ecosite phases, land cover classes, and species abundance.

The proposed end land use will return all disturbed areas to agricultural (improved pastures) use. The impact rating for all terrestrial vegetation resources are characterized as being no impact for habitat fragmentation, old growth forests, air emissions, species diversity, community diversity, and landscape diversity. Cumulative effects are characterized as being low impact for terrestrial vegetation including invasive and non-native vegetation species, rare plants, TEK vegetation and ecosites of limited distribution.

D.10.3.1.1 Potential Acid Input (PAI) and Nitrogen Deposition

The modelled baseline levels of PAI within the RSA range from 0.025 to 0.075 keq/ha/yr. The range of PAI shifts slightly to 0.025 to 0.10 keq/ha/yr when the Application Case model isopleths are overlain on the RSA map. The range of PAI within the RSA does not change between the Application Case and Project Development Case (PDC) models.

Baseline levels of PAI within the LSA range from 0.04 to 0.06 keq/ha/yr. This range shifts in the Application and Baseline Case models. The PAI does not exceed 0.1keq/ha/yr in either scenario.

There are no PAI isopleths that contain values that trigger critical load thresholds for the soils within the LSA or RSA across all modelled scenarios. The indirect impact to plants with respect to potential soil acidification can be considered negligible at the local and regional scale across all application assessment cases; consequently, PAI is not likely to affect vegetation within the LSA or RSA. Extending this to development scenarios, there is no change in levels of nitrogen deposition in either the RSA or LSA when the Application Case and PDC scenarios are examined.

CR #10, Table 6-1 gives a summary of impact assessment for acid input and nitrogen deposition in the LSA and RSA. Project 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 Project impact rating is no impact.

Cumulative effects likewise are characterized as being local in extent, extended in duration, continuous in frequency, reversible in the long term, of low magnitude, and having a neutral contribution. Overall, the impact rating is no impact.

D.10.3.2 Wetlands

The area of AWIS wetlands that will be affected in the LSA by the Project are presented in CR #10, Table 5-3 and Figure 5-3. Project construction and operation will remove 2.4% (85.9 ha) of the wetlands in the LSA. All wetland classes in the LSA will have some impact. Wooded fens with no internal lawns (FTNN) will be affected the most, with 6.4% (39.5 ha) being impacted. Project development will also impact 4.6% of shrub-dominated swamps with no patterning or permafrost present (SONS), 2.6% of open shrub-dominated fen (FONS), 1.4% of wooded coniferous swamp (STNN), and less than 1% of each of the remaining wetlands in the LSA.

The majority of wetlands affected by the Project are organic wetlands (Peatlands). This includes 39.5 ha of wooded fens and 32.5 ha of shrubby fens. To date there are no reported studies on the successful reclamation of organic wetlands such as bogs and fens (Raab and Bayley 2012, Rooney and Bayley 2011, Mitsch & Gosselink 2007). Organic wetlands are less likely to be reclaimed to their baseline conditions. The Project will remove 1 ha of marshes (MONG).

All four AWIS wetland types of limited distribution in the LSA will be affected by the Project. In total, wetland types of limited distribution make up 1.6% (367.8 ha) of the LSA. The Project will result in the removal of approximately 1.67% (6.1 ha) of wetland of limited distribution from the LSA. None of the AWIS wetland types of limited distribution will be completely removed from the LSA.

Wetland land cover classes in the RSA that will be affected by the Project are summarized in CR #10, Table 5-4. Because of the different classifications methods used for the RSA and LSA, the area of wetland that is removed at the RSA level is not equivalent to the area removed from the LSA. Project construction and operations will remove 31.7 ha (2.7%) of wetland area from the RSA. Shrubby wetlands and treed wetlands will be affected the most, with 15.8 and 15 ha respectively removed from the RSA during Project development and construction. At the regional level (RSA), treed wetlands (0.4%), sedge meadows (<0. 1%), and undifferentiated wetland areas (0.1%) are of limited distribution; they collectively occupy 0.5% of the RSA (CR #10, Table 4-7). Among them, only the treed wetlands will be affected, with approximately 2.1% of the existing treed wetlands being removed during Project development. Peatlands affected by the Project represent 3.1% (78.3 ha) of all peatlands in the LSA, and 0.4% (31 ha) of peatlands in the RSA.

CR #10, Table 6-1 provides a summary of impact assessment for assessed indicators in the LSA and RSA. Project effects are expected to be low with mitigation and monitoring. Residual effects are local in extent, extended in duration, continuous in frequency, reversible in the long term for majority of the wetlands that will be affected, of low magnitude, and have a neutral contribution. The confidence rating of the assessment is moderate because of the uncertainty in reclaiming wetlands (peatlands especially), the probability of the effect is high, and the impact rating is low because of the uncertainty surrounding reclamation of disturbed wetlands into functioning wetlands. The area of wetlands that will be disturbed is relatively low.

Cumulative effects are characterized as being regional in extent, extended in duration, residual in frequency, irreversible in the long term, of high magnitude, and having a negative contribution. The confidence rating is high and the probability of occurrence is high. The final impact rating is moderate because naturally existing wetlands will be lost as the majority of the disturbed area will be padded over and converted to pasture.

D.10.3.3 Ecosite Phases of Limited Distribution

Project development will impact 10 of the 15 ecosite phases of limited distribution in the LSA. The total area of ecosite phases of limited distribution in the LSA that will be affected by the Project is 15.7 ha. This area includes b1, c1, d3, e3, f1, f2, g1, h1, i1, and l1 ecosite phases. None of these ecosite phases will be completely removed from the LSA (CR #10, Table 5-5). Following decommissioning and reclamation, disturbed ecosite phases of limited distribution will be reclaimed to improved pastures.

CR #10, Table 6-1 provides a summary of impact assessment for assessed indicators in the LSA and RSA. With the implementation of the mitigation and monitoring measures proposed, the Project is expected to have a local effect on ecosites of limited distribution. The duration of the

effect will be extended, the frequency will be isolated. The effect is reversible in the long term, of low magnitude and will have a neutral contribution. The probability of occurrence is high. Overall, the Project impact rating is low.

Cumulative effects are characterized as being local in extent, extended in duration, isolated, reversible in the long term, of low magnitude, and having a negative contribution because the areas that will be removed will be reclaimed to improved pastures. However not all ecosite phases of limited distribution will be removed from the LSA. The confidence rating and the probability of the effect are high (CR #10, Table 6-1). Overall, the Project impact rating is low.

D.10.3.4 Rare Plants, Rare Plant Potential and Rare Plant Communities

Construction and operation of the Project will result in the removal of all rare plants observed within the Project footprint (CR #10, Table 5-6). Two plant species that appear on Alberta's list of tracked elements (eight occurrences) were observed within the Project footprint. Sixteen rare species identified in the LSA are also listed as "at Risk, may be at Risk and Sensitive" by ESRD. A total of thirty eight plant species identified are listed on the ESRD list. There are no species listed in Schedule 1 of the federal Species at Risk Act (SARA) or listed as at risk by COSEWIC.

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 locations of the lichens are approximate and mark the starting point for the rare plant wanders (CR #10, Sections 3.4 and 4.4) that may cover up to 100 m^2 or more.

Within the wander, the surveyors selected one or two representative areas and sample for small inconspicuous species. This involved crawling on hands and knees and collecting anything that could not be identified. Because this level of sampling is generally not done outside of academic studies, and the results are not consistently reported to tracking bodies (*i.e.*, ACIMS), reports of abundance and distribution of these species is at best incomplete (NatureServe 2012). The 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). It is difficult to determine if the 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.

The multiple occurrences of several of the species supports the conclusion that many of these small inconspicuous species present on the tracking lists may in fact be more prevalent than thought. Because it is not possible to identify these species in the field, and they often have specific microclimate requirements, transplanting is not an option. Modification of the Project footprint is also not practical as subsequent rare plant searches, if conducted in the same way, would likely find more examples of these small inconspicuous and underreported species.

The potential of each ecosite phase observed in the study areas to support rare plants is presented in CR #10, Section 4.4.2. Most of the ecosite phases in the LSA have low to moderate potential to support rare plants. Construction and operation of the Project will result in the removal and

reduction of 2.6% (361.1 ha) of ecosite phases with high rare plant potential in the LSA and 0.7% in the RSA.

CR #10, Table 6-1 provides a summary of impact assessment for assessed indicators in the LSA. The Project effects on rare plants are local in extent, extended in duration, isolated in frequency, reversible in the long term, initially of low magnitude, and have a neutral contribution. The confidence rating of the assessment is high, the probability of the effect is high. The final impact rating is no impact.

Cumulative effects likewise are characterized as being regional in extent, extended in duration, isolated in frequency, reversible in the long term, of moderate magnitude relative to the RSA, and having a negative contribution. The final impact rating is low because the actual area of ecosite phases with very high potential for rare plant occurrence that will be cleared during construction is low relative to the total area of the footprint that will be cleared.

D.10.3.5 Traditional Ecological Knowledge Vegetation

All ecosite phases within the LSA can support TEK vegetation used for food (berries), medicine or other uses. Most of the ecosite phases which are limited in distribution locally have a high or moderate potential to support TEK vegetation (CR #10, Table 4-15 and Figure 5-5).

Some vegetation species, including those used for medicine or food, are sensitive to anthropogenic atmospheric gases such as tropospheric ozone (Brace *et al.*, 1999). The greatest impact in regard to TEK vegetation may be completely removing ecosite phases in the LSA which are already limited in distribution. None of the ecosites of limited distribution will be completely removed from the LSA.

TEK vegetation was not assessed within the RSA. It is assumed that ecosite phases within the RSA are similar in composition and distribution as those in the LSA.

D.10.3.6 Old Growth Forests and Old Growth Potential

Within the LSA, construction and operation of the Project will result in the removal of 2.0% (449.6 ha) of ecosite phases with high potential to support old growth forests, and 98 ha of ecosite phases with moderate potential. In the RSA, this will result in the removal of 0.2% of land cover classes with high potential to support old growth, and <0.1% with moderate potential.

The amount of ecosite phases with high potential to support old growth forests that are to be removed from the LSA is small compared to the total area of ecosite phases with a high old growth potential in the LSA. The removed ecosite phases will not have an effect on the ability of forests in the area to become old growth forest stands.

CR #10, Table 6-1 provides a summary of impact assessment for assessed indicators in the LSA and RSA. Within the LSA, Project effects on old growth stands are related to the reduction in ecosite phases with the potential to support the development of old growth forest stands. Given that the majority of the LSA and RSA has no existing old growth forests as well as a low to moderate potential to support the development of old growth forests, the Project is expected to

have a negligible effect on old growth forests. Residual effects are local in extent, extended in duration, isolated in frequency, reversible in the long term, of low magnitude, and have a neutral contribution. The confidence rating of the assessment is moderate, the probability of the effect is high, and overall, the Project impact rating is no impact.

Cumulative effects likewise are characterized as being local in extent, extended in duration, isolated in frequency, reversible in the long term, of low magnitude, and having a neutral contribution. The Project impact rating is no impact.

D.10.3.7 Non-native and Invasive Species

Four noxious weed species were found in the LSA. Construction and operations activities may increase the spread and establishment of these species into areas adjacent to disturbed sites. With mitigation (including the implementation of an aggressive weed management and monitoring program), the Project is not expected to have a local or regional effect on the establishment and spread of non-native and invasive species.

CR #10, Table 6-1 provides a summary of impact assessment for assessed indicators in the LSA and RSA. With mitigation, 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 the Project impact rating is no impact.

Cumulative effects likewise are characterized as being local in extent, extended in duration, periodic in frequency, reversible in the long term, of low magnitude, and having a negative contribution. Overall, the Project impact rating is low.

D.10.3.8 Habitat Fragmentation

CR #10, Table 5-7 shows the predicted Project effects related to fragmentation within the LSA. Fragmentation in the LSA will increase because of the Project. The mean area per patch (ecosite phase) type will decrease while the number of patches will increase for those patch types that are affected by the Project. CR #10, Table 5-8 shows the Application Case effects related to fragmentation within the RSA. Overall, the Project will result in an increase in the number of patches and a decrease in patch area per land cover class in the RSA. Following closure and reclamation, fragmentation will decrease as larger patches than present at baseline will be revegetated for grazing use.

Project-specific effects on habitat fragmentation are expected to be minimal with mitigation due to the level of fragmentation that is presently on the landscape. For both the LSA and RSA, Project effects on habitat fragmentation are related to the reduction in patch types and sizes during Project construction and operations. Residual 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 the impact rating is no impact due to the large proportion of pastures which are present at baseline.

Cumulative effects predicted to be local in extent, extended in duration, continuous in frequency, reversible in the long term, of low magnitude, and having a negative contribution to patch type distribution (permanent loss of natural areas (ecosite phases) to grazing areas. The confidence rating of the assessment is high, the probability of the effect is certain. The final impact rating is no impact.

D.10.3.9 Biodiversity

The biodiversity VEC was assessed at three levels, including species biodiversity, community biodiversity, and landscape biodiversity. CR #10, Table 6-1 provides a summary of impact assessment for assessed indicators in the LSA and RSA.

D.10.3.9.1 Species Level Biodiversity

Construction and operation of the Project will result in the removal of all vegetation from the footprint resulting in reduced species level biodiversity in the LSA and RSA. After closure, species richness is expected to be lower than naturally developing ecosites. The current reclamation practice is to seed a limited number of native seed types that would quickly establish in order to stabilize reconstructed soils and to minimize sedimentation. The majority of the footprint will be reclaimed to pasture and agricultural end uses.

Potential Project effects are related to the reduction of species diversity resulting from vegetation clearing during construction and operation of the Project. With mitigation, residual 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 moderate, the probability of the effect is high, and the final impact rating is low impact because natural vegetation communities will not be reclaimed to their predisturbance conditions but to an agricultural end land use.

Cumulative effects likewise are characterized as being local in extent, extended in duration, continuous in frequency, reversible in the long term, of moderate magnitude, and having a neutral contribution. The confidence rating of the assessment is moderate and the probability of the effect is high. The final impact rating for species biodiversity is no impact.

D.10.3.9.2 Community Level Biodiversity

Considering both vascular and non-vascular species richness, construction and operation will result in the removal of 9.5% of the ecosite phases with high biodiversity potential in the LSA (CR #10, Figure 5-6, and 2.6% in the RSA (CR #10, Figure 5-7). Measures taken to mitigate the reduction in area of terrestrial vegetation, wetlands, and potential increase in non-native and invasive species will effectively mitigate for potential Project effects on community level biodiversity.

Potential Project effects are related to the reduction of community diversity resulting from the removal of ecosite phases from the LSA during construction and operation of the Project (CR #10, Figure 5-1). With mitigation, residual 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 moderate, the probability of the effect is high, and the impact rating is no impact. This rating is arrived at because none of the ecosite phases will be completely removed from LSA as a result of the Project.

Cumulative effects likewise are characterized as being local in extent, extended in duration, continuous in frequency, reversible in the long term, of moderate magnitude, and having a neutral contribution. The confidence rating of the assessment is moderate, the probability of the effect is high, and the impact rating is no impact.

D.10.3.9.3 Landscape Level Biodiversity

Fragmentation was considered in the assessment of landscape level biodiversity (CR #10, Section 4.8, 5.8). The Project will lead to increased fragmentation as the number of patches in the LSA increases while mean patch area decreases (CR #10, Table 5-9). Landscape diversity remains similar after the Project was assessed.

Regionally, the Project will have a negligible impact on community level biodiversity as the most impacted ecosite phase is common in the region. Although the Project will result in the removal of ecosite phases that are locally and regionally limited in distribution, the proportion of the ecosite phases that will be impacted is small.

Potential Project effects are related to the reduction in landscape diversity resulting from removal or alteration of land cover units in the RSA during construction and operation of the Project (CR #10, Figure 5-2). With mitigation, residual 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 the impact rating is no impact.

Cumulative effects likewise are characterized as being local in extent, extended in duration, continuous in frequency, reversible in the long term, of low magnitude, and having a neutral contribution. The confidence rating of the assessment is high, the probability of the effect is high, and the impact rating is no impact.

D.10.4 MITIGATION AND MONITORING

D.10.4.1 Mitigation

Disturbed lands will be reclaimed to achieve land capability suitable for the desired end land use of improved pasture. The reclaimed areas will be re-vegetated with a weed-free seed mixture suitable for pasture, as determined in consultation between Pengrowth, land managers, and ESRD reclamation specialists. A portion of the Project footprint is on private land and will be reclaimed to equivalent capability, likely to an agricultural end use.

The following documents and any other available updates/resources will be consulted:

- A Guide to Using Native Plants on Disturbed Lands (Gerling et al., 1996);
- Native Plant Re-vegetation Guidelines for Alberta (NPWG 2000);

- Reclamation Criteria for Wellsites and Associated Facilities for Cultivated lands (AENV 2010b); and
- Reclamation Criteria for Wellsites and Associated Facilities Application Guidelines (AENV 2011).

Based on above guidelines and criteria, mitigation measures for vegetation resources will include but will not be limited to the following:

- During Project development and construction:
  - preserving adjacent habitat by minimizing the area required for construction and operation of the Project;
  - preserving and maintaining landscape features and drainage patterns in order to preserve the integrity of undisturbed ecosites, including wetlands (CR #10, Section 5.2.3), outside of the Project Footprint;
  - reducing wetlands losses by creating new wetland features where feasible from abandoned associated facilities (*e.g.*, borrow pits and sumps) following the 2010 Reclamation Criteria for Wellsites and Associated Facilities Application Guidelines (AENV 2011) and the Guidelines for Wetland Establishment on Reclaimed Oil Sands Leases (CEMA 2007);
  - re-contouring to provide appropriate nutrient substrates and soil moisture for plant regeneration within different site conditions on the landscapes; and
  - where possible, avoiding or minimising disturbance in areas of valued vegetation resource *e.g.*, locations of rare species, Traditional Ecological Knowledge (TEK) species, and wetland areas;
    - Re-vegetation and reclamation programs:
  - developing re-vegetation plans, following the Native Plant Revegetation Guidelines for Alberta (NPWG 2000), that will promote the long term establishment of healthy grazing areas and ingress of native species where appropriate;
  - using appropriate seed mixes, determined in consultation with Pengrowth, land managers and ESRD, for the intended end land use of livestock grazing; and
  - enhancing the presence and abundance of traditional use species by increasing planting/seeding densities or using density-promoting re-vegetation techniques on any target ecosites that may be reclaimed to equivalent land capability. Targeted species should support berry plants (*e.g.*, blueberry, cranberry, raspberry *etc.*) and medicinal plants (*e.g.*, rat root, mint *etc.*), in order to increase reclamation success for traditional land use (CR #10, Section 5.5).

D.10.4.2 Monitoring

Indicators for re-vegetation success and methods for monitoring re-vegetation performers will be derived from the 2010 Reclamation Criteria for Wellsites and Associated Facilities for Cultivated lands (AENV, 2010b). Based on the above criteria, monitoring of re-vegetation and reclamation sites will include but will not be limited to the following:

- assessing the landscape features, vegetation and soils in following the 2010 cultivated criteria for assessing re-vegetation and reclamation success;
- performing survival, growth and health assessments of re-vegetated areas to monitor the effectiveness of re-vegetation targets;
- implementing strategies for avoiding herbaceous competition; and
- conducting rare plant surveys on any new proposed development areas not included in this report.

Pengrowth will develop appropriate vegetation and wetland monitoring programs in consultation with provincial regulators and regional stakeholders once the Project has been approved. These programs will allow for adaptive management strategies to be incorporated. During the life of the Project, reclamation of developed areas that are no longer required will be ongoing. Final reclamation design will be completed in consultation with ESRD and local stakeholders. Reclamation strategies are described in greater detail in the C&R Plan for the Project (Pengrowth 2013).

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.10.5-1.

Table D.10.5-1 Summary of Impact Rating on Residual Effects for Vegetation and Wetland VECs

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. Terrestrial Vegetation											
Reduction in area	Yes	Application	Local	Extended	Continuous	Reversible Long Term	Low	Neutral	Moderate	High	No impact
		Cumulative	Regional	Extended	Residual	Irreversible[10] Long Term	Moderate	Negative	Moderate	High	Low
2. Wetlands											
Reduction in Area	Yes	Application	Local	Extended	Continuous	Reversible Long Term	Low	Neutral to negative	Moderate	High	Low
		Cumulative	Regional	Extended	Residual	Irreversible[11] Long Term	High	Negative	Moderate	High	Moderate
3. Old Growth Forests											
Removal of areas with high Old Growth forest potential	Yes	Application	Local	Extended	Isolated	Reversible Long Term	Low	Neutral	Moderate	High	No impact
		Cumulative	Local	Extended	Isolated	Reversible Long Term	Low	Neutral	High	High	No impact
4. Ecosite Phases of Limited Distribution											
Reduction in Area	Yes	Application	Local	Extended	Isolated	Reversible Long Term	Low	Neutral	High	High	Low
		Cumulative	Local	Extended	Isolated	Reversible Long Term	Low	Negative	High	High	Low

Table D.10.5-1 Summary of Impact Rating on Residual Effects for Vegetation and Wetland VECs

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]
5. Rare Plants											
Removal from Project footprint	Yes	Application	Local	Extended	Isolated	Reversible Long Term	Low	Neutral	High	High	No impact
		Cumulative	Regional	Extended	Isolated	Reversible Long Term	Moderate	Negative	High	High	Low
6. Non-Native and Invasive Species											
Invasions into cleared areas in the Project footprint	Yes	Application	Local	Extended	Periodic	Reversible Long Term	Low	Neutral	High	High	No impact
		Cumulative	Local	Extended	Periodic	Reversible Long Term	Low	Negative	High	High	Low
7. Traditionally Used Plants											
Removed from Project footprint	Yes	Application	Local	Extended	Continuous	Reversible Long Term	Low	Neutral	High	High	Low
		Cumulative	Local	Extended	Continuous	Reversible Long Term	Low	Neutral	High	High	Low
8. Air emissions											
Effect on vegetation	Yes	Application	Local	Extended	Continuous	Reversible Long Term	Low	Neutral	High	High	No impact
		Cumulative	Local	Extended	Continuous	Reversible Long Term	Low	Neutral	High	High	No impact

Table D.10.5-1 Summary of Impact Rating on Residual Effects for Vegetation and Wetland VECs

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]
9. Habitat Fragmentation											
Fragmentation	Yes	Application	Local	Extended	Continuous	Reversible Long Term	Low	Neutral	High	High	No impact
		Cumulative	Local	Extended	Continuous	Reversible Long Term	Low	Neutral	High	High	No impact
9. Biodiversity											
Reduction in Genetic-Species Diversity	Yes	Application	Local	Extended	Continuous	Reversible Long Term	Low	Neutral	Moderate	High	Low
		Cumulative	Local	Extended	Continuous	Reversible Long Term	Moderate	Neutral	High	High	No impact
Reduction of Community Diversity	Yes	Application	Local	Extended	Continuous	Reversible Long Term	Low	Neutral	Moderate	High	No impact
		Cumulative	Local	Extended	Continuous	Reversible Long Term	Moderate	Neutral	High	High	No impact
Reduction of Landscape Diversity	Yes	Application	Local	Extended	Continuous	Reversible Long Term	Low	Neutral	High	High	No impact
		Cumulative	Local	Extended	Continuous	Reversible Long Term	Low	Neutral	High	High	No impact

1. Local, Regional, Provincial, National, Global
2. Short, Long, Extended, Residual
3. Continuous, Isolated, Periodic, Occasional
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
10. Deemed irreversible because a large portion of natural vegetation in the LSA is permanently being converted to grazing lands
11. Deemed irreversible because peatlands (majority of the wetlands) have not been shown to be successfully reclaimed to pre-development conditions

D.11 WILDLIFE

Pengrowth conducted a wildlife assessment for the proposed Project. 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 the Project on December 13, 2013. 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 General Status of Alberta Wild Species (Alberta Environment and 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 map existing wildlife habitat and habitat disturbance including exploration activities. Identify habitat disturbances that are related to existing and approved projects.

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;*
- *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) potential effects on wildlife resulting from changes to air and water quality, including both acute and chronic effects to animal health; and*
- *d) potential effects on wildlife from the Proponent's proposed and planned exploration, seismic and core hole activities, including monitoring/4D seismic.*

[B]. Identify the key wildlife and habitat indicators used to assess Project impacts. Discuss the rationale for their selection.

The LSA boundary established for the wildlife assessment occupies 22,330.8 ha of land (CR #11, Figure 3-1). The LSA is slightly larger than Pengrowth's Lindberg lease (18,863.9 ha), as it includes an additional 500 m zone that was established around the lease boundary to account for potential direct and indirect effects of Project development on wildlife and wildlife habitat adjacent to the lease. The LSA also contains portions of two identified Environmentally Significant Areas (ESAs #484 and #488).

The regional study area (RSA) was defined as the area within 16 km of the LSA boundary, covering a total of 198,091.5 ha (CR #11, Figure 4-1). This RSA was also used for the soils, vegetation, and biodiversity components of the EIA. Beyond the RSA, Project-related effects on wildlife are not expected.

Various sources of existing information were reviewed to obtain background information on the lease area and surrounding region including:

- Fish and Wildlife Management Information System (FWMIS);
- Alberta Biodiversity Monitoring Institute (ABMI);
- Federation of Alberta Naturalists (FAN);
- Committee on the Status of Endangered Wildlife in Canada (COSEWIC);
- published species habitat use accounts and distribution maps; and
- various environmental assessments.

In accordance with current practice in Alberta, the wildlife assessment focused on a number of wildlife species that were selected as Valued Environmental Components (VECs). Based on this approach, 10 wildlife VECs comprised of one amphibian, five mammalian, and four avian species/ groups were selected for the wildlife assessment. These were further subdivided into four "valued species" (moose, beaver, fisher, and lynx) and six "Species at Risk" (Canadian toad, northern myotis, barred owl, yellow rail, old-growth forest bird community, and mixedwood forest bird community) (CR #11, Table 4-3).

D.11.1 BASELINE CONDITIONS

D.11.1.1 Habitat Availability

Fourteen habitat types comprised of 29 natural and 10 anthropogenic ecosite phases were identified in the LSA at baseline (CR #11, Table D.11.2-1, Figure 3-1). At a landscape level, upland communities (ecosite phases a to h) occupy 70% (15,631.5 ha) of the LSA while lowland communities (ecosite phases i to l) occupy 30% (6,699.2 ha). Based on tree-coring data collected in 2013, the LSA does not contain old-growth forest habitat although there are 541 ha of mature forest that has the potential of reaching old-growth status in the absence of any disturbance.

Table D.11.1-1 Wildlife Habitat Types and Ecosite Phases Present in the LSA

Habitat Type	Ecosite Phase	Ecological Site Description of Dominant Cover	Total Area (ha)	% of Total Area
Jack Pine	***a1***	***Lichen/jack pine***	***5.9***	***0.0***
Deciduous	b2	Blueberry/aspen (paper birch)	1.2	0.0
	d1	Low-bush cranberry/aspen	8,807.6	39.4
	e1	Dogwood/paper birch-aspen	2,743.9	12.3
	f1	Horsetail/balsam poplar-aspen	169.3	0.7

Table D.11.1-1 Wildlife Habitat Types and Ecosite Phases Present in the LSA

Habitat Type	Ecosite Phase	Ecological Site Description of Dominant Cover	Total Area (ha)	% of Total Area
Sub-total Deciduous			***11,722.0***	***52.5***
Mixedwood	b1	Blueberry/jack pine–aspen	126.4	0.6
	d2	Low bush cranberry/aspen–white spruce	1,141.1	5.1
	e2	Dogwood/paper birch–white spruce	420.5	1.9
Sub-total Mixedwood			***1,688.0***	***7.6***
White Spruce	d3	Low bush cranberry/white spruce	5.1	0.0
	e3	Dogwood/white spruce	22.5	0.1
	f3	Horsetail/white spruce	35.7	0.2
Sub-total White Spruce			***63.3***	***0.3***
Mixed Coniferous	b4	Blueberry/white spruce–jack pine	0.5	0.0
	c1	Labrador tea-mesic/jack pine-black spruce	30.4	0.1
	f2	Horsetail/paper birch–white spruce	102.6	0.5
	g1	Labrador tea-subhygric/black spruce–jack pine	92.7	0.4
	h1	Labrador tea-horsetail/white spruce–black spruce	107.0	0.4
Sub-total Mixed Coniferous			***333.2***	***1.5***
Lowland Shrub	j2	Shrubby poor fen	48.9	0.2
	k2	Shrubby rich fen	1,289.5	5.8
Sub-total Lowland Shrub			***1,338.4***	***6.0***
Lowland Treed	i1	Treed bog	8.9	0.0
	j1	Treed poor fen	374.1	1.7
	k1	Treed rich fen	242.3	1.1
Sub-total Lowland Treed			***625.3***	***2.8***
Sedge Meadow	k3	Graminoid rich fen	656.2	2.9
Upland Meadow	HF, HG	Upland meadow	45.4	0.2
Upland Shrub	SC, SO	Upland shrub	116.8	0.5
Sand	NMS	Sand	72.7	0.3
Marsh	l1	Marsh	209.6	0.9
Water Body	Water	Streams, ponds, and flooded areas	711.1	3.2
Disturbed	AIF, AIG, AIH, AII, CC, CIP, CIW, CL, CP, CPR	Areas of anthropogenic disturbance	4,742.9	21.2
Sub-total Disturbed			***4,742.9***	***21.2***
Totals			***22,330.8***	***100.0***

Deciduous habitat is the most abundant natural type in the LSA accounting for 52.5% (11,722.0 ha) of the LSA, with mixedwood habitat being the second most abundant natural type (CR #11, Table 3-1). Lowland shrub habitat is the third most abundant natural habitat type occupying 6.0% (1,338.4 ha) of the LSA. The remaining 10 natural habitat types comprise 12.6% of the LSA combined.

D.11.1.2 Wildlife Health

Wildlife health was assessed on the basis of the air quality assessment (CR #1) and a screening level wildlife risk assessment (CR #4, Appendix D) was conducted for the Project. These assessments indicate that threats to wildlife health as a result of Project-related emissions are very low.

D.11.1.3 Wildlife Diversity

Landscape wildlife diversity under baseline conditions was assessed at the LSA and RSA scales. (CR #11, Table 5-3, Figures 5-1 and 5-2). Based on field data and a review of range distribution maps, 240 wildlife species could potential occur in the LSA and RSA. High quality habitat was primarily composed of mixedwood (102 species), mixed coniferous (93 species), white spruce (89 species), and deciduous (85 species) habitats (CR #11, Appendix C and Table C1-1). A total of 97 species were considered to use some disturbance feature present in the LSA and RSA. Individually, disturbances (both natural and anthropogenic) represent the largest portion of the low biodiversity habitat, although urban areas were expected to support moderate-low numbers (14 to 38) of species.

Table D.11.2-2 Wildlife Diversity in the LSA and RSA Under Baseline Conditions

Diversity Rating	No. of Species	LSA		RSA	
		Area (ha)	% of LSA	Area (ha)	% of RSA
Low	0-13	487.3	2.2	2,540.4	1.3
Moderate-low	14-38	2,296.1	10.3	10,195.5	5.1
Moderate	39-63	4713.2	21.1	61,828.2	31.2
Moderate-high	64-89	13,155.5	58.9	122,446.0	61.8
High	90-148	1,678.7	7.5	1,081.4	0.5
Totals[1]		**22,330.8**	**100.0**	**198,091.5**	**100.0**

[1] Due to rounding of values, totals may not equal the sum of the individual values presented in the table.

D.11.1.4 Canadian Toad

At baseline, the LSA contains 2,776.6 ha (12.4%) of effective breeding habitat for Canadian toads (CR #11, Table 5-4 and Figure 5-3). High quality breeding habitat was limited to water bodies and marshes and only accounted for 4.1% of the LSA. Only 15.0% (29,712.8 ha) of the RSA was classified as effective toad breeding habitat (CR #11, Table 5-4 and Figure 5-4).

Potential hibernation habitat was considered to be upland sites containing sparse tree cover and sandy soils (ecosite phases a1, b1, and b4) within 1.5 km of watercourses or wetlands. Based on these requirements, only <0.1% (132.8 ha) of the LSA provides suitable over-wintering habitat for Canadian toads (CR #11, Figure 5-5). Potential hibernation habitat is slightly more abundant within the RSA at 1.1% (2,170.8 ha; CR #11, Figure 5-6).

The risk of Canadian toad mortality from anthropogenic disturbances is low within the LSA under baseline conditions. No Canadian toads were detected during the amphibian surveys conducted in the LSA. If present, they likely occur at a very low density.

D.11.1.5 Mixedwood Forest Bird Community

Mixedwood forests support a high density and diversity of birds because these forests tend to have greater vegetation and structural diversity relative to pure stands (Westworth and Telfer 1993). The ecosite phases that were classified as mixedwood forest included b1, b3, d2, e3, and f2.

The birds considered to be representative of mixedwood forests here included boreal owl, yellow-bellied sapsucker, pileated woodpecker (provincially "Sensitive"), blue jay, brown creeper (provincially "Sensitive"), red-breasted nuthatch, black-capped chickadee, winter wren, blue-headed vireo, magnolia warbler, Cape May warbler (provincially "Sensitive", black-throated green warbler (provincially "Sensitive"), Canada warbler (provincially "Sensitive", federally "Threatened"), western tanager (provincially "Sensitive"), rose-breasted grosbeak and white-winged crossbill (Westworth and Telfer 1993).

Effective mixedwood forest bird community habitat was uncommon in the LSA (7.5%) and RSA (<0.1%) level at baseline (CR #11, Table 5-5, Figures 5-7 and 5-8). High-quality breeding habitat for the mixedwood forest bird community is limited in the LSA and RSA. The LSA and RSA are both largely fragmented at baseline by existing anthropogenic activity, largely associated with agriculture, rural residential, and oil and gas developments.

Aside from predation, the risk of mixedwood forest bird mortality resulting from anthropogenic disturbances is low in the LSA under baseline conditions. Mortality risks from bird collisions with towers and other structures (Taylor 1973, James 1998, Ghalambor *et al.*, 1999, Hejl *et al.*, 2002, Walters *et al.*, 2002, Wyatt and Francis 2002,) and road salting (Benkman 2012) would be expected to be higher in the RSA because of the higher level of anthropogenic activity.

Some representative mixedwood species recorded in the LSA included four yellow-bellied sapsuckers, two blue jays, one red-breasted nuthatch, eight black-capped chickadees, five blue-headed vireos, three Cape May warblers, one western tanager, and 19 rose-breasted grosbeaks. Similar species are expected to occur in the RSA.

D.11.1.6 Old Growth Forest Bird Community

The complex forest structure of old-growth forests provides a variety of niches for birds not available in other forest types and can also allow for increased reproductive success, reduced predation and increased foraging opportunities (Norton 1999, Norton 2001). The old-growth

forest bird community considered here consisted of bay-breasted warbler (provincially "Sensitive"), black-throated green warbler (provincially "Sensitive"), brown creeper (provincially "Sensitive"), Cape May warbler (provincially "Sensitive"), golden-crowned kinglet, red-breasted nuthatch, western tanager (provincially "Sensitive"), white-winged crossbill and winter wren. The ecosite phases that were classified as having old-growth forest potential included c1, j1, d1 and d2.

Tree core data from the LSA suggests that there is likely no 'true' old growth forest present, but there are a number of mature stands, as indicated by the structural stage data. Effective habitat for the old-growth forest bird community was limited in the LSA (2.9%) but potential old-growth habitat was widely available at the RSA (46.4%) level under baseline conditions (CR #11, Table 5-6, Figures 5-9 and 5-10).

There are 132 patches of mature forest stands within the LSA at baseline, ranging in size from <0.1 to 313.7 ha; only 11 patches were ≥5 ha. Given the size and spacing of patches, it is unlikely that many individual old-growth forest bird species would travel between these during the breeding season.

Like the mixedwood forest bird community, the only source of mortality in the LSA is likely associated with predation at baseline. Mortality risks from bird collisions with towers and other structures (Taylor 1973, James 1998, Ghalambor *et al.* 1999, Hejl *et al.* 2002b, Walters *et al.* 2002, Wyatt and Francis 2002,) and road salting (Benkman 1992) is likely higher in the RSA because of higher levels of anthropogenic activity.

It is unlikely that the old-growth bird community would be abundant at baseline because the LSA is highly fragmented, and only small fragmented patches of old-growth exist. During the breeding songbird surveys, only two bay-breasted warbler, one black-throated green warbler, and one western tanager were detected. Old-growth bird abundance is likely higher in the RSA where larger, more contiguous patches of old-growth occur, particularly in areas located away from rural residential and industrial developments.

D.11.1.7 Barred Owl

The greater structural complexity associated with mixedwood forests creates suitable forage habitat for forest owls (Mazur *et al.,* 1998) because of higher prey diversity and abundance relative to other habitats (Olsen *et al.*, 2006). Barred owls usually require large, unfragmented areas of forest for breeding and sufficient canopy cover for flightless owlets (Olsen 2005).

Effective barred owl breeding habitat was fairly abundant in the LSA (53%), but slightly less so in the RSA (46%; CR #11, Table 5-7, Figures 5-11 and 5-12). Deciduous forest was widely distributed in the LSA but was highly fragmented, with linear feature densities of 5.26 km/km^2 at baseline. Barred owls were detected within the LSA, but at low densities (0.03 individuals/km^2).

Under baseline conditions, there were no significant anthropogenic landscape features or disturbances that affected barred owl movements in the LSA or RSA.

Mid-flight collisions with tall structure (*e.g.*, towers) and vehicular collisions are the only anthropogenic sources of mortality risk.

Barred owl densities are relatively low in the LSA (0.03 individuals/km^2), possibly due to the high degree of fragmentation. In addition to the direct habitat loss, indirect habitat loss associated with existing sensory disturbances (*e.g.*, noise from industrial development, noise and light from vehicles) may also contribute to the low numbers.

D.11.1.8 Yellow Rail

Yellow rails are associated with emergent-dominated wetlands, preferring sedge- and grass-dominated wetlands for breeding. Wet meadows of ≥15 ha are preferential, with breeding sites that remain wet throughout the breeding period (water depths often <20 cm)(Bookhout 1995, Robert *et al.*, 2000, Goldade *et al.*, 2002, Wilson 2005).

Because yellow rails have very specific habitat requirements (sedge meadows), only 7.9% of the LSA and 3.2% of the RSA represents effective breeding habitat at baseline (CR #11, Table 5-8, CR #11, Figures 5-13 and 5-14). Yellow rail breeding habitat patches ≥15 ha were sparse, represented by only eight patches comprising 1.7% of the LSA (CR #11, Table 5-9). Similarly, only 46 core habitat patches for yellow rail were identified in the RSA, accounting for only 1.3 % of the area.

The LSA is highly fragmented by linear features, many of which can act as movement barriers for ground-nesting species like the yellow rail. Yellow rails are present in the LSA, indicating that they are able to accommodate existing baseline levels of disturbance.

As ground-nesters, predation is the largest source of mortality risk for yellow rails. Generally, it is thought that anthropogenic sources of yellow rail mortality risk are low.

There was only a single incidental yellow rail observation in the LSA. The small patch size and wide distribution of wet meadows in the LSA suggest that yellow rails occur but only at a low density.

D.11.1.9 Fisher

The fisher is classified as “Sensitive” in Alberta because of uncertainty in population trends, potential reduction in preferred habitat, and declines in harvest since 1985. Fisher were detected in the LSA during the 2012 winter track survey, and are known to occur in the region based on FWMIS and trapping records.

Fisher prefer mature to old-growth forests, which are used for foraging, resting and denning (Buskirk *et al.*, 1994). Optimal fisher habitat includes dense old coniferous and mixedwood forest stands with continuous canopy closure (Powell 1993) characterized by at least 50% closure but with a preference for 70 to 80% (Kelly 1977). Effective fisher winter habitat was limited, comprising only 6.4% of the LSA and 0.8% of the RSA (CR #11, Table 5-10). Effective winter habitat for fisher was scattered throughout the LSA and RSA (CR #11, Figures 5-15 and 5-16).

Fishers tend to occupy relatively large home ranges of 8 to 32 km^2 for females and 16 to 50 km^2 for males (Banci 1989, Powell and Zielinski 1994). With consideration of the highly fragmented nature of habitats in the LSA and RSA, movements of fisher are not expected to be affected too much under baseline conditions.

Under baseline conditions, there are a number of traplines present in the LSA that have basic quotas of six fishers/trapper (ESRD 2013e). Trapping is likely the main source of mortality risk to fisher in the region.

There were 20 fisher observations during the 2011 winter tracking in the southwest portion of the LSA. In addition to historical trapping records of fisher in the area, fisher occur in the LSA but likely at low densities at baseline.

D.11.1.10 Beaver

Beavers occur throughout Alberta (Pattie and Fisher 1999, ASRD 2010) and are considered "Secure" at both the provincial and federal levels. Beavers prefer water bodies that are ≥1.5 m deep and may travel up to 200 to 250 m to forage (Skinner 1984, Nietfeld *et al.* 1985, Mueller-Schwarze and Sun 2003).

Effective habitat for beaver was relatively abundant and widely distributed throughout the LSA (24.8%; CR #11, Table 5-11, Figure 5-17) and in the RSA scale (29.3%; CR #11, Table 5-11, Figure 5-18) at baseline. Because effective beaver habitat is restricted to water bodies with suitable adjacent foraging habitat, most of the LSA (75.2%) and RSA (70.7%) was classified as unsuitable or non-effective habitat.

Beaver movements are likely affected to some extent by the proximity of effective beaver habitat to existing highways and rural and industrial developments under baseline conditions at both the LSA and RSA scales.

Beaver in Alberta are managed as a furbearing species and trapping is likely the only human-related mortality risk to this species in the LSA and RSA under baseline conditions.

Beaver activity was abundant and widespread throughout the LSA (0.55 colonies/km of watercourse). In addition, 10 incidental beaver observations from the 2013 amphibian and waterfowl surveys were recorded, comprised of eight lodges (three of which were active) and two animal sightings.

D.11.1.11 Northern Myotis

The northern myotis is an old-growth deciduous and mixedwood forest specialist. Like the little brown myotis, this species may preferentially select roosts near surface water and in mature forests because of the abundance of prey (Pattie and Fisher 1999) and the presence of snags and hollow trees.

Approximately 34% of the LSA represented potential effective northern myotis roosting habitat (CR #11, Table 5-12, Figure 5-19). The proportion of effective habitat was lower at the regional

scale, comprising 28% of the RSA (CR #11, Table 5-12, Figure 5-20). The abundance and wide distribution of water bodies and clearings (both natural and anthropogenic) in the LSA provides ample foraging habitat for the northern myotis and other bat species.

Northern myotis, as well as the other bat species in the region, should be able to move freely through the LSA and RSA since many existing disturbance features do not likely pose serious barriers to them.

Aside from potential collisions with tall infrastructure, there are no other major anthropogenic sources of mortality risk for northern myotis in the LSA and RSA at baseline.

The highly fragmented nature of the LSA and RSA suggests that northern myotis densities may be lower than similar habitats with fewer disturbance features (Marinelli 2000). Although no individuals were captured in mist nets during the 2013 bat survey, northern myotis were detected in the LSA using acoustic recorders.

D.11.1.12 Canada lynx

The Canada lynx is considered "Sensitive" in Alberta because of recent population declines and increasing concerns regarding habitat loss and fragmentation, but they are still considered "Not At Risk" federally.

Under baseline conditions, effective lynx habitat accounted for 69.6% (15,541.6 ha) of the LSA and 48.6% (96,277.4 ha) in the RSA (CR #11, Table 5-13, Figures 5-21 and 5-22).

As a wide ranging species in northern Alberta, lynx are relatively tolerant of human presence (Brand and Keith 1979) but are affected by anthropogenic disturbances such as road density (Bayne *et al.,* 2008). Disturbance features, such as roads, can provide access for competitors such as coyotes (Buskirk *et al.,* 1994) which collectively, can negatively affect lynx density (Bayne *et al.,* 2008).

Lynx in Alberta are managed as a furbearing species and trapping is likely the only human-related mortality risk to this species in the LSA and RSA under baseline conditions.

Based on winter track frequencies and wildlife camera monitoring, lynx were one of the more common carnivores in the LSA (next to coyotes), with an average track density of 0.09 tracks/km-day. At baseline, lynx were reported most frequently in lowland treed and mixedwood habitats. Lynx are expected to be common in relatively undisturbed areas of RSA under baseline conditions.

D.11.1.13 Moose

Moose are distributed throughout the forested region of Alberta (Pattie and Fisher 1999), and baseline surveys confirm that they occur in the LSA. Moose use a variety of habitats, but are most closely associated with deciduous, shrub, riparian, and lowland treed habitats that provide ample browse species. In the LSA, moose were most often detected in lowland treed, deciduous,

mixedwood and disturbed habitats. Approximately 85% and 83% of the LSA and RSA were considered effective moose habitat under baseline conditions, respectively (CR #11, Table 5-14).

Core security habitat was distributed throughout the LSA in 678 patches (CR #11, Table 5-15, Figure 5-25) and in 4,442 patches throughout the RSA (CR #11, Table 5-15, Figure 5-26). Patches >100 ha, the largest blocks of undisturbed habitat, accounted for 11.6% (2,588.3 ha) and 33.5% (66,412.4 ha) of effective moose habitat in the LSA and RSA, respectively (CR #11, Table 5-15). Smaller patches ranging from 5 to 20 ha comprised the largest proportion of moose core habitat in terms of number of patches in both the LSA and RSA. Approximately 64.3% (14,347.5 ha) of the LSA is characterized as effective core moose habitat, and 72.8% (144,208.6 ha) of the RSA. These results indicate that a relatively large proportion of the LSA and RSA provides suitable core habitat for moose.

A number of existing disturbance features in the LSA and RSA that could potentially affect moose movements were identified. Linear feature density (*e.g.*, seismic lines) was 5.26 km/km^2 in the LSA at baseline (CR #11, Figure 5-25). Although there are considerably more physical barriers to moose movements in the RSA, the linear feature density (3.76 km/km^2) was slightly lower (CR #11, Figure 5-26). Winter roads and seismic lines, along with regenerating pipelines and inactive well pads were rated as highly permeable, whereas all-season access roads and highways were expected to have moderate to low permeability. The greatest barriers were areas with extensive urban/rural residential and industrial developments, which were considered impermeable. Moose are expected to move freely throughout the LSA and RSA at baseline but will avoid areas of high human activity.

Moose in Alberta are managed as a game species and therefore, hunting is one of two major human-related mortality risks for this species under baseline conditions in the LSA and RSA. The second major mortality risk are moose-vehicle collisions which likely occur throughout the LSA and RSA along major roads and highways.

Moose abundance in the LSA and RSA is expected to be similar to these reported densities at baseline.

D.11.2 PREDICTED CONDITIONS

The following section describes the predicted changes of Project development on wildlife species or groups selected as VECs. The Application Case includes the Baseline Case plus the Lindbergh SAGD Expansion Project.

At present, no additional Projects are planned for the foreseeable future within the wildlife RSA. Effects of the Project on wildlife for the Planned Development Case assessment were assumed to be the same as those in the Application Case.

D.11.2.1 Change in Wildlife Habitat

The Project footprint, which will occupy 812.7 ha of land will result in the loss of 3.6% natural habitat in the LSA (Table D.11.2-1 and CR #11, Figure 6-1). The largest change in areal extent is associated with deciduous habitat of which 449.5 ha (3.8% of the LSA) will be affected by the

Project, followed by the mixedwood (53.8 ha or 3.2%), and lowland treed (40.3 ha or 6.4% loss) types. Project development will also result in an increase of 11.3% (or 605.5 ha) of anthropogenic disturbance features in the LSA, prior to reclamation.

Table D.11.2-1 Changes in Wildlife Habitat Between the Baseline and Application Cases in the LSA

Habitat Types	Area (ha)[1]			% Change
	Baseline Case	Application Case	Change	
Jack Pine	5.9	5.9	0	0.0
Deciduous	11,722	11,272.5	-449.5	-3.8
Mixedwood	1688	1,634.1	-53.8	-3.2
White Spruce	63.3	62.3	-1	-1.6
Mixed Coniferous	333.2	326	-7.2	-2.2
Lowland Shrub	1,338.4	1,301.7	-36.7	-2.7
Lowland Treed	625.3	585	-40.3	-6.4
Sedge Meadow	656.2	649.9	-6.3	-1.0
Upland Meadow	45.4	43.58	-1.82	-4.0
Upland Shrub	116.8	110.4	-6.4	-5.5
Sand	72.7	72.7	0	0.0
Marsh	209.6	208.6	-1	-0.5
Water Body	711.1	709.6	-1.5	-0.2
Disturbance	4,742.9	5,348.42	605.5	+11.3
Totals[1]	**22,330.7**	**22,330.7**		

[1] Due to rounding of values, totals may not equal the sum of the individual values presented in the table.

At the RSA scale, the largest change in areal extent resulting from Project development will occur in deciduous habitat (571.1 ha) (Table D.11.2-2 and CR #11, Figure 6-2) although this only represents a 0.6% loss of habitat in the region. Overall, only 0.4% (812.7 ha) of the natural habitats in the RSA will be affected by Project development, while anthropogenic disturbance features will be increased by only 0.8% (602.7 ha, CR #11, Table 6-2).

Table D.11.2-2 Changes in Wildlife Habitat Between the Baseline and Application Cases in the RSA

Habitat Types	Area (ha)[1]			% Change
	Baseline Case	Application Case	Change	
Deciduous	91,121.0	90,549.9	-571.1	-0.6
Mixedwood	52.2	52.2	0.0	0.0
Coniferous	2,142.1	2,142.1	0.0	0.0
Upland Shrub	1,343.4	1,343.4	0.0	0.0
Sedge Meadow	6.7	6.7	0.0	0.0
Lowland Shrub	2,741.2	2,725.4	-15.8	-0.6
Lowland Treed	707.9	693.0	-14.9	-2.1
Water Body / Wetland	22,651.7	22,651.0	-0.7	-<0.1
Riparian	321.3	321.3	0.0	0.0
Anthropogenic	73,010.8	73,613.5	602.7	+0.8
Totals[1]	**198,091.5**	**198,091.5**		

[1] Due to rounding of values, totals may not equal the sum of the individual values presented in the table.

D.11.3.2 Special Status Wildlife Species

Special status species that may occur in or around the LSA were identified using various information sources including ASRD (2010), COSEWIC (2013), and the Species at Risk Public Registry (*SARA* 2013) as well as published species range maps (Pattie and Fisher 1999, Russell and Bauer 2000, FAN 2007). The FWMIS data base was also queried for the occurrence of any special status species in the LSA. Based on this information, 65 wildlife species of concern comprised of three herptiles, 53 birds, and nine mammals could potentially occur or have previously been reported in the LSA (CR #11, Table 3-2).

D.11.2.3 Wildlife Diversity

Areas of moderate to high wildlife diversity in the LSA are expected to be reduced by 6.4% (524.2 ha) following Project development (CR #11, Table D.11.2-3). The remaining moderate to high diversity areas are widely distributed at both the LSA and RSA scales (CR #11, Figures 6-3 and 6-4, respectively). In contrast, while the Project footprint will increase low diversity habitats in the LSA and RSA by 45.2% and 17.5% respectively, this represents a spatial increase of <540 ha, which is considered negligible at both scales (CR #11, Table D.11.2-3).

Table D.11.2-3 Changes in Wildlife Diversity Between the Baseline and Application Cases in the RSA

Diversity Rating	No. of Species	LSA				RSA			
		Baseline (ha)	Application (ha)	Change (ha)	% Change	Baseline (ha)	Application (ha)	Change (ha)	% Change
Low	0-13	487.3	889.7	402.4	+45.2	2,540.4	3,079.4	539.0	+17.5
Moderate-low	14-38	2,296.1	2,418.1	122.0	+5.0	10,195.5	10,361.0	165.5	+1.6
Moderate	39-63	4,713.0	4,710.9	-2.1	-0.0	61,828.2	61,726.4	-101.8	-0.2
Moderate-high	64-89	13,155.5	12,680.1	-475.4	-3.6	122,446.0	121,858.3	-587.7	-0.5
High	90-148	1,678.7	1,632.0	-46.7	-2.8	1,081.4	1,066.4	-15.0	-1.4

D.11.2.4 Canadian Toad

The Project is expected to result in the loss of 38.3 ha (1.4%) of effective Canadian toad breeding habitat in the LSA (CR #11, Table 6-4, CR #11, Figure 6-5). Changes in effective toad habitat as a result of the Project at the RSA level are negligible (0.1%), and effective breeding habitat will remain widespread (CR #11, Table 6-4, CR #11, Figure 6-6). Loss of Canadian toad hibernation habitat in the LSA and RSA is also negligible, with only 4.3 ha (1.0%) and <0.1% affected by Project development (CR #11, Figures 6-7 and 6-8). The Project effects on habitat availability for Canadian toads are expected to be local, extended in duration, isolated, reversible in the short-term, of low magnitude, negative, and low impact (CR #11, Table 7-1).

The effects on Canadian toad movement will be continuous throughout the life of the Project, these effects are expected to be local, extended, reversible in the long-term, low in magnitude, negative, and of low impact (CR #11, Table 7-1). The probability of increased mortality rates for Canadian toads associated with Project activities is considered low.

The Project footprint is relatively small and does not affect large areas of effective breeding or hibernating habitats. Only boreal chorus frogs and wood frogs were detected during the field surveys. The Project is unlikely to affect the abundance of Canadian toads (if they occur) at either the LSA or RSA scales with the effects expected to be local, long-term in duration, continuous, reversible in the short-term, low in magnitude, negative, and low impact (CR #11, Table 7-1).

D.11.2.5 Mixedwood Forest Bird Community

The Project will result in the loss of 46.7 ha (2.8%) of effective mixedwood forest bird habitat in the LSA (CR #11, Table 6-5, Figure 6-9). In the RSA, loss of effective mixedwood bird habitat associated with Project development is negligible (<0.1%; CR #11, Table 6-5, Figure 6-10). The Project effects on mixedwood bird community habitat availability are expected to be local, extended in duration, continuous over the life of the Project, reversible in the long-term, of low magnitude, negative, and of low impact once the disturbed areas are reclaimed (CR #11, Table 7-1).

Fragmentation of mixedwood forests in the LSA will increase which could affect movements of birds that tend to avoid edges and crossing linear features such as winter wren (Hejl *et al.*, 2002a) and brown creeper (Hejl *et al.*, 2002b). The amount of change within the mixedwood bird community habitat as a result of the Project will be limited. The effects of the Project on the mixedwood forest bird community movements are expected to be local, long-term in duration, continuous over the life of the Project, reversible in the short-term, of low magnitude, negative, and of low impact (CR #11, Table 7-1).

Risk of collisions with Project infrastructure will increase in the LSA but the effect on bird populations in the LSA and RSA is expected to be negligible. Vehicular and bird collisions may also increase, but the effect is expected to be negligible since speed restrictions on access roads within the Project footprint will be enforced. Increased fragmentation associated with Project development could increase predation risk.

Since noise associated with Project operations is expected to be within current AER guidelines (*i.e.*, <40 dBA Leq Night; ACI 2013), effects on the mixedwood bird community is expected to be low. Project effects on mixedwood forest bird mortality risk are expected to be local, long-term in duration, continuous, reversible in the short-term, of low magnitude, negative, and of low impact CR #11, Table 7-1).

Although provincial population estimates for mixedwood bird species are not available, it is highly unlikely that either local or provincial populations will be affected by the Project as the amount of mixedwood habitat which will be altered either directly through habitat loss or indirectly through sensory disturbance is considered minimal. Project effects on mixedwood forest bird abundance are expected to be local, long-term in duration, continuous, reversible in the short-term, of low magnitude, negative, and of low impact (CR #11, Table 7-1).

D.11.2.6 Old Growth Forest Bird Community

Project development will result in the loss of 11.7 ha (2.2%) of effective old-growth forest bird habitat in the LSA (CR #11, Table 6-6, Figure 6-11). At the RSA scale, effective old-growth bird habitat will be reduced by 586.1 ha (0.6%; CR #11, Table 6-6, Figure 6-12). Project-related effects on old-growth bird community habitat availability are expected to be local, extended in duration, continuous over the life of the Project, reversible in the long-term, of low magnitude, negative, and of low impact once the disturbed areas are reclaimed (CR #11, Table 7-1).

Fragmentation within the LSA will increase slightly. This could affect movements of birds that typically avoid edges and crossing linear features. Because the areal extent of old-growth habitat in the LSA is so small and the amount of this habitat that will be affected by Project development is also limited, the effects on bird movement is also expected to be negligible. The effects of the Project on old-growth bird communities are expected to be local, long-term in duration, continuous over the life of the Project, reversible in the short-term, of low magnitude, negative, and low impact (CR #11, Table 7-1).

Risk of collisions with Project-related infrastructure will increase in the LSA but the effect on bird populations in the LSA and RSA is expected to be negligible. Vehicular and bird collisions

may also increase, but the effect is also expected to be negligible since speed restrictions on access roads within the Project footprint will be enforced. Increased fragmentation could increase predation risk.

Since noise associated with Project operations is expected to be within current AER guidelines (*i.e.*, <40 dBA Leq Night; ACI 2013), effects on the old-growth forest bird community is expected to be low. Project effects on old-growth bird communities mortality risk are expected to be local, long-term in duration, continuous, reversible in the short-term, of low magnitude, negative, and low impact (CR #11, Table 7-1).

Old-growth forest bird abundance was low because old-growth habitat is limited in the LSA, occurring in only eight isolated patches. Project effects on old-growth bird communities abundance are expected to be local, long-term in duration, continuous, reversible in the short-term, of low magnitude, negative, and low impact (CR #11, Table 7-1).

D.11.2.7 Barred Owl

Project development will result in the loss of 572.2 ha (4.8%) of effective barred owl nesting habitat in the LSA, and 709.7 ha (0.8%) in the RSA (CR #11, Table 6-7, Figures 6-13 and 6-14). Project development is expected to fragment forested habitat that could be potentially used by barred owls which may cause some avoidance of nesting immediately adjacent to the Project. Barred owls are not expected to be displaced from the region because of Project development. Project-related effects on barred owl habitat are expected to be local, extended in duration, continuous, reversible in the long term, low in magnitude, negative, and low impact (CR #11, Table 7-1).

The relatively small components of the Project are unlikely to create barriers to owl movement. Project effects on barred owl movements are expected to be local, long-term in duration, continuous, reversible in the short-term, of low magnitude, negative, and low impact (CR #11, Table 7-1).

Mortality rates for barred owls have the potential to increase from Project development. This potential can be mitigated by following recommended construction timing windows, and clearing vegetation outside of the breeding season. Since noise associated with Project operations is expected to be within current AER guidelines (*i.e.*, <40 dBA Leq Night; ACI 2013), noise effects on the barred owls are expected to be low. Project effects on barred owl mortality risk are expected to be local, long-term in duration, continuous, reversible in the short-term, of low magnitude, negative, and low impact (CR #11, Table 7-1).

Habitats adjacent to the Project should be able to accommodate any displaced owls. Project effects on barred owl abundance are expected to be local, long-term in duration, continuous, reversible in the short-term, of low magnitude, negative, and low impact (CR #11, Table 7-1).

D.11.2.8 Yellow Rail

Yellow rails, which require wet meadow habitat to breed, are expected to experience a 108.4 ha loss of effective habitat in the LSA, representing 6.1% of habitat available at baseline (CR #11,

Table 6-8, Figure 6-15). The Project footprint will result in the loss of 177 habitat patches, although only one is ≥15 ha in size (CR #11, Table 6-9). This represents a 12.5% loss of large effective habitat patches. Project effects at the RSA level are negligible (CR #11, Tables 6-8 and 6-9, Figure 6-16). Project effects on yellow rail habitat availability are expected to be local, extended in duration, continuous, reversible in the long-term, low in magnitude, negative, and low impact (CR #11, Table 7-1).

The contribution of the Project footprint is negligible when considered in the context of baseline disturbance when investigating possible yellow rail movement restrictions. Linear feature densities only increase to 5.56 km/km^2 following Project development, from 5.26 km/km^2 at baseline. The Project effects on yellow rail movements are expected to be local, long-term in duration, continuous, reversible in the short-term, low in magnitude, negative, and low impact (CR #11, Table 7-1).

The primary mechanism by which the Project may contribute to yellow rail risk of mortality is through the clearing of breeding habitat and nest destruction during the breeding period, which can be eliminated by following recommended clearing timing windows. The Project effects on yellow rail mortality are expected to be local, long-term in duration, periodic over the life of the Project, reversible in the short-term, low in magnitude, negative, and low impact (CR #11, Table 7-1).

Yellow rail abundance is not expected to be affected by the Project, although localized displacement may occur if breeding habitat is removed. Project effects on yellow rail abundance are expected to be local, long-term in duration, continuous, reversible in the short-term, low in magnitude, negative, and low impact (CR #11, Table 7-1).

D.11.2.9 Fisher

Project development will result in the loss of 97.3 ha (6.8%) of effective habitat from the LSA (CR #11, Table 6-10, Figure 6-17 and 6-18). Project effects on fisher habitat availability are expected to be local, extended in duration, continuous, reversible in the long-term, low in magnitude, negative, and low impact (CR #11, Table 7-1).

The Project is not expected to impede fisher movement. Project effects on fisher movements are expected to be local, long-term in duration, continuous, reversible in the short-term, low in magnitude, negative, and low impact (CR #11, Table 7-1).

It is unlikely that trapping pressure will increase significantly with the Project, because the area is already widely accessible because of the high density of existing disturbance features. Increased traffic related to Project development may increase the risk of vehicular collisions, but enforcing lower traffic speeds (≤50 km/hr) should allow fisher and other mustelids to safely cross roads. Fishers are most active at night (Pattie and Hoffman 1992), when traffic levels are typically at their lowest levels (CR #11, Table 7-1).

As predators, fisher could be susceptible to bioaccumulation of pollutants in their prey (primarily rodents and birds). Project effects on fisher mortality are expected to be local, long-term in

duration, periodic, reversible in the short-term, low in magnitude, negative, and low impact (CR #11, Table 7-1).

Any potential increase in trapping pressure and localized extirpation by Project operations may reduce fisher abundance in the LSA but is considered unlikely. Project effects on fisher abundance are expected to be local, long-term in duration, continuous, reversible in the short-term, low in magnitude, negative, and low impact (CR #11, Table 7-1).

D.11.2.10 Beaver

Project development will result in the loss of only 96.0 ha (1.7%) of effective habitat for beaver (CR #11, Table 6-11, Figure 6-19). At the RSA scale, the effects of the Project on beaver habitat are negligible (0.2%; CR #11, Table 6-11, Figure 6-20). With mitigation the overall Project effects on beaver habitat availability are expected to be local, extended in duration, continuous, reversible in the long-term, low in magnitude, negative, and low impact (CR #11, Table 7-1).

The Project footprint will intersect with a permanent watercourse only once, and therefore, Project effects are expected to be negligible. Roads and utility corridors will be moderately permeable to beavers. Project effects on beaver movements are expected to be local, long-term in duration, continuous, reversible in the short-term, low in magnitude, negative, and low impact (CR #11, Table 7-1).

The Project has potential to affect the mortality risk of beavers. Direct mortality resulting from collisions with vehicles is among the most likely mechanism but beavers will tolerate human activity, so the effects of sensory disturbance are expected to be negligible. Project effects on beaver mortality are expected to be local, long-term in duration, periodic, reversible in the short-term, low in magnitude, negative, and low impact (CR #11, Table 7-1).

Because Project effects on habitat availability, movement, and mortality risk are expected to be minimal, beaver abundance at the local and regional scales is unlikely to be affected by Project development. Project effects on beaver abundance will be local, long-term in duration, continuous, reversible in the short-term, low in magnitude, negative, and low impact (CR #11, Table 7-1).

D.11.2.11 Northern Myotis

The Project footprint and associated sensory disturbance will reduce effective northern myotis roosting habitat by 540.0 ha (7.1%) in the LSA and 1.2% (644.9 ha) in the RSA (CR #11, Table 6-12, Figures 6-21 and 6-22). With mitigation, Project effects on habitat availability for northern myotis are expected to be local, extended in duration, continuous, reversible in the long-term, low in magnitude, negative, and low impact (CR #11, Table 7-1).

The Project is not expected to restrict northern myotis movement, and may in fact create additional foraging habitat and commuting flyways. Project effects on northern myotis movements are expected to be local, long-term in duration, continuous, reversible in the short-term, low in magnitude, negative, and low impact (CR #11, Table 7-1).

The Project is not expected to increase the northern myotis mortality risk. With mitigation the Project effects on northern myotis mortality are expected to be local, long-term in duration, continuous, reversible in the short-term, low in magnitude, negative, and low impact (CR #11, Table 7-1).

As one of the more abundant bat species recorded during mist netting and acoustic monitoring, the Project is not expected to reduce northern myotis abundance at either the LSA or RSA scales, even though there will be some localized direct (vegetation clearing) and indirect (sensory disturbance) habitat losses. The Project is not expected to affect movements or the mortality risk of this bat species. Project effects on northern myotis abundance are expected to be local, long-term in duration, continuous, reversible in the short-term, low in magnitude, negative, and low impact (CR #11, Table 7-1).

D.11.2.12 Canada lynx

Project development will reduce effective Canada lynx habitat in the LSA by 607.3 ha (3.9%) (CR #11, Table 6-13, Figure 6-23). At the RSA scale, effective lynx habitat is relatively unaffected by the Project (loss of 0.6%; CR #11, Table 6-13, Figure 6-24). Indirect habitat loss associated with sensory disturbance is expected to be greatest during construction, after which avoidance by lynx is expected to decrease.

Progressive reclamation of unused disturbance features (*e.g.*, inactive well pads and utility corridors) will help offset habitat loss throughout the life of the Project. Project-related effects on lynx habitat availability are expected to be local, extended in duration, continuous, reversible in the long-term, low in magnitude, negative, and low impact (CR #11, Table 7-1).

Some disturbance features may affect with lynx movement behaviour. Lynx have fairly large home ranges (26 to 54 km^2; Vashon *et al.*, 2008), and are capable of travelling 5 to15 km in a single night (Pattie and Hoffman 1992). Lynx are known to readily cross roads and highways, so access roads and utility corridors should not be significant barriers at all. Lynx are fairly short (46 to 58 cm; Pattie and Fisher 1999) and will be able to pass beneath above-ground pipelines unless prohibited by deep snow, in which case aboveground crossing structures should facilitate movement. With mitigation the Project effects on lynx movements are expected to be local, long-term in duration, continuous, reversible in the short-term, low in magnitude, negative, and low impact (CR #11, Table 7-1). With mitigation, the Project effects on lynx movements are expected to be local, long-term in duration, continuous, reversible in the short-term, low in magnitude, negative, and low impact (CR #11, Table 7-1).

Like other wildlife VECs, the mortality risk for lynx may change with Project development as a result of vegetation clearing, increased access, collisions with vehicles, and potentially an increase in trapping. With mitigation the Project effects on lynx mortality are expected to be local, long-term in duration, periodic, reversible in the short-term, low in magnitude, negative, and low impact (CR #11, Table 7-1).

Because the Project is anticipated to have relatively minor effects on habitat availability, movement or mortality risk, Project effects on lynx abundance are expected to be local,

long-term in duration, continuous over the life of the Project, short-term in reversibility, low in magnitude, negative, and low impact (CR #11, Table 7-1).

D.11.2.13 Moose

The Project footprint and associated sensory disturbance is expected to reduce effective moose habitat by 4.0% (750.3) in the LSA, and 0.5% (759.5 ha) in the RSA (Table 6-14, Figures 6-25 and 6-26). The distribution of effective habitat in the LSA is also anticipated to change with Project development through the fragmentation of larger continuous patches (CR #11, Table 6-15). The fragmentation of these patches accounts for 670.1 ha of the effective habitat loss (CR #11, Table 6-16). The loss of core moose habitat is considered low, especially in the regional context of the RSA.

Reclamation of disturbed areas will occur progressively throughout the life of the Project. Moose are expected to 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. The effects of the Project on moose habitat availability are expected to be local, extended in duration, continuous, reversible in the long term, low in magnitude, negative, and low impact (CR #11, Table 7-1).

The ability of moose and other 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 Project footprint (CR #11, Figure 6-27), particularly by road and utility corridors with adjacent aboveground pipelines (Ng *et al.*, 2004). Permeability in the RSA is not expected to change appreciably as a result of Project development (CR #11, Figure 6-28). With mitigation the Project-related effects on moose movements are expected to be regional, long-term in duration, continuous over the life of the Project, reversible in the short-term, low in magnitude, negative, and low impact (CR #11, Table 7-1).

Increased access could increase the risk of ungulate mortality associated with hunting and poaching, and potentially even predation, although this is unlikely based on existing baseline levels of disturbance. 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 generated by the project. With mitigation the Project effects on moose mortality are expected to be local, long-term in duration, periodic during the life of the Project, reversible in the long-term, low in magnitude, negative, and low impact (CR #11, Table 7-1).

Because the Project is anticipated to have relatively minor effects on habitat availability, movement, or mortality risk in the LSA, the overall effects of the Project on moose abundance are expected to be local, long-term in duration, continuous, reversible in the long-term, low in magnitude, negative and low impact (CR #11, Table 7-1).

D.11.3 MITIGATION AND MONITORING

D.11.3.1 Mitigation

The Project has the potential to affect wildlife through various mechanisms, including direct and indirect habitat loss and fragmentation, changes to movement behaviour, and increased mortality risk. Pengrowth is optimizing Project design as one method of minimizing the effects of the Project on wildlife. In addition, existing disturbance features will be used whenever possible. To avoid or further minimize Project-related effects on wildlife, Pengrowth will also implement a number of other mitigation measures which are summarized below.

Habitat Availability

- Project development will integrate existing anthropogenic disturbances and other proposed land use activities to the extent possible so that habitat fragmentation, new linear disturbance features, industrial noise, and cumulative habitat loss are minimized. Linear corridor widths to low use facilities (*e.g.*, well pads) will be minimized to the extent possible;
- where possible, heavy construction activity within the Key Wildlife and Biodiversity Zone located in the northern portion of the LSA will be avoided between January 15 and April 30 (GOA 2013b). Exceptions include well tie-in activities, well site or pipeline installations accessed using class IV (≤ 15 m ROW) or V (10 m ROW) roads, and all activities that can be completed within 100 m of existing all weather access (GOA 2013a);
- the Project footprint will avoid mature forest and riparian areas as much as possible to minimize the impact of habitat loss to mature forest (*e.g.*, fisher, forest warblers, *etc.*) and riparian (*e.g.*, amphibians, waterbirds) specialist species, respectively. Mature forest habitat is scarce in the LSA and there are no areas containing old-growth forest, which increases the importance of conserving mature forest habitats;
- site preparation and construction activities will be timed to avoid the migratory bird nesting period, in accordance with the *Migratory Birds Convention Act* (Regulation 12:1)*;*
- in the event that vegetation clearing must occur within the restricted activity periods, a pre-disturbance nesting survey will be conducted by experienced wildlife biologists according to established sensitive species inventory guidelines (GOA 2013b). Any active nest sites encountered will be buffered with the recommended setback distances based on specific species requirements (GOA 2013b);
- ESRD will be contacted should hibernating black bears be disturbed during the course of winter vegetation clearing activities;
- water bodies and riparian areas will be avoided to protect habitat for amphibians, waterbirds, beavers and other species, allow for wildlife movement, and to reduce the potential of water body contamination from accidental spills;
- because the presence of uncontrolled external artificial lighting can affect use of habitats adjacent to the Project Pengrowth will consider a plan that reduces stray and non-essential artificial lighting; and

- reclamation using appropriate vegetation species determined in consultation with ESRD, land owners and occupants will be carried out progressively over the life of the Project, where reclamation will be initiated soon after an area is no longer required including winter roads and seismic lines.

Movement

- above-ground pipelines can act as barriers to wildlife movement, particularly ungulates such as moose, white-tailed deer, and mule deer. ESRD has provided guidelines for constructing wildlife crossings (ESRD 2012e), although these guidelines will be revised with further research. The Lindbergh area is also a transition from forested lands to agricultural lands and is completely within the white zone. A considerable portion of the post project reclamation will convert lands to agricultural end uses. As such the implementation of the ESRD guidelines will be considered and a more site specific approach should be considered. Pengrowth will employ the following mitigation strategies as per the ESRD guidelines:
  - wildlife crossing structures will be used to facilitate wildlife movement through the LSA. Wildlife overpasses will be 10 m wide with an incline of 6:1 to maintain line of sight for ungulates. These will be naturalized by planting/seeding them with vegetation that is compatible with the adjacent habitat. Under pipe crossings will also be established, where possible, to take advantage of natural topography. In these cases, a minimum clearance of 175 cm will be maintained where possible;
  - wildlife crossings will be strategically placed in locations that maximize the chances of use by moose and other wildlife. These locations might include existing wildlife trails (*i.e.*, game trails), riparian areas, and high quality habitat;
  - pre-disturbance surveys (in addition to the baseline surveys presented in this assessment) will be conducted to identify important wildlife habitat and trails, which will facilitate proper placement of wildlife crossings;
  - because the Project is not located in known caribou range, wildlife crossings will be placed at a minimum frequency of three crossings/1,000 m to ensure that overall landscape permeability for moose and other wildlife in the LSA is preserved;
  - wildlife crossings will be marked to prevent vehicle collisions with wildlife; and
  - wildlife crossing structures will be monitored (*e.g.*, wildlife cameras, track counts) following construction. Additional mitigation will be considered if the above ground pipelines appear to be acting as barriers to wildlife movement.
- winter plowing/grading will be conducted in a manner that does not restrict wildlife from crossing access roads or accessing wildlife crossings. Breaks in snow berms resulting from plowing access routes will be created by alternately placing berms on either side of the roads at 100 m intervals (GOA 2013b). Pengrowth will also make an effort to ensure that snow berm breaks are placed at known and potential moose movement corridors and aligned with the above ground pipeline crossings; and
- where possible, doglegs will be used and slash berms will be placed where cleared corridors intersect main access roads to reduce lines of sight and discourage off-road travel on cleared seismic and pipeline corridors.

Mortality Risk

- Pengrowth will restrict and actively monitor access onto its site to reduce the effects of vehicles and human activity on wildlife. Common operational practices for employees that are at work include but will not be limited to:
  - restricting recreational use of snowmobiles and ATVs in the LSA by employees and contractors;
  - prohibiting hunting, harassment, or feeding of wildlife by workers in the LSA;
  - implementing a zero tolerance policy on the use of firearms by workers in the LSA which will be strictly enforced; and
  - consulting with First Nations to maintain access to the LSA for traditional land uses.
- a detailed Waste Management Plan will be implemented prior to construction and operational activities to minimize the attraction of wildlife (particularly bears and other predators), which could increase wildlife mortality rates and endanger site personnel. Pengrowth will follow the Best Management Practices for camps, fences and barriers as described in Bear Smart: Best Management Practices for Camps (ASRD 2011), and ensure all waste is stored in wildlife-proof containers and disposed of properly. Some of the waste management and bear awareness/Bear Smart guidelines that will be implemented include:
  - ensuring that food waste, refuse and other attractants are securely contained in enclosed and approved bear-proof containers and/or facilities (*e.g.*, hard-sided buildings, fenced compounds, and bear-proof transfer station) prior to transportation to a disposal facility to prevent access by scavenging bears;
  - providing adequate signage to inform employees of the location and proper use of bear-proof storage containers/facilities;
  - ensuring that waste storage containers/facilities are not filled beyond capacity;
  - ensuring that regular inspection and maintenance of waste storage containers/facilities is carried out;
  - ensuring that measures contained in the bear management plan are diligently followed by all employees and contractors;
  - staff that work in remote areas of the lease will be instructed in the proper use of bear deterrent devices (*i.e.*, pepper spray, air horns, and bear bangers); and
  - bear warning signs will be installed to advise staff of locations where problem bears have been reported.
- an Emergency Spill Response Plan will be implemented to limit the effect of accidental spills. The effects of spills will be minimized by restricting fuel storage and filling to designated areas that are at least 100 m from watercourses.
- enforcement of speed limits (≤50 km/hr) along access roads and utility corridors, and placement of signs at identified wildlife crossings to increase driver diligence to minimize wildlife-vehicle collisions. Vehicles will yield to all wildlife crossing access roads.

D.11.3.2 Monitoring

The wildlife monitoring program will be based on the terms and conditions of the EPEA Approval and will be developed in consultation with provincial regulators and regional stakeholders as required. Some of the elements of the monitoring program are expected to include the following considerations and actions:

- participate in the ABMI program to assist with monitoring regional cumulative effects on biological resources; and
- engage regulators (both provincial and federal), First Nations, and traditional land-users in discussion regarding approaches to further minimize effects on species of special interest. Such approaches might include continued monitoring, habitat management, and participation in regional initiatives.

An important consideration in selecting monitoring procedures will be the need to minimize observer influence and ensure that monitoring activities do not create added disturbance to sensitive wildlife species. The monitoring program will involve the use of low-disturbance monitoring approaches to quantitatively measure changes in use of preferred habitats by wildlife species of management concern

Another consideration is focusing monitoring efforts on parameters that are directly related to effects mitigation and that provide opportunities to improve mitigation performance over time. This wildlife monitoring approach will enable Pengrowth to evaluate the effectiveness of their wildlife protection, mitigation, and reclamation procedures and to ensure that the Project does not adversely affect wildlife in the region.

D.11.4 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.11.4-1.

Table D.11.4-1 Summary of Impact Rating on Residual Effects for Wildlife VECs

Wildlife VEC / Potential Effects	Geographic Extent[1]	Duration[2]	Frequency[3]	Reversibility[4]	Magnitude[5]	Project Contribution[6]	Confidence Rating[7]	Probability of Occurence[8]	Impact Rating[9]
Canadian Toad:									
Habitat Availability	Local	Extended	Isolated	Short-term	Low	Negative	Moderate	Moderate	Low
Movement	Local	Extended	Continuous	Long-term	Low	Negative	Moderate	Moderate	Low
Mortality Risk	Local	Extended	Periodic	Short-term	Low	Negative	Low	Moderate	Low
Abundance	Local	Long-term	Continuous	Short-term	Low	Negative	Moderate	Moderate	Low
Mixedwood Forest Bird Community:									
Habitat Availability	Local	Extended	Continuous	Long-term	Low	Negative	High	Moderate	Low
Movement	Local	Long-term	Continuous	Short-term	Low	Negative	High	Moderate	Low
Mortality Risk	Local	Long-term	Continuous	Short-term	Low	Negative	High	Moderate	Low
Abundance	Local	Long-term	Continuous	Short-term	Low	Negative	High	Moderate	Low
Old-growth Forest Bird Community:									
Habitat Availability	Local	Extended	Continuous	Long-term	Low	Negative	High	Moderate	Low
Movement	Local	Long-term	Continuous	Short-term	Low	Negative	High	Moderate	Low
Mortality Risk	Local	Long-term	Continuous	Short-term	Low	Negative	High	Moderate	Low
Abundance	Local	Long-term	Continuous	Short-term	Low	Negative	High	Moderate	Low
Barred Owl:									
Habitat Availability	Local	Extended	Continuous	Long-term	Low	Negative	Moderate	Moderate	Low
Movement	Local	Long-term	Continuous	Short-term	Low	Negative	Moderate	Moderate	Low
Mortality Risk	Local	Long-term	Continuous	Short-term	Low	Negative	Moderate	Moderate	Low
Abundance	Local	Long-term	Continuous	Short-term	Low	Negative	Moderate	Moderate	Low
Yellow Rail:									
Habitat Availability	Local	Extended	Continuous	Long-term	Low	Negative	High	Moderate	Low
Movement	Local	Long-term	Continuous	Short-term	Low	Negative	Moderate	Moderate	Low
Mortality Risk	Local	Long-term	Periodic	Short-term	Low	Negative	Moderate	Moderate	Low

Table D.11.4-1 Summary of Impact Rating on Residual Effects for Wildlife VECs

Wildlife VEC / Potential Effects	Geographic Extent[1]	Duration[2]	Frequency[3]	Reversibility[4]	Magnitude[5]	Project Contribution[6]	Confidence Rating[7]	Probability of Occurence[8]	Impact Rating[9]
Abundance	Local	Long-term	Continuous	Short-term	Low	Negative	Moderate	Moderate	Low
Fisher:									
Habitat Availability	Local	Extended	Continuous	Long-term	Low	Negative	Moderate	Moderate	Low
Movement	Local	Long-term	Continuous	Short-term	Low	Negative	Moderate	Moderate	Low
Mortality Risk	Local	Long-term	Periodic	Short-term	Low	Negative	Moderate	Moderate	Low
Abundance	Local	Long-term	Continuous	Short-term	Low	Negative	Moderate	Moderate	Low
American Beaver:									
Habitat Availability	Local	Extended	Continuous	Long-term	Low	Negative	High	Moderate	Low
Movement	Local	Long-term	Continuous	Short-term	Low	Negative	Moderate	Moderate	Low
Mortality Risk	Local	Long-term	Periodic	Short-term	Low	Negative	Moderate	Moderate	Low
Abundance	Local	Long-term	Continuous	Short-term	Low	Negative	Moderate	Moderate	Low
Northern Myotis:									
Habitat Availability	Local	Extended	Continuous	Long-term	Low	Negative	Moderate	Moderate	Low
Movement	Local	Long-term	Continuous	Short-term	Low	Negative	Moderate	Moderate	Low
Mortality Risk	Local	Long-term	Continuous	Short-term	Low	Negative	Low	Moderate	Low
Abundance	Local	Long-term	Continuous	Short-term	Low	Negative	Moderate	Moderate	Low
Canada Lynx:									
Habitat Availability	Local	Extended	Continuous	Long-term	Low	Negative	Moderate	Moderate	Low
Movement	Local	Long-term	Continuous	Short-term	Low	Negative	Moderate	Moderate	Low
Mortality Risk	Local	Long-term	Periodic	Short-term	Low	Negative	Low	Moderate	Low
Abundance	Local	Long-term	Continuous	Short-term	Low	Negative	Moderate	Moderate	Low
Moose:									
Habitat Availability	Local	Extended	Continuous	Long-term	Low	Negative	High	Moderate	Low
Movement	Regional	Long-term	Continuous	Short-term	Low	Negative	Moderate	Moderate	Low

Table D.11.4-1 Summary of Impact Rating on Residual Effects for Wildlife VECs

Wildlife VEC / Potential Effects	Geographic Extent[1]	Duration[2]	Frequency[3]	Reversibility[4]	Magnitude[5]	Project Contribution[6]	Confidence Rating[7]	Probability of Occurence[8]	Impact Rating[9]
Mortality Risk	Local	Long-term	Periodic	Long-term	Low	Negative	Moderate	Moderate	Low
Abundance	Local	Long-term	Continuous	Long-term	Low	Negative	Moderate	Moderate	Low

[1]. Local, Regional, Provincial, National, Global;
[2]. Short, Long, Extended, Residual;
[3]. Continuous, Isolated, Periodic, Occasional;
[4]. Reversible in short term, Reversible in long term, Irreversible – rare;
[5]. Nil, Low, Moderate, High; Number in parenthesis indicates proportion of effective habitat altered and direction of change;
[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

D.12.1 INTRODUCTION

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

ESRD issued the final ToR for the Project on December 13, 2013. The specific requirements for the greenhouse gas and climate change component are provided in Section 2 and 3, 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 ensure 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) control technologies used to reduce emissions;

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

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

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

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

m) 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

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 PROJECT GREENHOUSE GAS EMISSIONS

Table D.12.2-1 summarizes the maximum annual greenhouse gas (GHG) emissions from each individual source during the operation of the Lindbergh facilities. The emission estimates of CO_2, CH_4, and N_2O are based on emission factors and the estimated fuel consumption rates. GHG estimates are presented for the expanded Lindbergh Project (Pilot + Phase 1 + Phase 2). The fuel consumption rates are estimated based on typical operations at full design production capacity. GHG emissions from fugitive sources as well as from diesel combustion from bitumen trucking have been included. The use of on-site cogeneration negates the need for additional electricity purchase; indirect GHG emissions from electricity purchases are zero.

Fuel gas blanketing will be used to control emissions from storage tanks. Some leaks from the gas blanketing system will be expected. The bulk fugitive emission rates for blanket gas were based on estimates made for the Osum Taiga project (Osum 2009) and then pro-rated on the basis of bitumen production. Most of the fugitive GHG emissions from the expanded facility will be from this source. At full operation, the Lindbergh facilities will be generating 1.07 MT/yr of CO_2e (CO_2 equivalent).

Table D.12.2-1 Detailed Project Greenhouse Gas Emissions During Operations at Design Capacity

Emission Source	Number of Units	CO_2 (t/d)	CH_4 (t/d)	N_2O(t/d)	CO_2e (t/d)
Steam Generators	5	2506	4.5E-03	0.11	2540
Utility Boilers	2	50	9.0E-05	2.2E-03	51
Cogeneration	5	553	9.9E-04	2.4E-02	560
Tank Vapour Combustion (LP Flare)	1	27	1.3E-03	2.6E-04	27
Evaporator Gas Combustion (HP Flare)	1	13	5.6E-04	1.1E-04	13
Diesel Combustion – Trucking	n/a	25	1.5E-03	1.1E-02	28
Fugitive Emissions	n/a	1.5E-02	2.1	0	44
Total Project (Stream Day Basis) (t/d)					**3264**
Total Annual – Plant availability 90% (t/a)					**1,072,125**

Table D.12.2-2 summarizes the total greenhouse gas emissions for the Project, based on an approximate Project lifespan of 25 years for both Phase 1 (2015 to 2042) and Phase 2 (2017 to 2042), assuming 90% plant availability. This estimate includes the construction and reclamation phases of the Project. The expanded Lindbergh facility is estimated to contribute 28 Mt CO_2e of

GHG emissions during its operational life. Detailed information on how GHG emissions were estimated for the construction and reclamation phases are included in CR #1, Appendix B.

Table D.12.2-2 Summary of Total Greenhouse Gas Emissions for the Lindbergh Project[a]

Project Phase	Direct Emission Rates[b]				Indirect Emission Rates[b]	Overall Total
	CO_2	CH_4	N_2O	CO_2e	CO_2e	CO_2e
Maximum Annual Emission Rates [t/y]						
Construction Phase	17,892	1.1	7.7	20,301	0.0	20,301
Full Operations Phase	1,042,743	699	47	1,072,125	0.0	1,072,125
Reclamation Phase	17,892	1.1	7.7	20,301	0.0	20,301
Total Emissions – Project Lifetime [kt]						
Construction Phase	17,892	1.1	7.7	20,301	0.0	20,301
Operations Phase	27,634,192	18,537	1,258	28,404,084	0.0	28,414,084
Reclamation Phase	17,892	1.1	7.7	20,301	0.0	20,301
Overall Project Total	**27,669,976**	**18,539**	**1,273**	**28,444,686**	**0.0**	**28,454,687**

[a] Annual GHG emission rates are based on 90% plant availability. Total emissions are based on a Project life of 25 years.
[b] SF6 and chlorofluorocarbon emissions were considered negligible.

The GHG emission estimates of CO_2, CH_4, and N_2O directly resulting from natural gas or diesel combustion are based on emission factors, which are summarized in Table D.12.2-3.

Table D.12.2-3 Summary of GHG Emission Factors

GHG Component	Emission Factor	Units	Source
Natural Gas and Produced Gas Combustion			
CO_2	56	t/TJ_{net}	Intergovernmental Panel on Climate Change (IPCC) Emission Factor Database (EFDB) (2006)
CH_4	1×10^{-4}	t/TJ_{net}	IPCC EFDB (2006)
N_2O	2.4×10^{-3}	t/TJ_{net}	IPCC EFDB (2006)
Diesel Combustion – Construction Phase			
CO_2	2.56	kg/L	B.C. Guidelines (B.C. MOE 2012)
CH_4	1.5×10^{-4}	kg/L	B.C. Guidelines (B.C. MOE 2012)
N_2O	1.1×10^{-3}	kg/L	B.C. Guidelines (B.C. MOE 2012)

Table D.12.2-4 compares emissions from annual Project operations to total 2010 provincial and national GHG emissions.

Table D.12.2-4 Contribution of the Project to 2010 Provincial and National GHG Emission Inventories During Operations

GHG Emissions	GHG Emissions [Mt CO2e/year]	% of Alberta Total	% of Canada Total
Phase 2 Only	0.64	0.26	0.09
Lindbergh Expanded Project	1.07	0.44	0.15
Alberta Total	242[(a)]		
Canada Total	702[(a)]		

[(a)] Source: Environment Canada (2013a) National Inventory Report 1990 to 2011: Greenhouse Gas Sources and Sinks in Canada, Part 3.
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. At full build-out, the Project (Phase 2 only) is expected to generate 1,758 t of CO_2e for a production rate of 17,500 barrels of bitumen per calendar day, resulting in a GHG operations emission intensity of 100 kg CO_2e per barrel of produced bitumen. The emission intensity is reported incorporating the assumption of 90% plant availability. This emission intensity is consistent with published GHG emission intensity estimates from similar projects (Table D.12.2-5).

Table D.12.2-5 Greenhouse Gas Emission Intensity for the Project and Other Similar Developments

Project	Production Capacity (bpd)	Total GHG Emissions (CO_2e t/d)	GHG Intensity (kg CO_2e/barrel)	Reference
Lindbergh Expansion Project	17,500	1,758	100	-
Brion Energy Dover Project	250,000	23,639	95	DOC 2010
Connacher Great Divide Expansion	44,000	4527	103	Connacher 2010
Osum Taiga	35,000	3,199	91	Osum 2009
Osum Sepiko Kesik	60,000	5,286	88	Osum 2013
Cenovus Telephone Lake	90,000	11,299	126	Cenovus 2011
Southern Pacific Resources McKay River	24,000	2,991	125	STP 2011

D.12.3 GREENHOUSE GAS MANAGEMENT PLAN

Pengrowth is committed to responsible environmental management and management of the Project's GHG footprint. The Greenhouse Gas Management Plan for the Project can be summarized as follows:

- the Project will utilize process equipment that will minimize GHG emissions. Examples of such equipment include high-efficiency boilers, VRUs to reduce fugitive methane vapours, optimized and insulated piping to reduce pumping energy requirements and heat loss;
- Pengrowth will continuously improve Project associated technologies during the operational phase to increase energy efficiency and reduce greenhouse gases;
- Pengrowth will continuously monitor and measure performance and compare performance metrics against initial design plans to identify opportunities for emission and efficiency improvement;
- Pengrowth will develop GHG quantification tools to track and monitor GHG emissions. This will include training staff in GHG quantification and reporting procedures; and
- Pengrowth will comply with emission limits imposed on the Project as per the Specified Gas Emitters Regulation either through efficiency improvements, purchase of GHG offsets, or contributing to Alberta's Climate Change and Emissions Management Fund.

D.12.4 CLIMATE CHANGE

This section defines the expected climate change in the region around the Project and identifies impacts on all stages of the Project from projected changes in climate factors. Climate change may affect construction, operation, decommissioning and reclamation stages of the development.

Assessment of climate change impacts is facilitated by climate change predictions. A large number of institutions around the world have developed global climate models that address a wide range of potential climate change scenarios based on various global growth and technology implementation approaches. The effect of global warming on climate variables in Alberta have been assessed by the Prairie Adaptation Research Collaborative (PARC) using IPCC growth scenarios and various international global climate models (GCMs).

Barrow and Yu (2005) assembled a series of climate projections from the GCM experiments for Alberta. Predictions 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 futures: cooler and wetter, cooler and drier, warmer and wetter, warmer and drier, and the median.

The climate change assessment for the Project included the following elements:

1.0 determine projections for climate parameters during the Project lifetime;

2.0 identify potential effects of climate change on Project stages; and

3.0 identify implications that climate change may have on the Project.

D.12.4.1 Predicted Climate Change

The existing and projected changes to the selected climate parameters are provided for the region near the Project. The selected parameters are:

- average annual temperature;
- annual precipitation;
- degree days; and
- annual moisture index.

Predicted median changes in the 2050s, near the expected end of the Project lifetime, for these parameters are listed in Table D.12.4-1.

Table D.12.4-1 Projected Climate Parameters near Fort McMurray - Median Change Scenario

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

D.12.4.2 Project Sensitivity to Climate Change

For the construction phase of the Project, extreme weather conditions may affect fugitive dust emissions and the frequency of windblown dust. Construction of the access roads, central processing facility, and initial well pads will occur early in the Project life. As most construction would take place in the near term, when climatic conditions will be similar to today's, the impact is low, and duration of the construction phase is short (*i.e.*, less than 2 years). 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.

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;

- increased precipitation may reduce fugitive dust from access and infield roadways and disturbed borrow pits, possibly balanced by additional drying from increased temperature. $PM_{2.5}$ concentrations, which primarily result from fuel combustion, are not expected to change; 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 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.

Mean annual temperatures are projected to increase over the life of the Project by about 2.4°C (Barrow and Yu 2005). January (coldest month) mean temperatures are projected to increase by 1.9°C (GCM experiments) although the observed rate of warming appears to have been greater than that predicted by model projections considered by Barrow and Yu.

For the decommissioning phase of the Project, 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. The anticipated change in climate over the life of the Project will have low to no impact on air quality associated with the Project.

D.12.5 MITIGATION AND MONITORING

D.12.5.1 Mitigation

To reduce GHG emissions, the Project will:

- use process equipment that will minimize GHG emissions including high-efficiency boilers, VRUs to reduce fugitive methane vapours, optimized and insulated piping to reduce pumping energy requirements and heat loss, *etc.*;
- use continuously improving Project technologies;
- comply with emission limits imposed on the Project as per the Specified Gas Emitters Regulation either through efficiency improvements, purchase of GHG offsets, or contributing to Alberta's Climate Change and Emissions Management Fund; and
- design the process with appropriate heat integration strategies to improve heat recovery and reduce energy demand.

D.12.5.2 Monitoring

Pengrowth will conduct source monitoring of produced gas composition and fuel use to determine GHG emissions.

D.13 LAND AND RESOURCE USE

D.13.1 INTRODUCTION

This section provides a description of existing land and resource uses within the land use study area (LSA) and an assessment of potential impacts to the land and resource use. Included in this section is a summary and discussion of the land use policies that govern development of the oil sands for the Project. As well, this section provides a summary of environmentally sensitive areas, parks reservations, unique features, and land ownership. Subsurface rights as it pertains to oil sands development, surface dispositions including mineral rights, industrial dispositions, trapelines, forestry resources, aggregate resources, access, recreation activities and traditional use within the Project Area is provided. Existing baseline information is provided as well as the potential impacts for the Project with proposed mitigation strategies.

ESRD issued the Terms of Reference for the Project on December 13, 2013. The specific requirements for the Land Use and Management 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 dispositions 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 such as Parks and Protected Areas, Heritage Rivers, Historic Sites, Environmentally Significant Areas, culturally significant sites and other designations (e.g., World Heritage Sites, Ramsar Sites, Internationally Important Bird Areas).

[D]. Describe and map land clearing activities, showing the timing of the activities.

[E]. Describe the status of timber harvesting arrangements, including species and timing.

[F]. 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) development and reclamation on commercial forest harvesting and fire management in the Project Area;

e) 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;

f) how the Project impacts Annual Allowable Cuts and quotas within the Forest Management Agreement area;

g) the operations of any agricultural crown leases and provincial grazing reserves;

h) anticipated changes (type and extent) to the topography, elevation and drainage patterns 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]. Describe how Integrated Land Management has been used (e.g., sharing of infrastructure, access requirements).

[C]. 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 Field Guide for the Upstream Oil and Gas Industry.

D.13.1.1 Study Area

The study area is comprised of approximately 72 sections of land. Approximately, 43 sections fall within the Pengrowth lease area and the study area boundary encompasses, at minimum, one off-setting section of land outside the lease boundary (Figure C.2.4-1). The off-setting lands have been included in the study area to ensure adjacent land uses are identified and potential impacts as a result of the Project evaluated. The study area was used to analyze the effects of the Project on land use and resource use for the study area.

The lease area is 11,132 ha in size and the study area is 30,713 ha.

D.13.1.2 Valued Environmental Components

The land and resource use VECs chosen for the assessment are outlined in Table D.13.1-1.

Table D.13.1-1 Summary of VECs and Indicator Parameters	
Valued Environmental Component	**Measurable Parameter**
Compatibility with land use planning	Land use policies (*i.e.*, zoning)
	Environmentally important areas
Compatibility with existing land uses and dispositions	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
	Hunting resources
	Recreation

D.13.1.3 Information Sources

Baseline information was collected and analyzed from the following information sources:

- existing provincial land use policies and municipal land use policies and bylaws;
- the geographic Land Information Management Planning System for surface dispositions (GLIMPS);
- publication on Environmental Sensitive Areas (ESAs);
- Abacus Datagraphics ABADATA database;
- various environmental assessment reports prepared for this Project (Consultant Reports provided in Volumes 2 and 3);
- Alberta government shapefiles; and
- conversations with various stakeholders.

D.13.2 BASELINE CONDITIONS

D.13.2.1 Land and Resource Use Policies

The Project is being developed on both Crown and private land. The Project is to be developed in accordance with a number of provincial land management policies and has also been developed in accordance with municipal land use polies and plans.

A brief account of the policies that apply to the proposed Project are highlighted as follows.

Lower Athabasca Regional Plan (LARP)

The Project lease partially falls within the south LARP boundary (Figure D.13.2-1) in eastern Alberta near Muriel Lake. Although the majority of the Project footprint does not fall within the LARP area, a number of planned wellheads, access roads, and soil storage piles do. The Projects study areas also fall partially within the LARP area. A brief summary of the LARP follows.

The LARP is one of the seven land-use regions established under Alberta's Land-Use Framework (LUF), released in December 2008. The LARP:

- establishes a long-term vision for the region;
- aligns provincial policies at the regional level to balance Alberta's economic, environmental and social goals;
- reflects ongoing commitment to engage Albertans, including aboriginal peoples, in land-use planning;
- uses a cumulative effects management approach to balance economic development opportunities and social and environmental considerations;
- sets desired economic, environmental and social outcomes and objectives for the region;
- describes the strategies, actions, approaches and tools required to achieve the desired outcomes and objectives;
- establishes monitoring, evaluation and reporting commitments to assess progress; and
- provides guidance to provincial and local decision-makers regarding land-use.

The vision for the Lower Athabasca region is to balance the region's diverse economic opportunities with social and environmental considerations using a cumulative effects management approach. Strategic directions for the region involve:

- improving integration of industrial activities;
- developing strategic directions for the region;
- managing air, water, and biodiversity and minimizing land disturbance;
- creating new conservation areas;
- strengthening infrastructure planning;
- providing new recreation and tourism opportunities; and
- inclusion of aboriginal peoples in land-use planning.

The LARP provides a strategic plan for the region with desired regional outcomes and establishes a set of strategic directions that help achieve the regional vision and outcomes. The LARP also provides an implementation plan and actions that will be undertaken to support achievement of the regional vision and outcomes and indicators to measure and evaluate progress.

Within the Lower Athabasca Region, integrated resource plans have been developed which identify objectives for long-term management of specific landscapes. The Cold Lake Sub-Regional Integrated Resource Plan, falls within a portion of the southern LARP zone.

North Saskatchewan Regional Plan

The southern half of the Land Use LSA is located within the North Saskatchewan Regional Plan (NSRP) area. Similar to LARP, NSRP is one of the seven land-use regions established under Alberta's LUF. As of 2013, the plan has not been developed or distributed for use.

Sub-Regional Integrated Resource Plan

The Project footprint falls within the Cold Lake Sub-Regional Integrated Resource Plan (IRP). The purpose of this plan is to obtain maximum economic, environmental, and social benefits through the coordinated management of public lands and resources within the area. This is partially achieved through the effective allocation of various resources within the area, to best suit environmental capabilities and provincial requirements.

To effectively manage resources, the Cold Lake area has developed a strategy consisting of a broad management outline, which is supported through individual strategies based on each resource.

"The broad management strategy for the Cold Lake planning area [focuses] on using the areas natural competitive advantage, building upon the significant resources that are its major strengths; energy, agriculture, forestry and recreation. More specifically, the plan provides for optimal development of oil sands resources; that is, development in a manner that does not compromise the natural environment or other resources. Particular care is taken to protect attributes such as water, fisheries, wildlife and aesthetic, along with recreation facilities, that make the planning area valuable for wildland and water based recreation" (Government of Alberta 1996).

Within the Cold Lake IRP zone, the Project Area falls under the Six Lakes, Twelve Lakes, La Corey-Moose Hills-Tulliby Lakes, and Many lakes Resource Management Areas (RMA); these areas each have their own sub-management objectives.

Six Lakes RMA consists of the areas within and immediately surrounding (800 m) Cold Lake, Marie Lake, Moose Lake, Frog Lake, Whitney Lake, and Muriel Lake, of which the latter is relevant to the Project. The management intent of these lakes is as major recreation destinations, with emphasis on protecting recreational and ecological values that contribute to their attractiveness. The Twelve Lakes RMA, which consists of the areas within and immediately surrounding (800 m) Bangs, Reita, Moosehills, Minnie, Garnier, Hilda, Little Bear, Long, Sinclair, Soars, Thompson and Tucker Lakes, has the same management intent of the Six Lakes RMA with more emphasis on smaller recreational development, such as campgrounds and trail systems (Government of Alberta 1996).

La Corey-Moose Hills Tulliby Lakes RMA includes all White Area lands in the Cold Lake area and is part of the Boreal Forest Ecoregion, with Aspen parkland to the south. Much of this land

is used for agriculture, or is suitable for grazing or cultivation, with Oil sands underlying the majority. Consequentially, much of the area is under lease. The management intent of this area is to conserve a healthy ecosystem and enhance wildlife resources, particularly moose populations (Government of Alberta 1996).

Lastly, the Many Lakes RMA is comprised of lands within 800 m of small lakes and streams. These water bodies are deemed to have little recreation or sport fishing opportunities, however, the surrounding lands are more appropriate for activities such as hunting, bird-watching, and educational or scientific research. The management intent for this RMA is "*to conserve critical wildlife habitat and populations, and sensitive watersheds and associated ecosystems*".

Comprehensive Regional Infrastructure Sustainability Plan for the Cold Lake Oil Sands Area

The Comprehensive Regional Infrastructure Sustainability Plan (CRISP) is a guideline for long-term infrastructure development in the Cold Lake Oil Sands Area (CLOSA). The CLOSA CRISP focuses on community development and identifies infrastructure needs related to transportation, water and wastewater servicing, education and health care.

The CRISP offers a phased approach to infrastructure planning, with each phase linked to oil production levels and associated population growth. This measured approach to planning allows the Government of Alberta to monitor growth and identify short term needs within the context of a long term plan.

The near term visions of the plan are outlined, ranging on topics from new transportation corridors to First Nations consultation. Two feasibility studies, one for a potential new north-south road linkage between Elizabeth and Fishing Lake Metis settlements, and one for the recommended Cold Lake regional waterline are planned, along with a business case for obtaining regularly scheduled air service into the area. The plan also aims to encourage the completion of Inter-municipal Development Plans, as well as consultation with First Nations and Metis to identify training needs for increased employment in the oil sands industry.

Industry will need to align its project planning with the CRISP: Industry roads and air facilities should, for example, be planned and developed to integrate with the broader CRISP transportation network, while worker accommodation practices should work in concert with growth solutions identified in the CRISP.

Municipal Land-Use Bylaws

Municipal District of Bonnyville No. 87

The Project lies within the southern boundary of the Municipal District of Bonnyville No. 87 (Figure A.1.0-1). The Project is subject to the Municipal District of Bonnyville No. 87 Land Use Bylaw No. 1207, March 2000 and amended June 12, 2013.

The Land Use Bylaw is a statutory document created to regulate and control the use and development of land and to achieve the orderly and economic development of land within the M.D. of Bonnyville No. 87. With the establishment of processes the Planning Department at the

M.D. of Bonnyville can use this bylaw to make decisions that enhance and support the quality of life to their communities.

All Project components lie within the municipality's 'Rural Industrial District', with natural resource extraction industries development, which includes oil and gas developments, being a permitted use. The land use LSA also encompasses three Country Residential Zones (CR, CR1, CR2) and an Intensive Recreation Zone. These zones exist primarily around the edge of Muriel Lake and are all located well away from any Project disturbances. None of these areas permit the development of natural resource extraction of processing.

County of St. Paul No. 19

The Project lies within the northern boundary of the County of St. Paul No. 19 (Figure A.1.0-1). The Project is subject to the County of St. Paul No. 19 Land Use Bylaw 2013-11.

The land use bylaw is a statutory document created to regulate and control the use and development of land and to achieve the orderly and economic development of land within the County of St. Paul No. 19. With the establishment of processes the Planning Department at the County of St. Paul can use this bylaw to make decisions that enhance and support the quality of life to their communities.

D.13.2.2 Oil Sands Leases and Permits

Pengrowth plans to develop the Lloydminster Formation for this Project. Within the LSA, there are 38 Oil Sands Leases (OSLs) and two Oil Sands Permits as shown in Table D.13.2-1 and Figure D.13.2-2.

Table D.13.2-1 Oil Sands Leases and Permits

Disposition	Disposition Holder	Location	Formation
Oil Sands Leases			
0727290120057	Baytex Energy Ltd.	06-060-03 W4M 01 and 02-060-04 W4M	Oil sands in the Sub-Colony Cretaceous
0757595040069		03-060-04 W4M	Oil sands in the L Colony to T McMurray
0747401030003	Canadian Natural Resources Limited	16 and 21-058-04 W4M	Oil sands in the Mannville Group excepting oil sands in the Lower Grand Rapids
0747404020506		N½ 06, 07, 16, 18 and 21-058-04 W4M	Oil sands in the Lower Grand Rapids
0747404050813		22-058-05 W4M	Oil sands in the Mannville Group excepting oil sands in the Grand Rapids Formation
0747407030001		04-060-04 W4M	Oil sands in the Mannville Group excepting oil sands in the L Colony to T McMurray

Table D.13.2-1 Oil Sands Leases and Permits

Disposition	Disposition Holder	Location	Formation
0747407080243		06-060-04 W4M	Oil sands in the Mannville Group excepting oil sands in the L Colony to T McMurray
0747407080530		01-059-04 W4M	Oil sands in the Mannville Group
0747492020357		34, 35 and 36-057-05 W4M	Oil sands in the Mannville Group
0747492020358		28 and 33-058-04 W4M	Oil sands in the Mannville Group
0747492020367		15-059-04 W4M	Oil sands in the Mannville Group
0747492020368		32-059-04 W4M	Oil sands in the Mannville Group
074749202A369		25 and 36-059-05 W4M 01-060-05 W4M	Oil sands in the Mannville Group
0747492100393		N½ 31-057-04 W4M S½ 06-058-04 W4M	Oil sands in the Mannville Group
0747492100395		N½ 08 and 17-058-04 W4M	Oil sands in the Mannville Group
0747494110463		S½ 31 and 32-057-04 W4M	Oil sands in the Mannville Group
0747495070502		04, 05, S½ 08 and 09-058-04 W4M	Oil sands in the Mannville Group
0747495070503		21 and 28-058-05 W4M	Oil sands in the Mannville Group
0747495070505		19 and 20-059-04 W4M	Oil sands in the Mannville Group
0747495070506		29 and 30-059-04 W4M	Oil sands in the Mannville Group
074749507A506		31-059-04 W4M	Oil sands in the Mannville Group
0747497120893		N½ 06, 07 and 18-058-04 W4M	Oil sands below the top of the Mannville Group to the top of the Lower Grand Rapids
0747497120894		01, 02, E½ 03, 10, 11, 12, 13 and 14-058-05 W4M	Oil sands below the base of the Grand Rapids Formation to the base of the Mannville Group
0747497120895		W½ 03, 04 and 09-058-05 W4M	Oil sands below the base of the Grand Rapids Formation to the base of the Mannville Group
0757595040420		04-060-04 W4M	Oil sands in the L Colony to T McMurray
075759504A069		05 and 06-060-04 W4M	Oil sands in the L Colony to T McMurray
075759504B069		07, 18, 19, 30 and W½ 31-059-03 W4M 02, 03, 04, 08, 10, 11, 18, 27 and 28-059-04 W4M	Oil sands in the L Colony to T McMurray
075759609A625		16-058-05 W4M	Oil sands in the Mannville Group
0747413070191	Cavalier Land Ltd.	03 and 10-059-05 W4M	Oil sands in the Mannville Group

Table D.13.2-1 Oil Sands Leases and Permits

Disposition	Disposition Holder	Location	Formation
0747493060419	Canadian Natural Resources Ltd. (50%) & Devon NEC Corporation (50%)	33-057-04 W4M	
0747412070246	Madison Land Co. Ltd.	06-060-03 W4M	Oil sands in the Mannville Group excepting oil sands in the Sub-Colony Cretaceous
0727288080033	Pengrowth Energy Corporation	19, 20, 29, 31 and 32-058-04 W4M 05, 06 and 07-059-04 W4M 26, 27, 34, 35 and 36-058-05 W4M 01, 02, 11, 12, 13 and 14-059-05 W4M	Oil sands in the Mannville Group
072728808A033		30-058-04 W4M 23, 24 and 25-058-05 W4M	Oil sands in the Mannville Group
0757596090625		15-058-05 W4M	Oil sands in the Mannville Group
0757598040172		12, 13, 23, 24, 25, 26, 33, 34, 35 and 36-059-04 W4M	Oil sands in the Mannville Group
0757598120181		31, 32 and 33-057-05 W4M 01, 02, 03, 04, 06, 07, 09, 10, 11, 12, 13, 14, 18 and 22-058-05 W4M	Oil sands in the Grand Rapids Formation
0747407080526	Sandstone Land & Mineral Company Ltd.	06-059-03 W4M	Oil sands in the Mannville Group
0747495070504	Windfall Resources Ltd.	09, 16, 21 and 22-059-04 W4M	Oil sands in the Mannville Group
Oil Sands Permits			
0707010080617	Scott Land & Lease Ltd.	17-059-04 W4M	Oil sands in the Mannville Group
0707010080661	Scott Land & Lease Ltd.	14-059-04 W4M	Oil sands in the Mannville Group

D.13.2.3 Petroleum and Natural Gas Leases

Thirty-five 5 Year Plains Petroleum and Natural Gas Leases, three Natural Gas Leases and 11 Petroleum and Natural Gas Leases are held in the LSA, as shown in Table D.13.2-2 and Figure D.13.2-3 (A and B).

Table D.13.2-2 Petroleum and Natural Gas Leases within in Land Use Study Area

Disposition	Disposition Holder	Location	Formation
5 Year Plains Petroleum and Natural Gas Lease			
0040490010499	Barnwell of Canada, Limited (11.25%) & Bonavista Energy Corporation (88.75%)	01 and 12-059-05 W4M	To the base of the Mannville Group
0040489110596	Barnwell of Canada, Limited (11.25%) & Gear Energy Ltd. (88.75%)	03 and 05-060-04 W4M	To the base of the Mannville Group
0040400070432	Baytex Energy Ltd.	21-058-05 W4M	To the base of the Mannville Group
0040405030281		14-059-05 W4M	To the base of the Viking Formation
0040499030428		13-059-05 W4M	To the base of the Mannville Group
0040400010226	Bonavista Energy Corporation	28-059-04 W4M	To the base of the Mannville Group
0040480080204		23, 25, 26, 33, 34 and 35-059-04 W4M	To the base of the Mannville Group
0040481090175		29, 30, 31 and 32-058-04 W4M 23, 24, 25, 26 and 36-058-05 W4M	To the base of the Mannville Group
0040494030387		24-059-04 W4M	To the base of the Mannville Group
0040499030427		11-059-05 W4M	To the base of the Mannville Group
0040400080117	Canadian Natural Resources Limited	18-058-04 W4M	To the base of the Mannville Group
0040405060779		06-058-04 W4M	Below the base of the Viking Formation to the base of the Mannville Group
0040410010116		31-059-03 W4M	
0040410010305		12-059-04 W4M	
0040410010312		06-060-03 W4M	
0040479010144		32 and 33-057-05 W4M 04 and 09-058-05 W4M	To the base of the Grand Rapids Formation
0040488040397		36-059-05 W4M	To the base of the Mannville Group
0040495030940		32-057-04 W4M	Below the base of the Viking Formation to the base of the Mannville Group
0040495030947		07-058-04 W4M	Below the base of the Viking Formation to the base of the Mannville Group
0040496120186		34-057-05 W4M	To the base of the Mannville Group
0040496120187		35-057-05 W4M	To the base of the Mannville Group
0040496120188		36-057-05 W4M	To the base of the Mannville Group
0040496120189		01-058-05 W4M	To the base of the Mannville Group

Table D.13.2-2 Petroleum and Natural Gas Leases within in Land Use Study Area

Disposition	Disposition Holder	Location	Formation
0040400070179	Conserve Oil & Gas No. II Corporation (80.00%) & Conserve Oil Corporation (20.00%)	32-059-04 W4M	To the base of the Mannville Group
0040407010153		19-059-03 W4M	To the base of the Mannville Group, excepting natural gas in the Upper Colony
0040481120340		08 and 10-059-04 W4M	To top of McMurray
0040400070174	Conserve Oil Corporation (50.00%) & Crescent Point Energy Corp. (50.00%)	18-059-03 W4M	To the base of the Mannville Group
0040400070444		18-059-04 W4M	To the base of the Mannville Group
0040495010584		24-059-05 W4M	To the base of the Mannville Group
0040495010585		25-059-05 W4M	To the base of the Mannville Group
0040490010497	Crescent Point Energy Corp.	15-059-04 W4M	To the base of the Mannville Group
0040490010503	Husky Oil Operations Limited	20 and 35-058-05 W4M	To the base of the Mannville Group
0040410010117	Scott Land & Lease Ltd.	04-060-04 W4M	
0040410010304		11-059-04 W4M	
0040410010306		14-059-04 W4M	
0040410010307		17-059-04 W4M	
Natural Gas Lease			
002 1436	Conserve Oil Corporation (20.00%) & Conserve Oil & Gas No. II Corporation (80.00%)	19 and 30-059-03 W4M 27-059-04 W4M	Natural gas in the Upper Colony
002 770	The Canadian Salt Company Limited	13 and 18-058-05 W4M	Natural gas in the Upper Mannville Formation
002 771		06, 07, 10, 11 and 12-058-05 W4M	Natural gas in the Viking Formation and Upper Mannville Formation
Petroleum and Natural Gas Lease			
001 33653	Baytex Energy Ltd. (50.00%) & Marquee Energy Ltd. (50.00%)	32 and 33-058-05 W4M	To the base of the Mannville Group
001 38474	Bonavista Energy Corporation	02-060-04 W4M	To the base of the Mannville Group, excepting natural gas in the Sub-Colony Cretaceous
001 33652	Canadian Natural Resources Limited	16-058-05 W4M	To the base of the Mannville Group
001 41576		04, 05, 06, 07, 08 and 09-058-04 W4M	To the base of the Mannville Group (Section 9); to the base of the Viking Formation (Sections 4 to 8)
001 41577		16 and 21-058-04 W4M	To the base of the Mannville Group
001 6857		15-058-05 W4M	To the base of the Mannville Group

Table D.13.2-2 Petroleum and Natural Gas Leases within in Land Use Study Area			
Disposition	**Disposition Holder**	**Location**	**Formation**
001 41575	Canadian Natural Resources Limited (50.00%) & Devon NEC Corporation (50.00%)	04, 05, 12 and 13-27, 28, 29, 31, 32, 33 and 04, 05, 12 and 13-34-057-04 W4M	To the base of the Mannville Group (Section 33); to the base of the Viking Formation (27, 28, 29, 31, 32, 34)
001 38474A	Conserve Oil & Gas No. II Corporation (80.00%) & Conserve Oil Corporation (20.00%)	01 and 12-060-04 W4M	To the base of the Mannville Group, excepting petroleum and natural gas in the Sub-Colony Cretaceous
001 9244		21 and 22-059-04 W4M	To the base of the Mannville Group
001 9245		19, 20, 29, 30 and 31-059-04 W4M	To the base of the Mannville Group
001 38115	Gear Energy Ltd.	09 and 16-059-04 W4M	To the base of the Mannville Group

D.13.2.4 Metallic and Industrial Minerals Leases

There are two metallic and industrial mineral permits within the LSA as identified in Table D.13.2-3 and Figure D.13.2-3.

Table D.13.2-3 Metallic and Industrial Minerals Leases		
Disposition	**Disposition Holder**	**Location**
074749202A369	Smith, Angela Erin	25 and 36-059-05 W4M 01-060-05 W4M
075759504A069		05, 06, 07, 08, 09, 10, 17 and 18-060-04 W4M

D.13.2.5 Surface Dispositions

Industrial Land Dispositions

There are numerous industrial land dispositions within the LSA as presented in Table D.13.2-4 and Figure D.13.2-4 (A to C).

Table D.13.2-4 Summary of Industrial Land Use Dispositions				
Surface Activity	**Definition**	**Disposition Holder**	**Number of Dispositions Held**	**Purpose**
EZE	Easement	Armand D.	1	Transmission Line
		ATCO Electric Ltd.	9	Transmission Line
		Claude R.	2	Transmission Line
		Leonard J.	1	Transmission Line
		Marcel F.	1	Transmission Line
		Paul B.	1	Transmission Line

Table D.13.2-4 Summary of Industrial Land Use Dispositions

Surface Activity	Definition	Disposition Holder	Number of Dispositions Held	Purpose
LOC	License of Occupation	AltaGas Ltd.	2	Timber Logging Road/Pipeline
		Arthur K.	1	Timber Logging Road
		Baytex Energy Ltd.	9	Mineral Surface
		Bonavista Energy Corporation	11	Mineral Surface; Timber Logging Road
		Bonnyville 87, M.D. of	3	Timber Logging Road
		Canadian Natural Resources Limited	49	Mineral Surface; Timber Logging Road
		Chinook Energy Inc.	1	Mineral Surface
		Conserve Oil & Gas No. II Corporation	3	Mineral Surface; Timber Logging Road
		Conserve Oil Corporation	3	Mineral Surface
		Enbridge Pipelines (Athabasca) Inc.	1	
		Gear Energy Ltd.	4	Mineral Surface; Timber Logging Road
		Husky Oil Operations Limited	4	Mineral Surface; Timber Logging Road
		Koch Oil Sands Operating ULC	1	Mineral Surface
		Melvin S.	1	Timber Logging Road
		Mervyn B.	1	Timber Logging Road
		Pengrowth Corporation	28	Mineral Surface; Timber Logging Road; Pipeline
		Telus Communications Inc.	1	Timber Logging Road
		Zargon Oil & Gas Ltd.	1	Mineral Surface
MLL	Miscellaneous Lease	ATCO Electric Ltd	1	Mineral Surface
		Bonnyville 87, M.D. of	1	General Survey
		Pengrowth Energy Corporation	1	Mineral Surface
MLP	Miscellaneous Permit	Francis D.	1	Mineral Surface
MSL	Mineral Surface Lease	Baytex Energy Ltd.	8	Mineral Surface
		Bonavista Energy Corporation	19	Mineral Surface
		Canadian Natural Resources Limited	61	Mineral Surface
		Chinook Energy Inc.	3	Mineral Surface
		Conserve Oil & Gas No. II Corporation	5	Mineral Surface
		Conserve Oil Corporation	1	Mineral Surface
		Gear Energy Ltd.	3	Mineral Surface

Table D.13.2-4 Summary of Industrial Land Use Dispositions

Surface Activity	Definition	Disposition Holder	Number of Dispositions Held	Purpose
		Husky Oil Operations Limited	1	Mineral Surface
		Koch Oil Sands Operating ULC	2	Mineral Surface
		Pengrowth Corporation	34	Mineral Surface
		Petrobakken Energy Ltd.	1	Mineral Surface
		The Canadian Salt Company Limited	1	Mineral Surface
PIL	Pipeline Installation Lease	AltaGas Ltd.	1	Pipeline
		AltaGas Utilities Inc.	1	Pipeline
		Bonavista Energy Corporation	1	Pipeline
		Cold Lake Pipeline Ltd.	1	Pipeline
		Enbridge Pipelines (Athabasca) Inc.	3	Transmission Line; Pipeline
		Husky Oil Operations Limited	1	Pipeline
PLA	Pipeline Agreement	AltaGas Ltd.	13	Pipeline
		AltaGas Utilities Inc.	4	Pipeline
		Baytex Energy Ltd.	5	Pipeline
		Bonavista Energy Corporation	14	Pipeline
		Canadian Natural Resources Limited	30	Pipeline
		Chinook Energy Inc.	3	Pipeline
		Cold Lake Pipeline Ltd.	3	Pipeline
		Conserve Oil & Gas No. II Corporation		Pipeline
		Enbridge Pipelines (Athabasca) Inc.	6	Pipeline
		Gear Energy Ltd.	2	Pipeline
		Husky Oil Operations Limited	5	Pipeline
		Murphy Oil Company Ltd.		Pipeline
		North East Gas Co-op Ltd.	2	Pipeline
		Pengrowth Energy Corporation	4	Pipeline
		Pipeline Management Inc.	3	Pipeline
		TAQA North Ltd.	1	Pipeline
		The Canadian Salt Company Ltd.	1	Pipeline
RDS	Roadway	St. Paul 19, County of		Reservation/Notation Plans

Table D.13.2-4 Summary of Industrial Land Use Dispositions

Surface Activity	Definition	Disposition Holder	Number of Dispositions Held	Purpose
RIA	Range Improvement Agreement	Aarbo Ranching Ltd.		
		Garnier Lake Grazing Association		
		George V.		
		Philippe V.		
		Robert H.		
		Smoky Lake Grazing Association		
		Westman Farms Ltd.		
		William A.		
ROE	Right-of-Entry Agreement	Gear Energy Ltd.		General Survey
RRD	Registered Roadway	Bonnyville 87, M.D. of	8	Roadway
		St. Paul 19, County of	2	Roadway
		Transportation	1	Roadway
TFA	Temporary Field Authorization	Bonnyville Snowdusters Snowmobile Club	3	
		Canadian Natural Resources Limited	7	
		Cold Lake Pipeline Ltd.	4	
		Enbridge Pipelines (Athabasca) Inc.	2	
		Pengrowth Energy Corporation	13	
		Roger A.	1	
VCE	Vegetation Control Easement	ATCO Electric Ltd.		Transmission Line

Trapping and Traditional Ecological Knowledge

Seven Trapping Area (TPA) dispositions are held within the LSA (Table D.13.2-5, Figure D.13.2-5). There is one trapper's cabin within the LSA, located at 1-059-05 W4M (Figure D.13.2-5).

Table D.13.2-5 Trapping Area Dispositions

TPA #	Disposition Holder	Location
40	Robert B.	• 7, 18, 19, 30 and 31-059-03 W4M • 10, 11, 12, 13, 14, 15, E½ 22, 23, 24, 25, 26, E½ 27, E½ 34, 35 and 36-059-04 W4M
384	Georges B.	• E½ 20, 21, W½ 22, W½ 27, 28, E½ 29, E½ 32, 33 and W½ 34-059-04 W4M • 6-060-03 W4M • 1, 2, 3, 4 and E½ 5-060-04 W4M
386	Thomas M.	• N½ 3, N½ 4, 10 and 15-059-05 W4M
396	Raymond F.	• 6-059-03 W4M • 4, 5, 6, 7, 8, 9, 16, 17, 20, 21, 28, 29, 32, 33, 34, 35 and 36-058-04 W4M • 1, 2 and 3-059-04 W4M • 1 and 12-058-05 W4M
416	Francis D.	• 18, 19, 30 and 31-058-04 W4M • 4, 5, 6, 7, 8, 9, 16, 17, 18, 19, W½ 20, W½ 29, 30, 31 and W½ 32-059-04 W4M • W½ 5 and 6-060-04 W4M • 13, 24, 25 and 36-058-05 W4M • 1, 2, 11, 12, 13, 14, 24, 25 and 36-059-05 W4M • 1-060-05 W4M
424	Richard N.	• 9, 10, 11, 14, 15, 16, 21, 22, 23, 26, 27, 28, 33, 34 and 35-058-05 W4M • S½ 3 and S½ 4-059-05 W4M
426	Clarence F.	• 31-058-03 W4M

Forestry Resources

The Project is located within Forestry Management Unit (FMU) L01, which currently has no Forestry Management Agreements (FMA) held within it.

Aggregate Resources

There are three surface material licence (SMC) dispositions within the LSA. All three dispositions are held by Pengrowth for the purpose of non-manufactured clay.

Crown Reservations

There are numerous consultative notations (CNT) and protective notations (PNT) within the LSA as presented in Table D.13.2-6 and Figure D.13.2-6.

Table D.13.2-6 Summary of Crown Reservations

Disposition	Disposition Holder	Purpose	Location
Consultative Notations			
020209	Bonnyville Office - Land Use Area- Lands Division Dept. of Sustainable Resource Dev	Snowmobile Trails	16 to 21, and 28 to 33-058-04 W4M 03, 04, 10, 15, 21, 22, 27 to 29, and 32 to 34-059-04 W4M 03 to 05-060-04 W4M
920020	St Paul Office - Rangeland District- Lands Division Dept. of Sustainable Resource Dev	Range Improvement Plan	01, 06, 07, and 12-059-04 W4M 31-058-03 W4M
920025	St Paul Office - Rangeland District- Lands Division Dept. of Sustainable Resource Dev	Range Improvement Plan	25 to 29-059-04 W4M 33 to 36-059-04 W4M 03-060-04 W4M
920028	St Paul Office - Rangeland District- Lands Division Dept. of Sustainable Resource Dev.	Range Improvement Plan	25 and 36-058-05 W4M 12-059-05 W4M
920030	Bonnyville Office - Rangeland District-Lands Division Dept. of Sustainable Resource Dev	Range Improvement Plan	01-060-04 W4M
920110	Bonnyville Office - Rangeland District-Lands Division Dept. of Sustainable Resource Dev	Range Improvement Plan	30 and 31-059-03 W4M 06-060-03 W4M
920171	St Paul Office - Rangeland District- Lands Division Dept. of Sustainable Resource Dev	Range Improvement Plan	05 to 07-058-04 W4M
920252	St Paul Office - Rangeland District- Lands Division Dept. of Sustainable Resource Dev	Watershed Protection	05 to 07-058-04 W4M
920253	Bonnyville Office - Rangeland District-Lands Division Dept. of Sustainable Resource Dev	Watershed Protection	18 and 19-059-03 W4M 30-059-03 W4M
970030	St Paul Office - Rangeland District- Lands Division Dept. of Sustainable Resource Dev	Range Improvement Plan	14 and 15-059-04 W4M
Protective Notations			
010137	St Paul Office - Rangeland District- Lands Division Dept. of Sustainable Resource Dev	Land Use Protection	13-059-05 W4M 13 to 15, and 24-059-05 W4M
020230	St Paul Office - Fish and Wildlife Dept. of Sustainable Resource Dev	Rare and Endangered Species Habitat Protection Area	14-059-05 W4M
030206	St Paul Office - Fish and Wildlife Dept. of Sustainable Resource Dev	Rare and Endangered Species Habitat Protection Area	22, 23, 25, and 36-059-05 W4M

Table D.13.2-6 Summary of Crown Reservations

Disposition	Disposition Holder	Purpose	Location
070059	Lac la Biche Office - Fish and Wildlife Dept. of Sustainable Resource Dev	Colonial Nester Habitat Protection Area	30 and 31-059-03 W4M
070060	Lac la Biche Office - Fish and Wildlife Dept. of Sustainable Resource Dev	Colonial Nester Habitat Protection Area	25 and 36-059-04 W4M
080067	St Paul Office - Fish and Wildlife Dept. of Sustainable Resource Dev	Rare And Endangered Species Habitat Protection Area	14, 15, 22, and 23-059-05 W4M 01-060-05 W4M
110067	Transportation	Surface Materials Potential	14 to 16, 22, and 23-059-04 W4M
120021	St Paul Office - Rangeland District- Lands Division Dept. of Sustainable Resource Dev	Study Area	13 and 24-058-05 W4M
700064	Bonnyville Office - Rangeland District-Lands Division Dept. of Sustainable Resource Dev	Lakeshore Protection	06, 30, and 31-059-03 W4M
700071	St Paul Office - Rangeland District- Lands Division Dept. of Sustainable Resource Dev	Organic/Poorly Drained Soils	01, 04, and 09-058-05 W4M
700660	St Paul Office - Fish and Wildlife Dept. of Sustainable Resource Dev	Waterfowl Production Area	01-058-05 W4M
710006	St Paul Office - Fish and Wildlife Dept. of Sustainable Resource Dev	Waterfowl Production Area	36-058-04 W4M
712077	St Paul Office - Rangeland District- Lands Division Dept. Of Sustainable Resource Dev	Lakeshore Protection	31-058-03 W4M
712078	St Paul office - Fish and Wildlife Dept. of Sustainable Resource Dev	Waterfowl Production Area	31-058-03 W4M
712091	St Paul Office - Rangeland District- Lands Division Dept. of Sustainable Resource Dev	Lakeshore Protection	34 to 36-058-04 W4M
721793	St Paul Office - Fish and Wildlife Dept. of Sustainable Resource Dev	Waterfowl Habitat Protection Area	06-059-03 W4M
721796	St Paul Office - Rangeland District- Lands Division Dept. of Sustainable Resource Dev	General Topographic Constraints	01 to 17, 21 to 29, and 33 to 36-059-04 W4M

Table D.13.2-6 Summary of Crown Reservations

Disposition	Disposition Holder	Purpose	Location
721797	Bonnyville Office - Rangeland District-Lands Division Dept. of Sustainable Resource Dev	General Topographic Constraints	01 to 05-060-04 W4M
742805	St Paul Office - Rangeland District- Lands Division Dept. of Sustainable Resource Dev	Fragmented Land Pattern	17-059-04 W4M
770063	Tourism, Parks And Recreation - Parks And Protected Areas	Provincial Recreational Area Potential	13 to 14-059-05 W4M
776214	Bonnyville Office - Land Use Area- Lands Division Dept. of Sustainable Resource Dev	Lakeshore Recreational Site Potential	14-059-05 W4M
780068	St Paul Office - Rangeland District- Lands Division Dept. of Sustainable Resource Dev	General Topographic Constraints	13, 16, 21, 24 to 28, and 33 to 36-058-05 W4M
810023	Bonnyville Office - Rangeland District-Lands Division Dept. Of Sustainable Resource Dev	General Topographic Constraints	06, 07, 18, and 19-059-03 W4M
820300	Bonnyville Office - Rangeland District-Lands Division Dept. of Sustainable Resource Dev	Lakeshore Protection	03-060-04 W4M
840247	St Paul Office - Rangeland District- Lands Division Dept. of Sustainable Resource Dev	Fragile Slope Hazard	18 and 19-059-04 W4M
860177	Bonnyville Office - Rangeland District-Lands Division Dept. of Sustainable Resource Dev	Organic/Poorly Drained Soils	05 and 06-060-04 W4M
860184	St Paul Office - Rangeland District- Lands Division Dept. of Sustainable Resource Dev	Steep, Rolling Topography	29 and 32-059-04 W4M
860317	St Paul Office - Rangeland District- Lands Division Dept. of Sustainable Resource Dev	Adverse Soil Characteristics	15, 22, 25, 26, 27, and 36-058-05 W4M
860343	St Paul Office - Rangeland District- Lands Division Dept. of Sustainable Resource Dev	Adverse Soil Characteristics	01 and 12-059-05 W4M
860344	St Paul Office - Rangeland District- Lands Division Dept. of Sustainable Resource Dev	General Topographic Constraints	01 to 04, 10, and 11-059-05 W4M
890327	St Paul Office - Rangeland District- Lands Division Dept. of Sustainable Resource Dev	Adverse Soil Characteristics	16-058-05 W4M

Table D.13.2-6 Summary of Crown Reservations			
Disposition	**Disposition Holder**	**Purpose**	**Location**
900028	St Paul Office - Rangeland District- Lands Division Dept. of Sustainable Resource Dev	Steep, Rolling Topography	04 to 07-058-04 W4M
900029	Bonnyville office - Land Use Area- Lands Division Dept. of Sustainable Resource Dev	Potential Reservoir Area	05 to 07-058-04 W4M
910126	Bonnyville Office - Land Use Area- Lands Division Dept. of Sustainable Resource Dev	Lakeshore Recreational Site Potential	18 and 19-058-04 W4M
940241	St Paul Office - Rangeland District- Lands Division Dept. of Sustainable Resource Dev	Water Resource Management Area	24 and 25-059-05 W4M
950062	St Paul Office - Fish And Wildlife Dept. of Sustainable Resource Dev	Lakeshore Habitat Protection Area	30-059-03 W4M

Grazing Leases

There are grazing leases (GRL) across the majority of Crown land within the LSA. Grazing lease holders are presented in Table D.13.2-7 and Figure D.13.2-7.

Table D.13.2-7 Summary of Grazing Lease Holders		
GRL #	**Disposition Holder**	**Location**
000020	Aarbo Ranching Ltd.	31-058-03 W4M
080006	Arthur K.	30 and 31-059-04 W4M
090033	Barbara K.	29 and 32-059-04 W4M
16672	Beatrice G.	14 and 15-059-04 W4M
35296	Blair C.	04 and 09-058-05 W4M
35919	Bristow Ranching Ltd.	16, 21, 28, and 33-058-05 W4M
35922	David O.	01, 06, 07, and 12-059-04 W4M
36047	Donna L.	04 to 07-058-04 W4M
36466	Duane B.	36-058-04 W4M
36770	Garnier Lake Grazing Association	04, 05, 08, 09, 16 to 21, and 28 to 35-058-04 W4M 01 to 12-059-04 W4M
36782	George V.	01, 12 to 14, 23, 24, and 36-057-05 W4M
36881	Hillebrand Farms Ltd.	33-058-05 W4M 04 and 15-059-05 W4M

Table D.13.2-7 Summary of Grazing Lease Holders		
GRL #	**Disposition Holder**	**Location**
36989	John H.	18 and 19-059-04 W4M 13 and 24-059-05 W4M
37886	Lisa R.	15, 22, 26, 27, 34, and 35-058-05 W4M
37925	Michael C.	12 and 13-059-05 W4M 25 and 36-058-05 W4M
38239	Myles K.	03 to 05-060-04 W4M
38858	Robert H.	14 and 15-059-05 W4M
39220	Roger A.	05 and 06-060-04 W4M
39272	Shane F.	14, 15, 21 to 23, 26, and 27-059-04 W4M
39289	Stephen L.	01 to 03, 10, and 11-059-05 W4M
39439	U & E Herde Ranch Ltd.	25 to 29, and 33 to 36-059-04 W4M 03-060-04 W4M
40174	Victor R.	18, 19, and 30-059-03 W4M
40320	Westman Farms Ltd.	02-060-04 W4M
780380	Wilfred B.	01-060-04 W4M
820305	Bristow Ranching Ltd.	13, 24, and 25-059-04 W4M
870268	Robert H.	31-059-03 W4M 06-060-03 W4M
950007	John H.	07, 18, and 19-058-04 W4M
970058	Victor R.	16 and 17-059-04 W4M

D.13.2.6 Land Ownership

The lands within the land use study area are a mixture of Freehold and Crown land. Freehold land is identified in Table D.13.2-8 and Figure D.13.2-7.

Table D.13.2-8 Summary of Freehold Land Ownership	
Land Owner	**Location**
Alfred O.	33 and 34-057-05 W4M 02, 10, 11, 14, 15, 22, and 23-058-05 W4M
Alfred and Loretta O.	05-058-04 W4M
Beverly O.	30-059-04 W4M
Blair C.	10 and 15-058-05 W4M
Bruno K.	35-057-05 W4M
Calvin and Darren T.	16-059-04 W4M
Canadian Worldwide Energy Limited	30 and 31-059-04 W4M
Catherine A.	01 and 06-060-04 W4M

Table D.13.2-8 Summary of Freehold Land Ownership

Land Owner	Location
Claude and Paulette R.	01-060-05 W4M
Cody and Kyla L.	33-057-05 W4M
Cory C. and Melonie G.	32-059-04 W4M
Dallas G.	30-059-04 W4M
Daniel and Wilfred B.	19-059-04 W4M
David H.	03-058-05 W4M
David K. and Kristen T.	10-058-05 W4M
DDM Development Corp. Ltd.	18-059-04 W4M
Dennis H.	33-057-04 W4M
Diane Vachon	32-059-04 W4M
Diane and Philippe V.	31 and 32-059-04 W4M 04 and 06-060-04 W4M
Donald and Carol-Ann C.	30-059-04 W4M
Dwayne and Marie Y.	01-060-05 W4M
Edward R. and Tracey T.	30 and 31-059-04 W4M
Ernest L. and Dave C.	10-058-05 W4M
Erwin K.	16, 17, 20, and 21-059-04 W4M
Florent and Tracy D.	30-059-04 W4M
Fred and Mona B.	32-057-04 W4M
George J and Gilles V.	18 and 19-059-04 W4M
Gilles J V.	06-060-04 W4M
Gilles L.	29-059-04 W4M
Glen and Cathy O.	03 and 10-058-05 W4M
Glen and Marlon O.	12-059-05 W4M
Helene V.	17 and 20-059-04 W4M
Henry F.	06-060-04 W4M
Jessie and Ernest D.	20-059-04 W4M
John and Ella H.	03 and 07-058-04 W4M
Keith B. and Becky D.	29-059-04 W4M
Kenelm M., Richard M., Barbara G., and Heather B.	15-059-05 W4M
Kenneth W.	05 and 08-058-04 W4M
Kenneth and Nellie H.	31 and 32-057-04 W4M 35-057-05 W4M 03 and 10-058-05 W4M
Kenneth H., Nellie H., Michael L., and Kenna L.	34-057-05 W4M
Kenneth L and Donna S.	35-057-05 W4M

Table D.13.2-8 Summary of Freehold Land Ownership

Land Owner	Location
Kestutis O.	02 and 11-058-05 W4M
Kevin and Samantha K.	14-059-05 W4M
Kevin and Deborah L.	34-057-05 W4M
Lane L.	08-058-04 W4M
Larry W.	15-058-05 W4M
Le Diocese de Saint Paul	19-059-04 W4M
Loretta O.	35-057-05 W4M 03-058-05 W4M
Marc and Robin O.	19-059-04 W4M
Mark and Robbi A.	35-057-05 W4M
Melvin B. and Randy O.	33-057-04 W4M
Michael and Martha C.	32-059-04 W4M
Michael G and Kenna L.	31-057-04 W4M
Michelle H. and Christopher P.	36-057-05 W4M
Mildred and Trevor D.	32-057-04 W4M
Myles O.	34 and 36-057-05 W4M
Randy and Myles O.	06-058-04 W4M
Reginald B.	36-059-05 W4M
Reginald K.	32-059-04 W4M
Richard M. and Lisa B.	32-059-04 W4M
Robert O.	34 and 36-057-05 W4M
Scott R.	30 and 31-059-04 W4M
Shane and Joanne L.	32-059-04 W4M
Shawn C.	30 and 31-059-04 W4M
Stewart and Beverly P.	31-057-04 W4M
Terence B.	24 and 25-059-05 W4M
The County of St. Paul No. 19.	16-058-05 W4M
The Municipal District of Bonnyville No. 87	13-059-05 W4M
Timothy K.	30-059-04 W4M
Travis D.	10-058-05 W4M
Victor R.	18 and 19-059-04 W4M
Victor and Greta R.	16-059-04 W4M
Westman Farms Ltd.	32-057-04 W4M
Wilfred B.	19 and 30-059-04 W4M 04 and 05-060-04 W4M

Table D.13.2-8 Summary of Freehold Land Ownership	
Land Owner	**Location**
Wilfred and Terence B.	25-059-05 W4M
William and Edna Z.	35-057-05 W4M

D.13.2.7 Areas of Environmental Sensitivity

ESRD Wildlife Sensitivity Areas

ESRD has identified 19 wildlife sensitivity areas throughout the province and includes caribou zones, key wildlife and biodiversity zones, mountain goat and sheep areas, and grizzly bear zones.

A key wildlife and biodiversity zone is present in the northern section of the LSA (Figure D.13.2-8). These zones are areas of key winter ungulate habitat, with higher potentials for biodiversity. The areas differ from one another by displaying differing levels of riparian diversity and winter ranges for ungulates. In general, these zones act as an area of high winter food density, thereby reducing the need for movement and expenditure of much needed energy (Government of Alberta 2010).

Industrial activity may disrupt these zones by causing stress to ungulates within the area. The stress may be a product of disruptive activities and noise, decreased or limited access to vital areas, and/or relocation to less abundant food zones. It is therefore the objective of The Key Wildlife and Biodiversity Zone to:

- protect the long term integrity and productivity of key ungulate winter ranges and river corridors where ungulates concentrate;
- protect locally and regionally-significant wildlife movement corridors;
- protect areas with rich habitat diversity and regionally-significant habitat types; and
- protect key hiding and thermal cover for wildlife (Government of Alberta 2010).

Strategies for reaching these goals are include:

- reduce vegetation removal by minimizing any industrial activity;
- reduce access by avoiding development of new routes, and where possible find alternative access points, or temporary options. If a permanent access is required and access management plan and associated approval will be required;
- minimize the amount of activity that will take place during the winter months; and
- follow general timing restrictions:
  - all key wildlife and biodiversity zones North of HWY#1 should have no construction between Jan 15th and April 30th; and

- all key wildlife and biodiversity zones South of HWY#1 and West of Hwy #2 should have no construction between December 15th and April 30th (Government of Alberta 2010).

Environmentally Significant Areas

Under the Environmentally Significant Area Provincial Update 2009 (ESA 2009) ESAs represent places in Alberta that are important to the long-term maintenance of biological diversity, soil, water, or other natural processes, at multiple spatial scales. They are identified as areas containing rare or unique elements in the province, or areas that include elements that may require special management consideration due to their conservation needs. ESAs do not represent government policy and are not necessarily areas that require legal protection, but instead are intended to be an information tool to help inform land use planning and policy at local, regional and provincial scales.

Portions of the LSA lie within the internationally significant ESA #488 and provincially significant ESA #484 (Figure D.13.2-8). ESA #488 - surrounding Muriel Lake - is labeled as internationally significant as it contains a conservation concern regarding the Piping plover, contains important wildlife habitat and contains the Muriel Lake Important Bird Area, which is a site of recognized significance (ESA 2009). The Piping plover (*Charadrius melodus circumcinctus*) is ranked as S2B (breeding population is sub-nationally imperiled) and is labeled as endangered by the Wildlife Act, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and the Species at Risk Act (SARA) (ESA 2009). ESA #484 is a provincially significant area surrounding Reita Lake. The area of the ESA is 2,183.8 ha, which is labeled as significant as it contains important wildlife habitat.

D.13.2.8 Parks, Recreation Areas, Natural Areas, Unique Sites and Features

There are no national or provincial parks, wildland parks, or heritage rivers within the LSA. Unique sites or special features have not been identified within the LSA.

According to the LARP, the Project lies within Lakeland County, which is to be developed as a provincial tourism and recreation destination; a statement reflected in the MD of Bonnyville's Land Use bylaw, which sets aside areas around Muriel Lake for "intensive recreation". The purpose is to diversify the local economy by supporting hunting, fishing and trapping, providing a wide range of recreation and tourism activities and promoting cultural heritage, while still protecting and maintain private property rights. Statutory consents and tenures on public land will continue to be issued and existing ones honoured.

D.13.2.9 Access

The LSA is quite accessible due to the proximity of rural residences and towns such as Bonnyville and St. Paul. There are a number of Municipally controlled roadways in the LSA, including Range Road 50 which provides access to the Project. Secondary Highway 657 also lies within the LSA. The relatively high number of grazing leases and the presence of other natural resource extraction companies contribute to an increased density of roads and access points.

D.13.2.10 Fishing

There are limited fishing opportunities with the LSA. The streams contain forage fish and juveniles of larger bodied species. Only the two larger lakes (Garnier and Muriel) are known to contain sport fish.

D.13.2.11 Hunting

The Land Use LSA falls within the Boreal Wildlife Management Unit (WMU) 500, which permits the hunting of White –tailed Deer, Mule Deer, and Moose during parts of the fall and winter seasons.

D.13.3 PREDICTED CONDITIONS – APPLICATION CASE

The proposed Project is shown on Figure D.13.3-1.

D.13.3.1 Land and Resource Use Policies

The Project has been designed and is consistent with the current land use policies, plans and regulations. The proposed development and land use policy boundaries are shown on Figure D.13.3-1.

D.13.3.2 Oil Sands Leases

The proposed subsurface SAGD development will not impact adjacent oil sands lease holders as Pengrowth does not plan to conduct subsurface development within 100 m of an adjacent lease holder. If development is planned within the 100 m buffer, an agreement with the lease holder will be obtained. The proposed well pair trajectories for the initial development are shown on Figure B.2.3-5, which shows there is at least 100 m between the development and lease boundary. The proposed development and the oil sands leases are shown on Figure D.13.3-2.

Surface development that is planned for the Project may provide opportunities for adjacent lease holders to share the infrastructure. The planned surface development is generally on lands where the oil sands leases are held by Pengrowth, with the exception of the access and utility corridor and associated borrow that is required for the connection of the two lease areas as they are not contiguous. This development will parallel an existing pipeline right of way to minimize the disturbance impacts. Pengrowth will consult with Canadian Natural Resources Ltd. and Scott Land and Lease Ltd. to minimize any conflicts associated with crossing their oil sands leases. Project impacts on other oil sands lease holders in the LSA will be low.

D.13.3.3 Petroleum & Natural Gas Leases

There are several companies that hold Petroleum and Natural Gas Leases within the LSA (Figure D.13.3-3 A and B). Based on the information included in Section B.2.3.2 Pengrowth believes that the Lloydminster Formation is not capable of commercial gas production within the LSA. Potential impacts on Petroleum and Natural Gas rights are not anticipated for the Project.

D.13.3.4 Metallic and Industrial Minerals Leases

Two Metallic and Industrial Minerals Leases are located within the LSA. The leases are located outside of the Pengrowth leases and proposed development will not be impacted (Figure D.13.3-3A).

D.13.3.5 Surface Dispositions

Industrial Land Dispositions

The Project may have an impact on existing surface dispositions by being constructed over or across them (Figure D.13.3-4 A to C). Pengrowth will work with the potentially affected users and develop agreements to allow use of the infrastructure that will minimize the impacts.

Trapping and Traditional Ecological Knowledge

There are seven Trapping Area (TPA) dispositions found within the LSA but the Project footprint falls within only TPAs 40, 384, 396, 416 and 424 (Figure D.13.3-5). Pengrowth 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 the Project on the trapping resource.

Pengrowth is working with local First Nations to conduct Traditional Land Use (TLU) and Traditional Ecological Knowledge (TLU) studies. A summary of TLU activities conducted to date is provided in Appendix 10, including a map which shows identified sites.

Forestry Resources

Pengrowth will salvage all merchantable timber in compliance with regulatory requirements. The Project will have a very limited impact on commercial forestry harvesting and fire management over the LSA.

Aggregate Resources

There are no SMLs in the LSA and all SMCs are held by Pengrowth, therefore, potential impacts are not anticipated.

Crown Reservations

Pengrowth will contact any CNT or PNT holders prior to conducting any development within those areas (Figure D.13.3-6). Pengrowth will address any potential concerns raised.

Grazing Leases

There are several Grazing Leases across the LSA (Figure D.13.3-7). Pengrowth has conducted notification and consultation with all of the Grazing Lease holders within the EIA Project Area and will continue to consult with potentially affected lessees and develop agreements to minimize impacts through construction and operation of the Project. Pengrowth will continue to consult with lessees and Alberta Environment and Sustainable Resource Development (ESRD) through the reclamation of disturbed areas.

D.13.3.6 Land Ownership

Project development will affect some Freehold Land owners, as shown in Figure D.13.3-7. Pengrowth has maintained ongoing consultation with Freehold Land owners in the LSA through the development of the Pilot and Phase 1 Projects. This consultation will continue throughout development of the Project to ensure that impacts to land owners are minimized and that they are appropriately compensated for the use of their land.

D.13.3.7 Areas of Environmental Sensitivity

ESRD Wildlife Sensitivity Areas

A small proportion of the Project development lies within a Key Wildlife and Biodiversity Zone, which represents areas of key winter ungulate habitat, with higher potentials for biodiversity (Figure D.13.3-8). Pengrowth will avoid heavy construction during the timing restrictions where possible.

Environmentally Significant Areas

ESAs #484 and #488 fall within the LSA. A portion of the proposed Project development will lie within ESA #484, while ESA #488 is beyond the Project development footprint and will not be impacted. ESA #484 will be considered in the pre-disturbance assessment of vegetation, rare land forms, and wildlife and wildlife habitat.

D.13.3.8 Parks, Recreation Areas, Natural Areas, Unique Sites and Features

There are no significant parks, recreation areas, natural areas, unique sites or unique features found within the LSA therefore no impacts are predicted.

D.13.3.9 Access

No additional access to the Project will be required. A traffic impact assessment was conducted (Appendix 8) which addresses the increased volume of traffic associated with the Project. Pengrowth will consult with Alberta Transportation and the County of St. Paul to schedule and meet the necessary requirements for all large and oversize loads.

D.13.3.10 Fishing

The limited sport fishing opportunities in the LSA mean that any increase in access to the lakes will not impact the aquatic resources within the LSA and the effects of angling on LSA populations is expected to be low.

D.13.3.11 Hunting

Pengrowth will control access in the vicinity of direct disturbance and also restrict hunting activity in that area. Pengrowth will work closely with ESRD to ensure the wildlife resources in and around the Project do not become over-exploited as a result of increased access created by Project development.

D.13.4 PREDICTED CONDITIONS – PLANNED DEVELOPMENT CASE

The cumulative impact of projects in the LSA was considered. As there are no other activities planned in the LSA, the impact rating is low.

D.13.5 MITIGATION AND MONITORING

D.13.5.1 Mitigation

Mitigation to be implemented for the Project includes:

- design and implementation of a Trapper's Compensation Program;
- communication with existing surface and subsurface disposition holders, land owners, government agencies and Aboriginal groups;
- implementation of an annual fire control plan that contemplates Firesmart™ Industrial Zones 1 to 3 and is based upon ASRD's *Firesmart Guidebook for the Oil and Gas Industry* (2008) methodology for determining what activities and locations will require a fire control plan and what mitigation will be required (ASRD 2008, Part IV). The fire control plan, when deemed to be required, will:
  - provide contact information for Pengrowth's site, adjacent industrial partners, and community and provincial fire response;
  - specify fuel types, 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 SAGD project;
  - provides a map of evacuation/access routes and evacuation staging areas;
  - specify specific mitigation requirements of ASRD's *Firesmart Guidebook for the Oil and Gas Industry* (2008), Part IV, including clearing/thinning requirements; and
  - require that all contractors be given orientation on the fire control plan.
- receipt of necessary permit(s) and working agreement(s).

D.13.5.2 Monitoring

No additional monitoring specific to land use is required.

D.13.6 SUMMARY OF VECS

Characterization of the residual and cumulative effects of the Project on land use and management are presented in Table D.13.6-1.

Table D.13.6-1 Summary of Impact Rating on Residual Effects for Land and Resource Use VECs

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. Compatibility with land use planning												
	Compliance with land use planning	Preparation and submission of an annual Fire Control Plan. Receipt of necessary permit(s) and working agreement(s).	Application	Local	Long-term	Continuous	Reversible	Low	Negative	High	High	Low
			Cumulative	Local	Long-term	Continuous	Reversible	Low	Negative	High	High	Low
2. Compatibility with existing land uses and dispositions												
	Change in ability to use land (*e.g.*, change in trapping usage)	Implementation of a Trapper's Compensation Program. Communication with existing land disposition holders.	Application	Local	Long-term	Continuous	Reversible	Low	Negative	High	High	Low
			Cumulative	Local	Long-term	Continuous	Reversible	Low	Negative	High	High	Low

1. Local, Regional, Provincial, National, Global; 2. Short, Long, Extended, Residual; 3. Continuous, Isolated, Periodic, Occasional; 4. Reversible in short term, Reversible in long term, Irreversible; 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 many SAGD operators to identify potential areas of sensitivity related to Project development. As part of the application process, baseline information is collected for all the major environmental disciplines and areas of sensitivity, environmental (biophysical) and cultural are identified. Constraints mapping compiles and spatially presents potential constraints associated within the identified sensitivities within a development area. Figure D.14.0-1 shows potential constraints associated with the environmental, social, cultural, and resource development sensitivities identified for the Project.

The total footprint of the proposed Project encompasses approximately 792.3 ha of surface disturbance which includes:

- plant sites;
- well pads; and
- additional site infrastructure (campsite, borrow pits, access roads, surface pipelines, water source and disposal wells, observation wells, *etc.*).

The proposed footprint resulted from iterative and multi-disciplinary review of Project siting in light of constraints and for these Project features forms the basis of the constraints mapping exercise. The identification of a constraint does not imply no development can occur, it indicates that special development considerations or mitigative measures may be required.

D.14.1 APPROACH

The environmental and cultural sensitivities and operational resource development requirements were identified early in the Project design stages. Based on the identified sensitivities, the Project is designed to minimize environmental impacts and maximize resource recovery. Constraints were then applied through the use of "constraints mapping' to ensure identified sensitivities are managed or mitigated during the development phases. The following approach was used to ensure sensitivities were identified and integrated into the Project design:

- collected comprehensive environmental and cultural information from within the constraints study area;
- defined and mapped the environmental and cultural constraints;
- addressed each constraint individually or in conjunction with others if overlap occurred, rather than providing a weighted ranking (overlapping constraints were evaluated to determine the impacts on one or all, if the disturbance occurred); and
- demonstrated that planning and design considered the environmental and cultural constraints while optimizing resource recovery.

The following tiered decisions were applied to constraints or sensitive areas identified within the Project development:

- avoiding the environmental or cultural sensitivity (spatial) area; and

- minimizing impact through appropriate mitigation and monitoring.

The constraints mapping approach assists in the validation of the environmental assessment conclusions. Results can include avoidance or mitigation and monitoring programs to neutralize effects.

D.14.2 CONSTRAINTS – ENVIRONMENTAL AND CULTURAL CONSIDERATIONS

Constraints were identified as environmental or cultural sensitivities that exist within the study area and were noted in the various Consultant Reports supporting this application. Constraints that were non-spatial in nature were not included in this exercise since they cannot be mapped, and therefore managed.

D.14.2.1 Aquatic Resources (CR #2)

Potential impacts to surface water quality and fisheries resources occur primarily from the potential introduction of foreign substances into the watercourses. Substances of concern would include the introduction of suspended solids through surface runoff and introduction of contaminants due to product spills. Where possible, the maintenance of a 100 m setback from all waterbodies with fish habitat potential and 50 m from all defined channels with no fish habitat, would provide sufficient watershed protection along with erosion control measures such as revegetation. Spill prevention and emergency response plans mitigate the product spill potential.

- **Mapping Constraint –** where possible, 100 m setback along all waterbodies with fish habitat potential, and 50 m setback along watercourses with defined channels.

D.14.2.2 Hydrology (CR #6)

Potential impacts exist for transportation of sediment from the Project footprint by surface runoff to watercourses. Where possible, the maintenance of a 100 m setback from all waterbodies with fish habitat potential and 50 m from all defined channels with no fish habitat, which includes riparian areas, should be sufficient protection from surface runoff and potential sedimentation.

- **Mapping Constraint –** where possible, 100 m setback along all waterbodies with fish habitat potential, and 50 m setback along watercourses with defined channels.

D.14.2.3 Vegetation and Wetlands (CR #10)

There are three potential constraints related to vegetation and wetlands:

- ecosites of limited distribution;
- wetlands of limited distribution; and
- rare plants.

Ecosites and wetlands of limited distribution are defined as those comprising less than 1% of the vegetation local study area (LSA) (CR #10). If significant disturbance of these ecosites and wetlands cannot be avoided, then appropriate mitigation measures may be required. Within the LSA, 12 upland ecosite phases and three wetland ecosite phases are of limited distribution.

Project development will impact 10 of the 15 ecosite phases of limited distribution in the LSA. The total area of ecosite phases of limited distribution in the LSA that will be affected by the Project is 15.7 ha. This area includes b1, c1, d3, e3, f1, f2, g1, h1, i1, and l1 ecosite phases. None of these ecosite phases will be completely removed from the LSA. Following decommissioning and reclamation, disturbed ecosite phases of limited distribution will be reclaimed to improved pastures.

Wetlands of limited distribution in the LSA make up 1.6% (367.8 ha) of the LSA. They include wooded bogs with internal no lawns (BTNN), open graminoid-dominated marsh (MONG), open shrub dominated swamps (SONS), and wooded swamps (STNN). The marsh wetland class makes up less than 1% of the LSA. At a regional level marshes comprise a very small proportion of the boreal forest.

Construction and operation of the Project will result in the removal of the rare plants observed within the Project footprint. Two plant species that were found in the footprint and appear on Alberta's list of tracked elements (eight occurrences) were observed within the Project footprint and elsewhere in the LSA. The vascular plant *Chrysoplenium iowense* and the polar sunburst lichen *Xanthomendoza hasseana*. No mitigation is recommended for non-vascular species other than reporting these observations to ACIMS for updating of the tracking lists; and minimizing disturbance where practical in areas of potentially suitable habitat for rare plants and rare plant communities. No mitigation for *Chryososplenium iowense* is recommended in this case because it was common within the LSA and transplanting has a low success rate.

The study area contains no stands of old growth forest, with the oldest tree found to be approximately 117 years old. The forests within the study area are considered to be in a young or maturing seral stage which is characterized by tree ages of 30 to 140 years of age.

- **Mapping Constraints**
  - **Ecosites Of Limited Distribution** – portions of ten identified as being disturbed by Project development and elsewhere within the LSA; no mitigation required as the majority will not be disturbed by the Project;
  - **Wetlands Of Limited Distribution** – portions of four identified as being disturbed by Project development and elsewhere within the LSA; no mitigation required as the majority will not be disturbed by the Project;
  - **Rare Plants** – two species identified within Project footprint plus numerous locations elsewhere, no mitigation required.

D.14.2.4 Soils and Terrain (CR #9)

A potential constraint for soils and terrain is soils with a moderate to high risk of water erosion once the vegetation has been cleared off.

Within the Project footprint, approximately 47.5 ha of the area has a high risk of water erosion and 7.0 ha of the area has a severe risk of water erosion prior to vegetation establishment. Soils stockpiling presents less of a concern as 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 the project. Reclaimed landscapes that have a high-severe probability of erosion (*e.g.*, steep side slopes) will be reseeded with a quick establishing, non-invasive cover crop to minimize the length of time bare soil is exposed to potential wind and water erosion. In addition, soil stabilizers or other measures will be utilized to minimize the effect of water erosion (*e.g.*, check bales, silt fences, sediment traps and other erosion control measures) on susceptible slopes.

- **Mapping Constraint** – interim erosion control measures.

D.14.2.5 Wildlife (CR #11)

In the context of the Project, the LSA contains portions of two identified ESA's (ESAs #484 and #488). A section of ESA #484 (2,184 ha) enters the LSA along the northeastern boundary surrounding Reita Lake and was established to protect important wildlife habitat although focal species of concern were not mentioned. A section of ESA #488 (14,481 ha) also enters the northwest boundary of the LSA around Muriel Lake. ESA #488 contains the Nationally Designated Muriel Lake Important Bird Area which supports a large population of nesting colonial water birds and is also known to contain nesting pairs of piping plovers, a species of concern both provincially and nationally. There will be no impact to ESA #488 as no development will occur. The impact to ESA #484 is expected to be low as a 100 m setback will be utilized around Reita Lake and only two well pads encroach on the ESA.

There is also a Key Wildlife and Biodiversity Zone that extends into the northern portion of the LSA. Key Wildlife and Biodiversity Zones are designated to protect ungulate winter ranges, areas of high biodiversity, and wildlife movement corridors in Alberta and as such, are subject to specific development restrictions (GOA 2013a). The impact to this zone is limited to two well pads and connecting access corridor.

Where possible, the maintenance of a 100 m setback from all waterbodies with fish habitat potential and 50 m from all defined channels with no fish habitat can protect riparian areas from disturbance will help protect wildlife habitat.

- **Mapping Constraints**
  - **Key Wildlife and Biodiversity Zones** – where possible, heavy construction activity within the Key Wildlife and Biodiversity Zone located in the northern portion of the LSA will be avoided between January 15 and April 30; and
  - **ESAs** –where possible, ESA #484 will have a 100 m setback from the watercourses and Reita Lake; and
  - **Riparian areas** – where possible, 100 m setback from all waterbodies with fish habitat potential and 50 m from all defined channels with no fish habitat.

D.14.2.6 Historical (CR # 3)

The Project will avoid most of the identified significant historic site. Only two of these 19 sites (FlOp-56 and GaOp-25) will be impacted by the Project. No mitigation measures are suggested. Impacts to individual sites will be reviewed by Alberta Culture upon receipt of the final

Historical Resource Impact Assessment which will contain recommendations with the appropriate site mitigation requirements if avoidance is not possible. No cumulative effects are anticipated.

- **Mapping Constraints** - known historical or archaeological sites – avoidance or mitigation to be approved by Alberta Culture.

D.14.3 CONSTRAINTS – RESOURCE CONSIDERATIONS

D.14.3.1 Resource Utilization and Bitumen Recovery

The key consideration during the site selection process is the maximization of bitumen production. The bitumen reservoir is present in two separate lease areas, Lindbergh and Muriel. The reservoir is better defined in the Lindbergh lease area, and more drilling is required to help define the Muriel lease area better.

D.14.3.2 Project Costs

Capital and operating costs are important considerations and factor significantly into siting of the SAGD facilities. Each of the three main components considered were rated based on projected costs:

- construction;
- drilling; and
- reclamation.

D.14.3.3 Surface Land Use

Combining activities into a common corridor and using as much existing cleared areas as possible are important development considerations.

Three main components considered are:

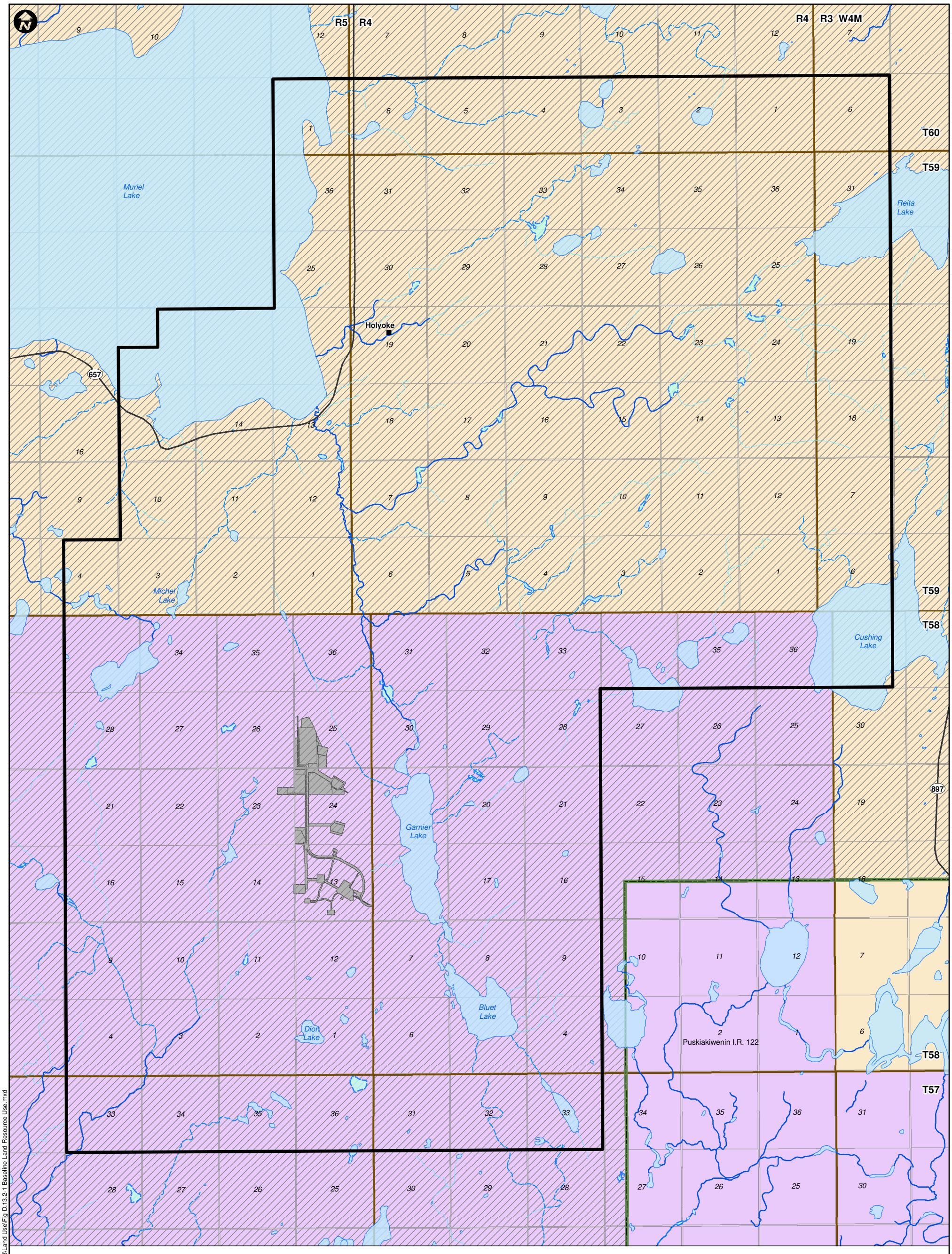
- minimizing resource conflict;
- utilizing common corridors; and
- minimizing new clearing.

A key component of this Project is the amount of legacy oil and gas activity that is present in the area, from a wide range of different companies. Working in and around these legacy sites can be challenging.

D.14.4 SUMMARY

Environmental, cultural, and economic constraints have been identified for the Project. Mitigation measures are required to minimize the impacts to some environmental and cultural aspects of the Project. These mitigation measures are discussed in further detail in Part E (Conservation and Reclamation), Part D.2.4 (Aquatic Resources), Part D.4.4 (Historical Resources), Part D.6.4 (Hydrology), Part D.10.4 (Vegetation), and Part D.11.4 (Wildlife).

FIGURES



Legend

- Land Use LSA
- Existing and Approved Development
- First Nations

Integrated Regional Plan Boundaries

- North Saskatchewan
- Lower Athabasca Regional Plan Area

Subregional Plan

- Cold Lake Integrated Resource Plan
- Secondary Highway
- Permanent Stream
- Ephemeral Stream
- Drainages without Defined Channels
- Lakes and Ponds
- Beaver Ponds

0 0.75 1.5 3
Kilometres

REF: NHC hydrology Oct 2013.

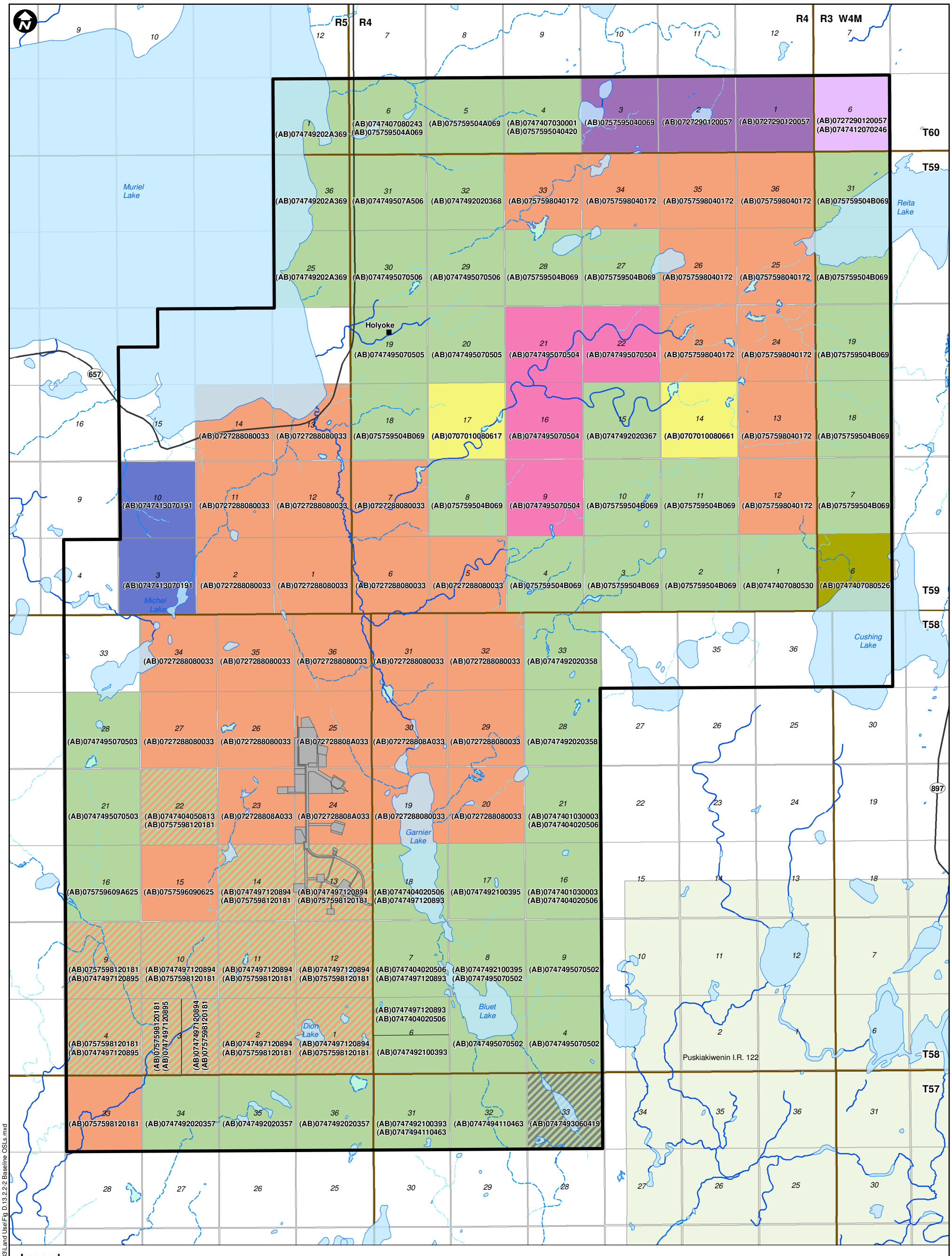
PROJECT: PENGROWTH — Lindbergh SAGD Expansion Project

TITLE: **Baseline Case Land and Resource Use Policies**

DRAWN: SL
CHECKED: KK
DATE: Dec 19/13
PROJECT: 11-033

FIGURE: **D.13.2-1**

Document Path: K:\Active Client\Pengrowth Lindbergh\Final Docs\11-033\Land Use\Fig D.13.2-1 Baseline Land Resource Use.mxd



Legend

- Land Use LSA
- Existing and Approved Development
- First Nations
- Secondary Highway
- Permanent Stream
- Ephemeral Stream
- Drainages without Defined Channels
- Lakes and Ponds
- Beaver Ponds

Oil Sands Lease Owner

- Baytex Energy Ltd.
- Baytex Energy Ltd./Madison Land Co. Ltd.
- Canadian Natural Resources Limited
- Canadian Natural Resources Limited/Pengrowth Energy Corporation
- Canadian Natural Resources Limited/Devon NEC Corporation
- Cavalier Land Ltd.
- Pengrowth Energy Corporation
- Sandstone Land & Mineral Company Ltd.
- Windfall Resources Ltd.

Oil Sands Permit Owner

- Scott Land & Lease Ltd.

0 0.75 1.5 3
Kilometres

PROJECT: PENGROWTH — Lindbergh SAGD Expansion Project

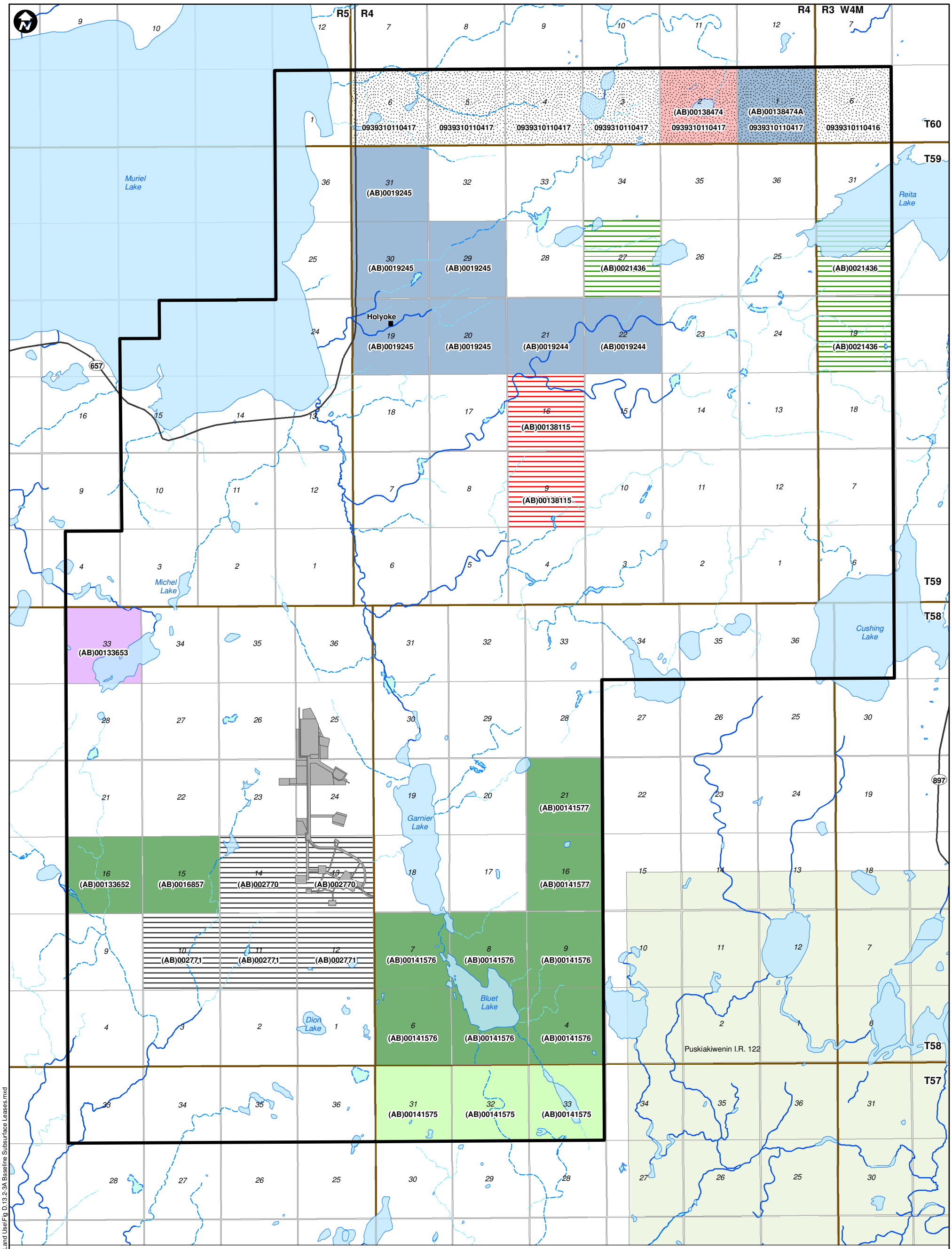
TITLE: **Baseline Case Oil Sands Leases and Permits**

DRAWN: SL
CHECKED: KK
DATE: Dec 19/13
PROJECT: 11-033

FIGURE: **D.13.2-2**

REF: NHC hydrology Oct 2013.

Document Path: K:\Active Client\Pengrowth Lindbergh\Final Docs\11-033\Land Use\Fig D.13.2.2-2 Baseline OSLs.mxd



Legend

- Land Use LSA
- Existing and Approved Development
- First Nations
- Secondary Highway
- Permanent Stream
- Ephemeral Stream
- Drainages without Defined Channels
- Lakes and Ponds
- Beaver Ponds

0 0.75 1.5 3
Kilometres

Metallic and Industrial Minerals Lease Owner
- Smith, Angela Erin

Natural Gas Lease Owner
- Conserve Oil Corporation/ Conserve Oil and Gas No. II Corporation
- Gear Energy Ltd.
- The Canadian Salt Company Ltd.

Petroleum and Natural Gas Lease Owner
- Baytex Energy Ltd, Marquee Energy Ltd.
- Bonavista Energy Corporation
- Canadian Natural Resources Limited
- Canadian Natural Resources Limited/ Devon NEC Corporation
- Conserve Oil and Gas No. II Corporation/ Conserve Oil Corporation

REF: NHC hydrology Oct 2013.

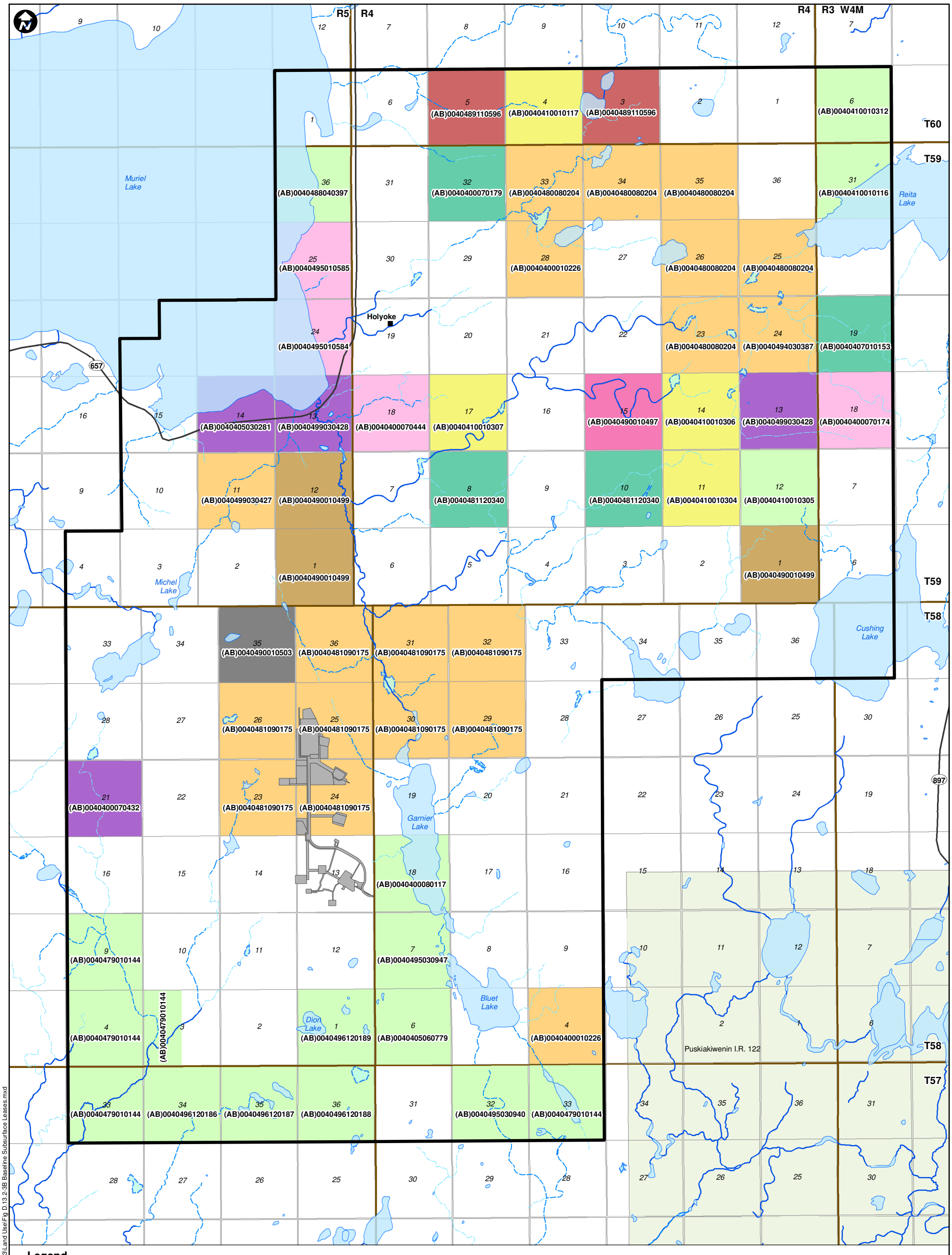
PROJECT: PENGROWTH — Lindbergh SAGD Expansion Project

TITLE: **Baseline Case Subsurface Leases and Permits**

DRAWN: SL
CHECKED: KK
DATE: Dec 19/13
PROJECT: 11-033

FIGURE: **D.13.2-3A**

Document Path: K:\Active Client\Pengrowth Lindbergh\Final Docs\11-033\Land Use\Fig D.13.2-3A Baseline Subsurface Leases.mxd



Legend

- Land Use LSA
- Existing and Approved Development
- First Nations
- Secondary Highway
- Permanent Stream
- Ephemeral Stream
- Drainages without Defined Channels
- Lakes and Ponds
- Beaver Ponds

0 0.75 1.5 3
Kilometres

5 Year Plains Petroleum and Natural Gas Lease Owner

- Baytex Energy Ltd.
- Bonavista Energy Corporation
- Bonavista Energy Corporation/ Barnwell of Canada Limited
- Canadian Natural Resources Limited
- Conserve Oil and Gas No. II Corporation/ Conserve Oil Corporation
- Crescent Point Energy Corp.
- Crescent Point Energy Corporation/ Conserve Oil Corporation
- Gear Energy Ltd./Barnwell of Canada Limited
- Husky Oil Operations Limited
- Scott Land & Lease Ltd.

REF: NHC hydrology Oct 2013.

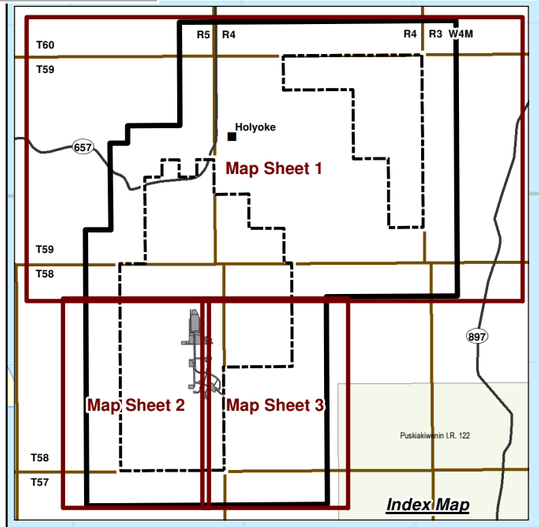
PROJECT: PENGROWTH — Lindbergh SAGD Expansion Project

TITLE: **Baseline Case Subsurface Leases and Permits**

DRAWN: SL
CHECKED: KK
DATE: Dec 19/13
PROJECT: 11-033

FIGURE: **D.13.2-3B**

Document Path: K:\Active Client\Pengrowth Lindbergh\Final Docs\11-033\Land Use\Fig D.13.2-3B Baseline Subsurface Leases.mxd



Muriel Lake
Michel Lake
Reita Lake
Cushing Lake
Holyoke
657
897

Legend

- Land Use LSA
- Pengrowth Lease
- Existing and Approved Development
- Pengrowth Disposition
- Non-Pengrowth Disposition
- Existing Human Use
- Freehold Land
- First Nations
- Secondary Highway
- Permanent Stream
- Ephemeral Stream
- Drainages without Defined Channels
- Lakes and Ponds
- Beaver Ponds

REF: NHC hydrology Oct 2013.

0 0.5 1 2
Kilometres

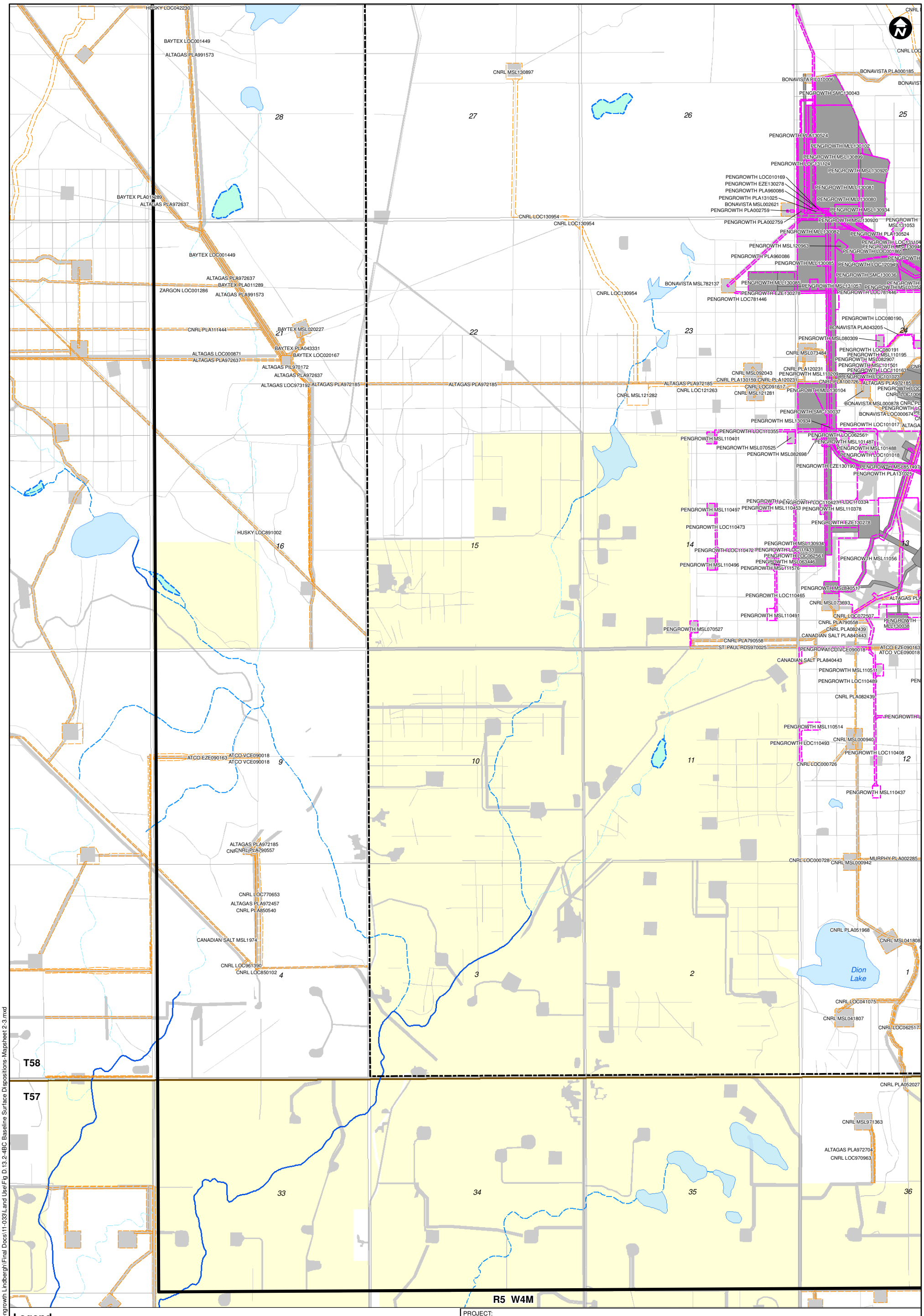
PROJECT: PENGROWTH Lindbergh SAGD Expansion Project

TITLE: Baseline Case Surface Dispositions - Map Sheet 1

DRAWN: SL
CHECKED: KK
DATE: Oct 29/13
PROJECT: 11-033

FIGURE: D.13.2-4A

Document Path: K:\Active Client\Pengrowth Lindbergh\Final Docs\11-033\Land Use\Fig D.13.2-4A Baseline Surface Dispositions-Mapsheet 1.mxd



Legend

- Land Use LSA
- Pengrowth Lease
- Existing and Approved Development
- Pengrowth Disposition
- Non-Pengrowth Disposition
- Existing Human Use
- Freehold Land
- First Nations
- Secondary Highway
- Permanent Stream
- Ephemeral Stream
- Drainages without Defined Channels
- Lakes and Ponds
- Beaver Ponds

0 250 500 1,000 Metres

REF: NHC hydrology Oct 2013.

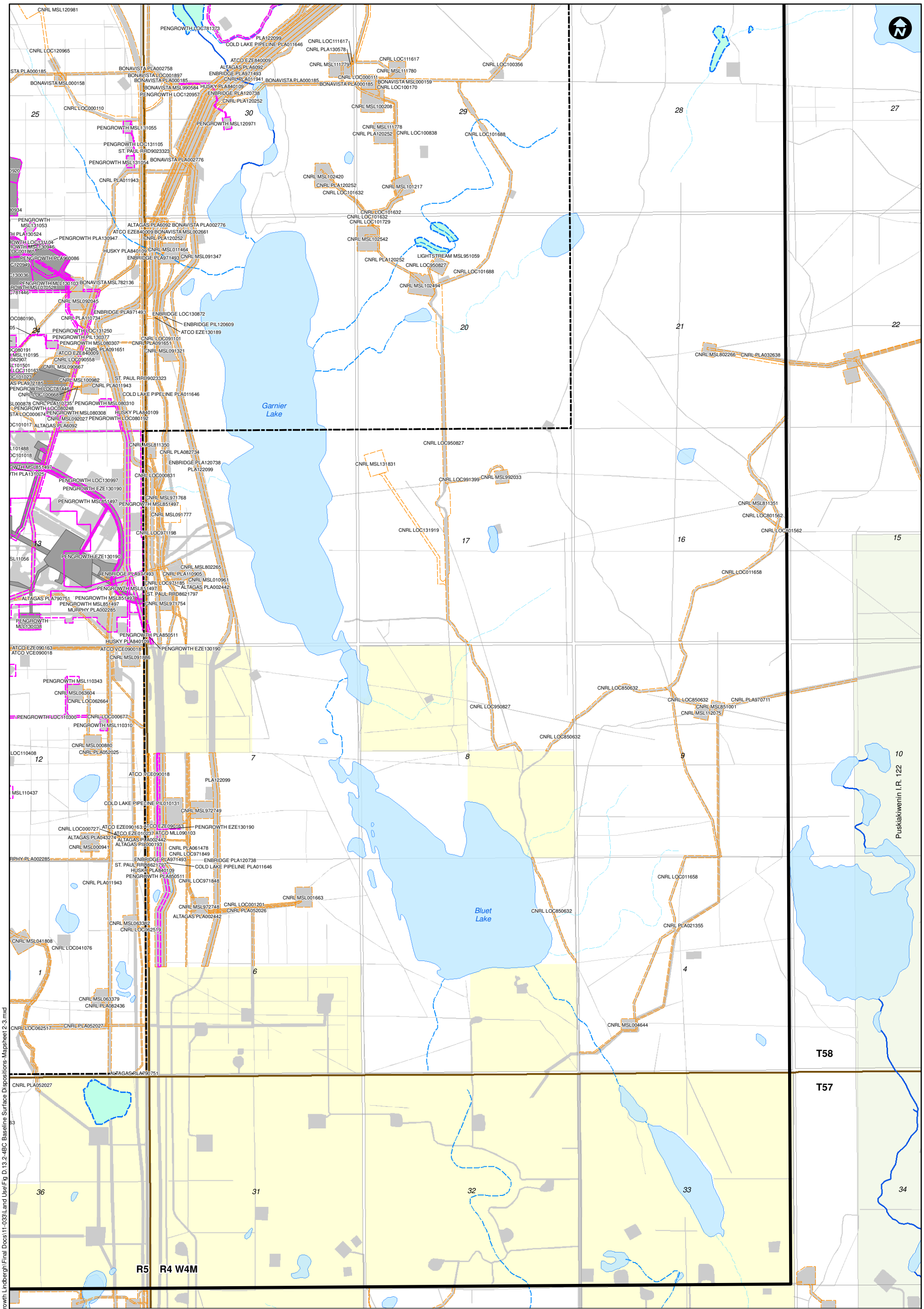
PROJECT: PENGROWTH Lindbergh SAGD Expansion Project

TITLE: **Baseline Case Surface Dispositions - Map Sheet 2**

DRAWN: SL
CHECKED: KK
DATE: Dec 19/13
PROJECT: 11-033

FIGURE: **D.13.2-4B**

Document Path: K:\Active Client\Pengrowth Lindbergh\Final Docs\11-033\Land Use\Fig D.13.2-4BC Baseline Surface Dispositions-Mapsheet 2-3.mxd



Legend

- Land Use LSA
- Pengrowth Lease
- Existing and Approved Development
- Pengrowth Disposition
- Non-Pengrowth Disposition
- Existing Human Use
- Freehold Land
- First Nations
- Secondary Highway
- Permanent Stream
- Ephemeral Stream
- Drainages without Defined Channels
- Lakes and Ponds
- Beaver Ponds

0 250 500 1,000 Metres

REF: NHC hydrology Oct 2013.

PROJECT: PENGROWTH Lindbergh SAGD Expansion Project

TITLE: **Baseline Case Surface Dispositions - Map Sheet 3**

DRAWN: SL
CHECKED: KK
DATE: Dec 19/13
PROJECT: 11-033

FIGURE: **D.13.2-4C**

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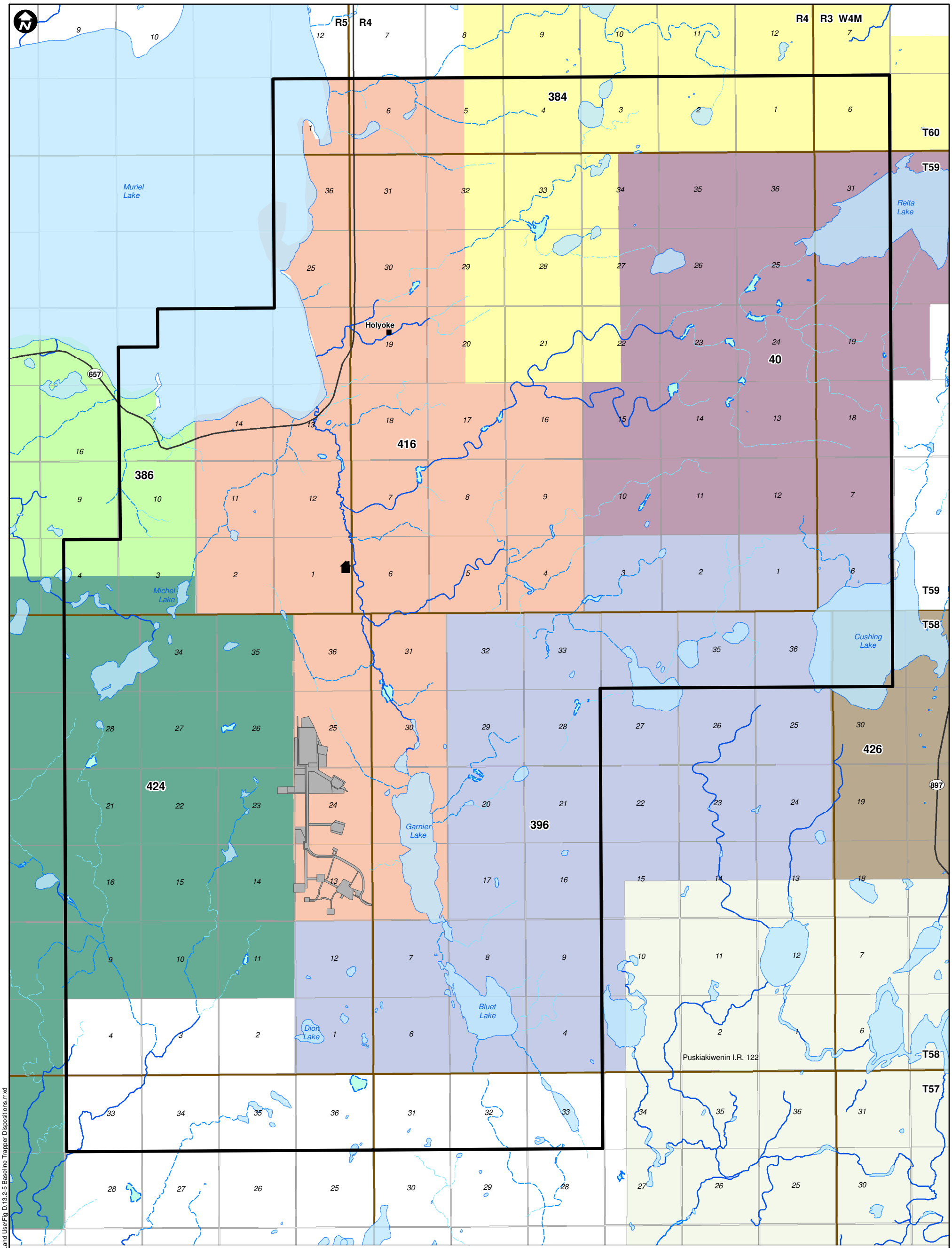


Legend

- Trapper's Cabin
- Land Use LSA
- Existing and Approved Development
- First Nations
- Secondary Highway
- Permanent Stream
- Ephemeral Stream
- Drainages without Defined Channels
- Lakes and Ponds
- Beaver Ponds

Trapline Number

- 40
- 384
- 386
- 396
- 416
- 424
- 426

0 0.75 1.5 3
Kilometres

REF: NHC hydrology Oct 2013.

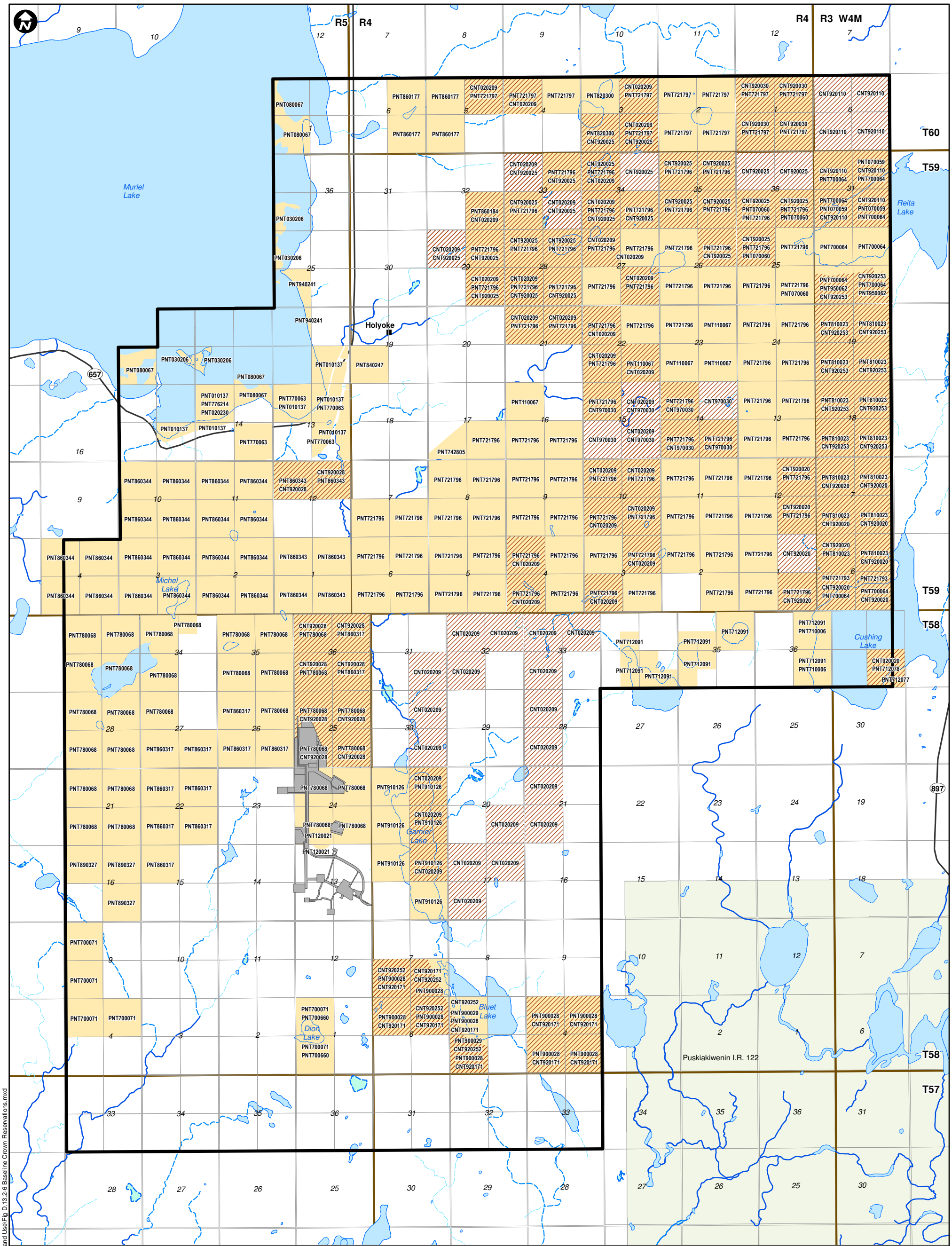
PROJECT: PENGROWTH — Lindbergh SAGD Expansion Project

TITLE: **Baseline Case Trapper Dispositions**

DRAWN: SL
CHECKED: KK
DATE: Dec 19/13
PROJECT: 11-033

FIGURE: **D.13.2-5**

Document Path: K:\Active Client\Pengrowth Lindbergh\Final Docs\11-033\Land Use\Fig D.13.2-5 Baseline Trapper Dispositions.mxd



Legend

- Land Use LSA
- Existing and Approved Development
- Consultative Notation
- Protective Notation
- First Nations
- Secondary Highway
- Permanent Stream
- Ephemeral Stream
- Drainages without Defined Channels
- Lakes and Ponds
- Beaver Ponds

0 0.75 1.5 3
Kilometres

PROJECT: PENGROWTH Lindbergh SAGD Expansion Project

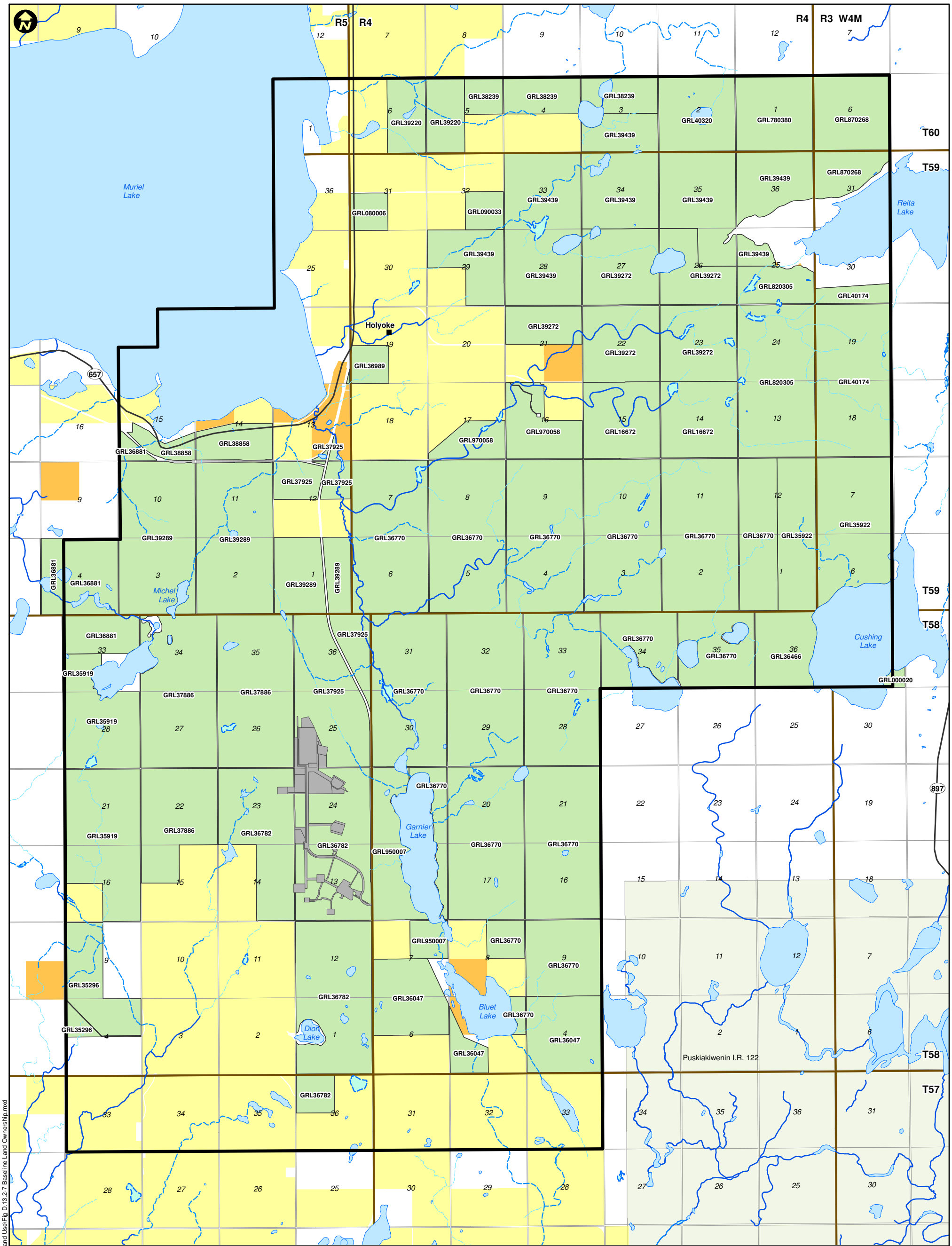
TITLE: Baseline Case Crown Reservations

DRAWN: SL
CHECKED: KK
DATE: Dec 19/13
PROJECT: 11-033

FIGURE: D.13.2-6

REF: NHC hydrology Oct 2013.

Document Path: K:\Active Client\Pengrowth Lindbergh\Final Docs\11-033\Land Use\Fig D.13.2-6 Baseline Crown Reservations.mxd



Legend

- Land Use LSA
- Existing and Approved Development
- Grazing Lease
- Crown Land
- Freehold Land
- First Nations
- Secondary Highway
- Permanent Stream
- Ephemeral Stream
- Drainages without Defined Channels
- Lakes and Ponds
- Beaver Ponds

0 0.75 1.5 3
Kilometres

PROJECT: PENGROWTH Lindbergh SAGD Expansion Project

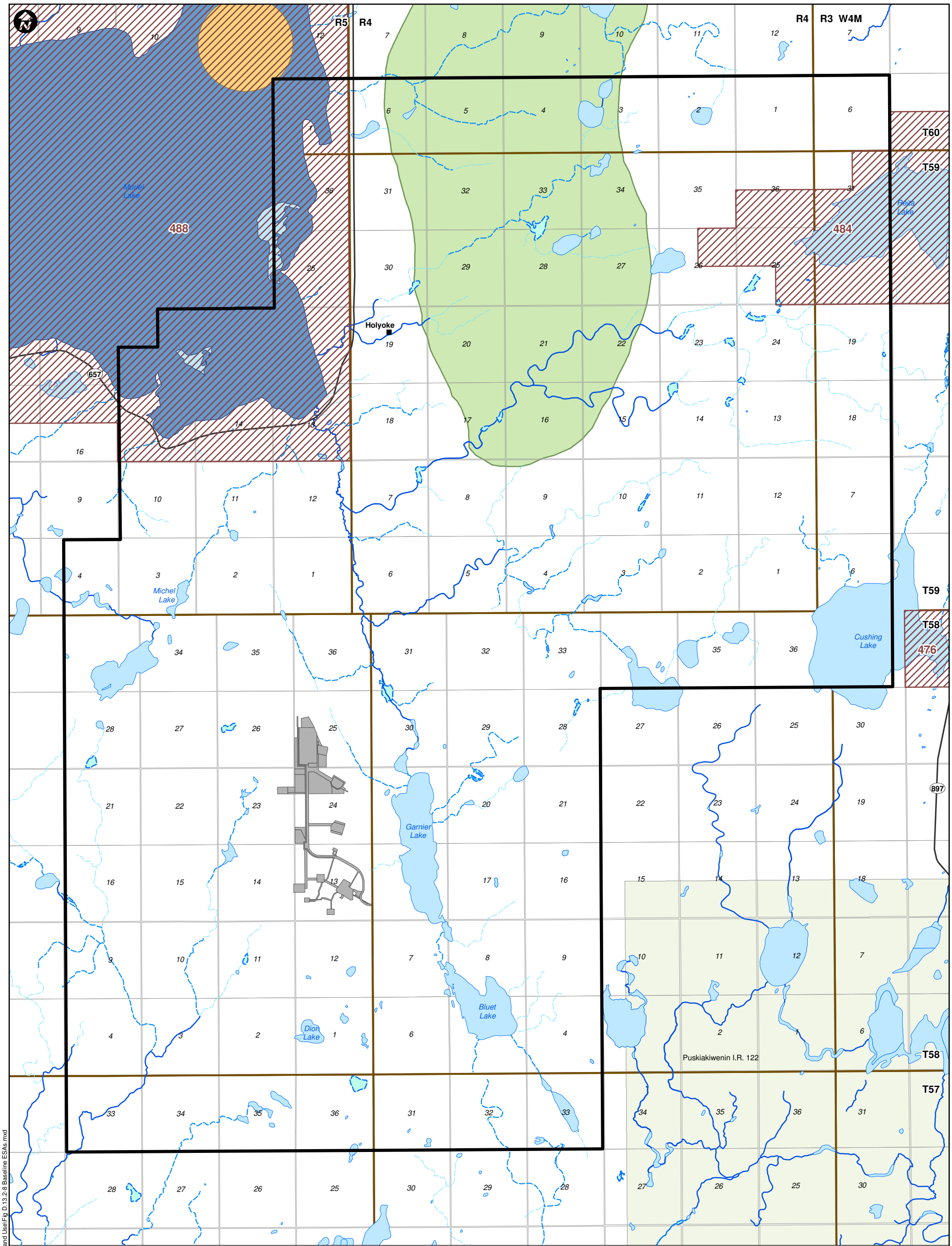
TITLE: **Baseline Case Land Ownership**

DRAWN: SL
CHECKED: KK
DATE: Dec 19/13
PROJECT: 11-033

FIGURE: **D.13.2-7**

REF: NHC hydrology Oct 2013.

Document Path: K:\Active Client\Pengrowth Lindbergh\Final Docs\11-033\Land Use\Fig D.13.2-7 Baseline Land Ownership.mxd



Legend

- Land Use LSA
- Existing and Approved Development
- First Nations
- Environmentally Significant Area (2009)
- Colonial Nesting Bird Area - American White Pelican
- Piping Plover Waterbody
- Key Wildlife and Biodiversity Zone
- Secondary Highway
- Permanent Stream
- Ephemeral Stream
- Drainages without Defined Channels
- Lakes and Ponds
- Beaver Ponds

0 0.75 1.5 3
Kilometres

REF: NHC hydrology Oct 2013.

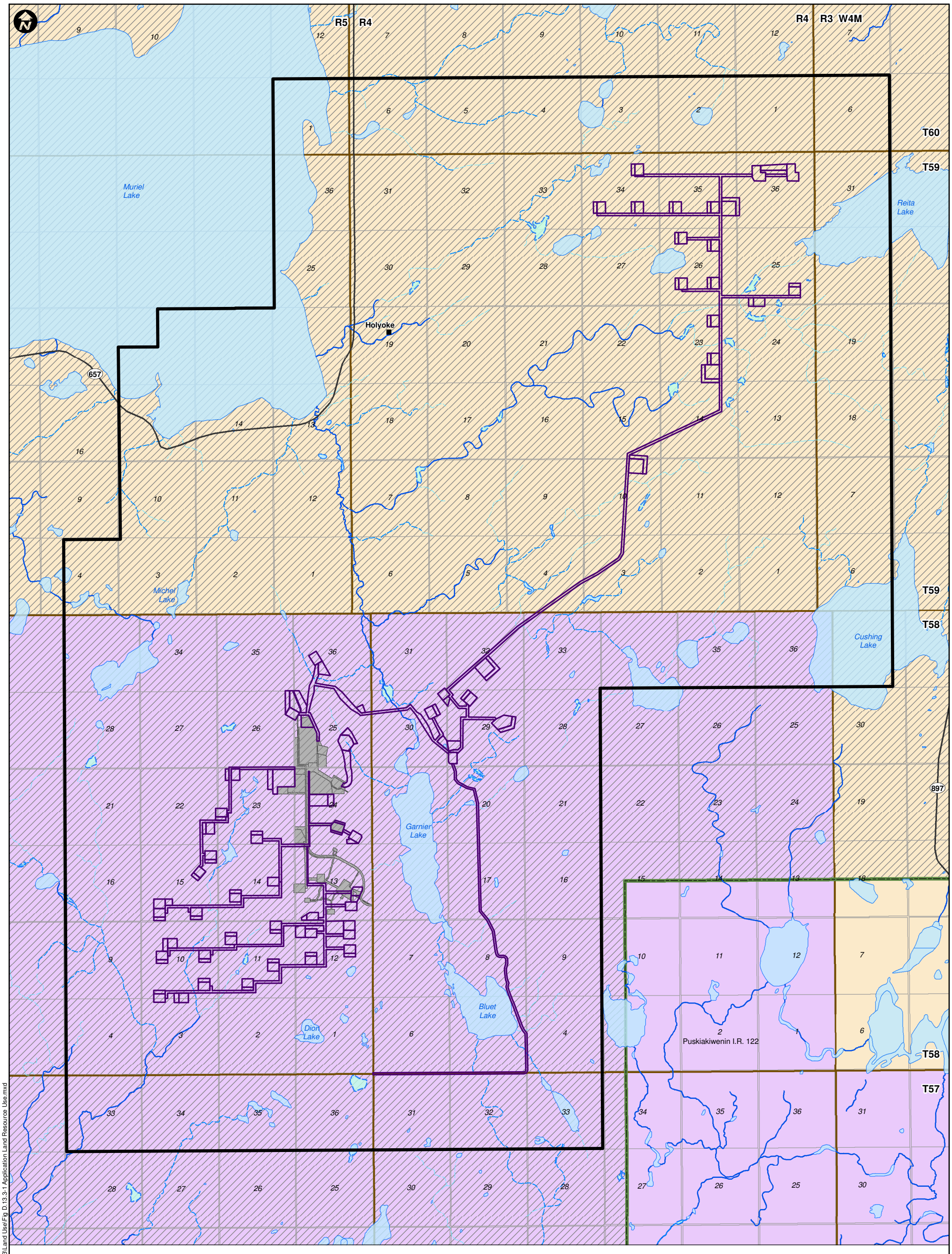
PROJECT: PENGROWTH — Lindbergh SAGD Expansion Project

TITLE: **Baseline Case ESAs and Wildlife Sensitivity Areas**

DRAWN: SL
CHECKED: KK
DATE: Dec 19/13
PROJECT: 11-033

FIGURE: **D.13.2-8**

Document Path: K:\Active Client\Pengrowth Lindbergh\Final Docs\11-033\Land Use\Fig D.13.2-8 Baseline ESAs.mxd



Legend

- Land Use LSA
- Development Footprint
- Existing and Approved Development
- First Nations

Integrated Regional Plan Boundaries

- North Saskatchewan
- Lower Athabasca Regional Plan Area

Subregional Plan

- Cold Lake Integrated Resource Plan

- Secondary Highway
- Permanent Stream
- Ephemeral Stream
- Drainages without Defined Channels
- Lakes and Ponds
- Beaver Ponds

0 0.75 1.5 3
Kilometres

REF: Drifter Projects Ltd., EIA Footprint REV 3.dwg; NHC hydrology Oct 2013.

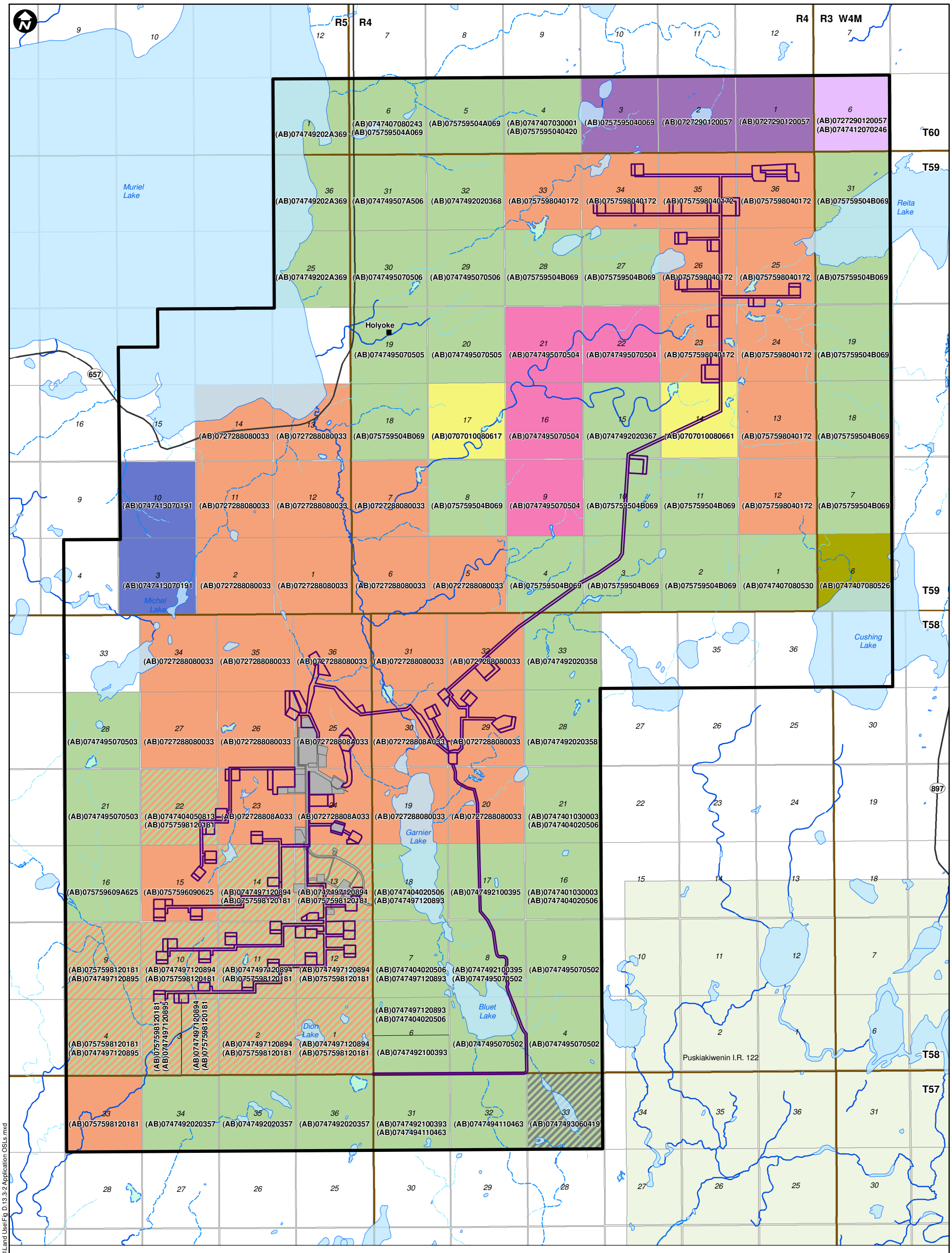
PROJECT: PENGROWTH — Lindbergh SAGD Expansion Project

TITLE: **Application Case Land and Resource Use Policies**

DRAWN: SL
CHECKED: KK
DATE: Dec 19/13
PROJECT: 11-033

FIGURE: **D.13.3-1**

Document Path: K:\Active Client\Pengrowth Lindbergh\Final Docs\11-033\Land Use\Fig D.13.3-1 Application Land Resource Use.mxd



Legend

- Land Use LSA
- Development Footprint
- Existing and Approved Development
- First Nations
- Secondary Highway
- Permanent Stream
- Ephemeral Stream
- Drainages without Defined Channels
- Lakes and Ponds
- Beaver Ponds

Oil Sands Lease Owner

- Baytex Energy Ltd.
- Baytex Energy Ltd./Madison Land Co. Ltd.
- Canadian Natural Resources Limited
- Canadian Natural Resources Limited/Pengrowth Energy Corporation
- Canadian Natural Resources Limited/Devon NEC Corporation
- Cavalier Land Ltd.
- Pengrowth Energy Corporation
- Sandstone Land & Mineral Company Ltd.
- Windfall Resources Ltd.

Oil Sands Permit Owner

- Scott Land & Lease Ltd.

0 0.75 1.5 3
Kilometres

PROJECT: PENGROWTH
Lindbergh SAGD Expansion Project

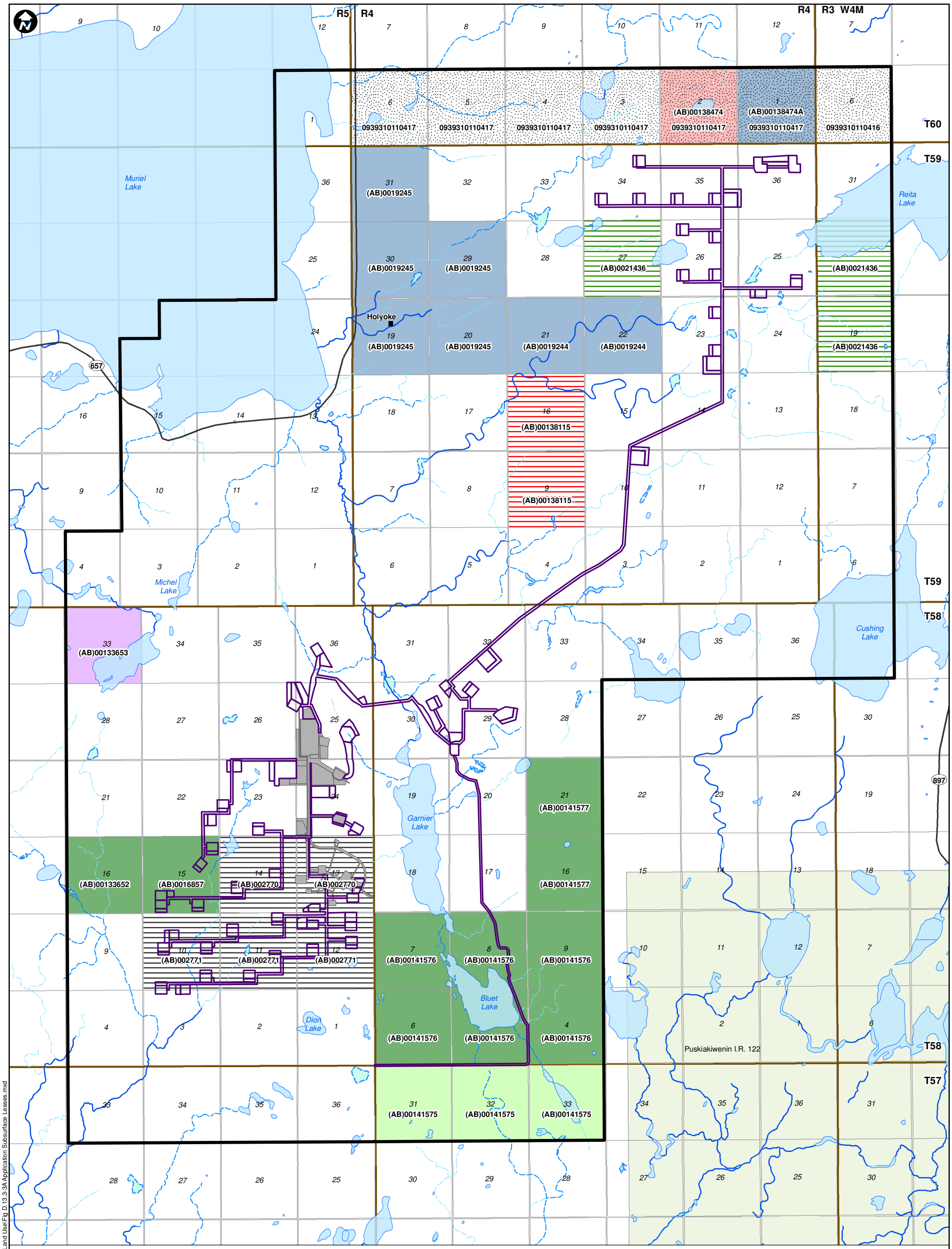
TITLE:
Application Case Oil Sands Leases and Permits

DRAWN: SL
CHECKED: KK
DATE: Dec 19/13
PROJECT: 11-033

FIGURE: **D.13.3-2**

REF: Drifter Projects Ltd., EIA Footprint REV 3.dwg; NHC hydrology Oct 2013.

Document Path: K:\Active Client\Pengrowth Lindbergh\Final Docs\11-033\Land Use\Fig D.13.3-2 Application OSLs.mxd



Legend

- Land Use LSA
- Development Footprint
- Existing and Approved Development
- First Nations
- Secondary Highway
- Permanent Stream
- Ephemeral Stream
- Drainages without Defined Channels
- Lakes and Ponds
- Beaver Ponds

0 0.75 1.5 3
Kilometres

Metallic and Industrial Minerals Lease Owner
- Smith, Angela Erin

Natural Gas Lease Owner
- Conserve Oil Corporation/ Conserve Oil and Gas No. II Corporation
- Gear Energy Ltd.
- The Canadian Salt Company Ltd.

Petroleum and Natural Gas Lease Owner
- Baytex Energy Ltd, Marquee Energy Ltd.
- Bonavista Energy Corporation
- Canadian Natural Resources Limited
- Canadian Natural Resources Limited/ Devon NEC Corporation
- Conserve Oil and Gas No. II Corporation/ Conserve Oil Corporation

REF: Drifter Projects Ltd., EIA Footprint REV 3.dwg; NHC hydrology Oct 2013.

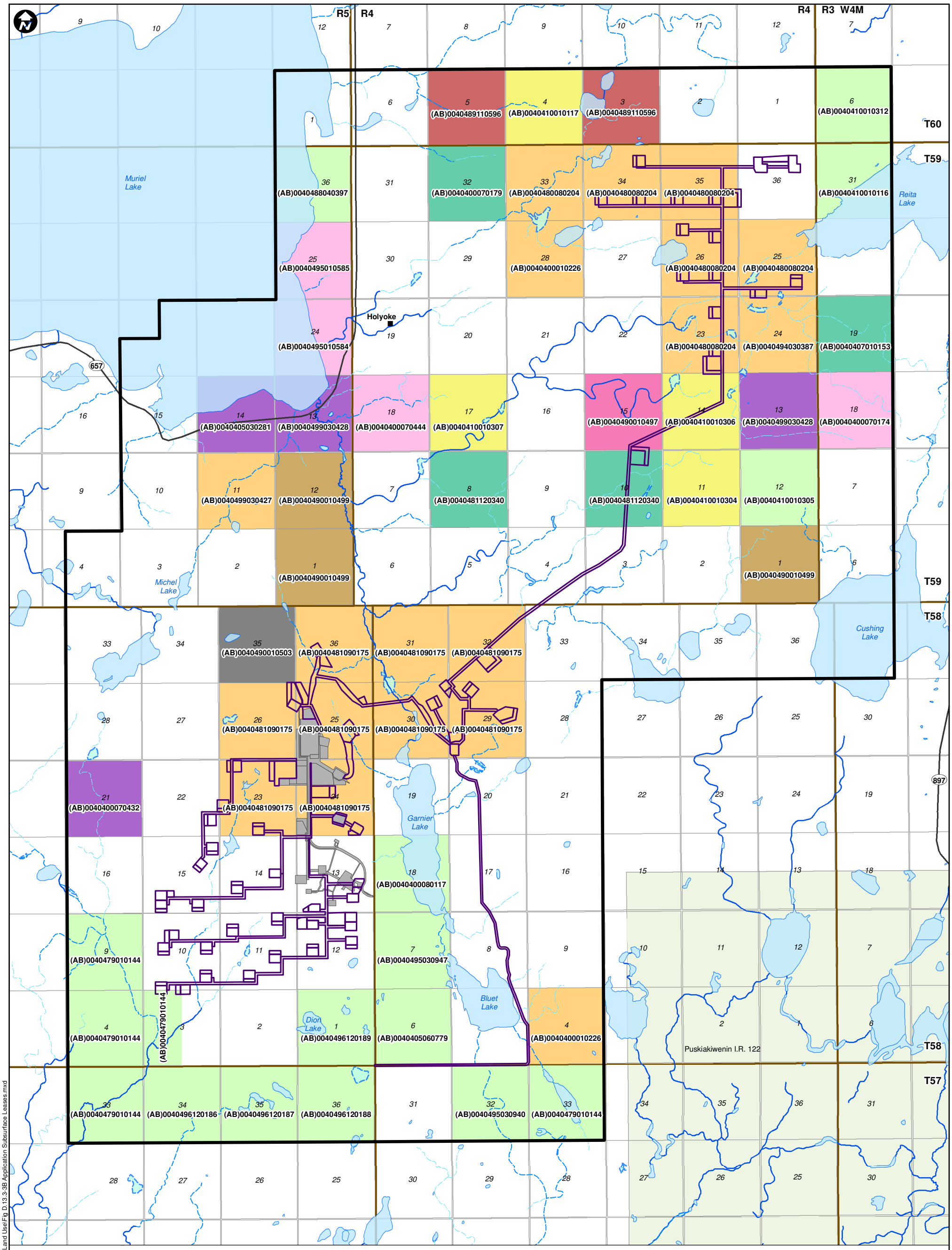
PROJECT: PENGROWTH — Lindbergh SAGD Expansion Project

TITLE: **Application Case Subsurface Leases and Permits**

DRAWN: SL
CHECKED: KK
DATE: Dec 19/13
PROJECT: 11-033

FIGURE: **D.13.3-3A**

Document Path: K:\Active Client\Pengrowth Lindbergh\Final Docs\11-033\Land Use\Fig D.13.3-3A Application Subsurface Leases.mxd



Legend

- Land Use LSA
- Development Footprint
- Existing and Approved Development
- First Nations
- Secondary Highway
- Permanent Stream
- Ephemeral Stream
- Drainages without Defined Channels
- Lakes and Ponds
- Beaver Ponds

0 0.75 1.5 3
Kilometres

5 Year Plains Petroleum and Natural Gas Lease Owner

- Baytex Energy Ltd.
- Bonavista Energy Corporation
- Bonavista Energy Corporation/ Barnwell of Canada Limited
- Canadian Natural Resources Limited
- Conserve Oil and Gas No. II Corporation/ Conserve Oil Corporation
- Crescent Point Energy Corp.
- Crescent Point Energy Corporation/ Conserve Oil Corporation
- Gear Energy Ltd./Barnwell of Canada Limited
- Husky Oil Operations Limited
- Scott Land & Lease Ltd.

REF: Drifter Projects Ltd., EIA Footprint REV 3.dwg; NHC hydrology Oct 2013.

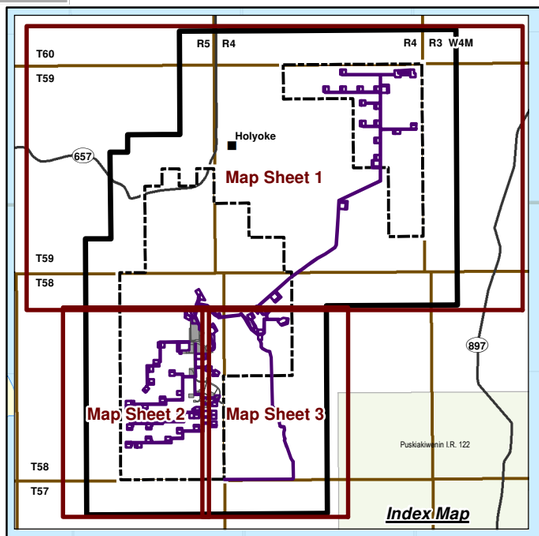
Document Path: K:\Active Client\Pengrowth Lindbergh\Final Docs\11-033\Land Use\Fig D.13.3-3B Application Subsurface Leases.mxd

PROJECT: PENGROWTH Lindbergh SAGD Expansion Project

TITLE: **Application Case Subsurface Leases and Permits**

DRAWN: SL
CHECKED: KK
DATE: Dec 19/13
PROJECT: 11-033

FIGURE: **D.13.3-3B**



Muriel Lake

Reita Lake

Michel Lake

Cushing Lake

Holyoke

Puskiakiwinin I.R. 122

T60
T59
T58
T57

R5 R4 R4 R3 W4M

657

897

Legend

- Land Use LSA
- Pengrowth Lease
- Development Footprint
- Existing and Approved Development
- Pengrowth Disposition
- Non-Pengrowth Disposition
- Existing Human Use
- Freehold Land
- Secondary Highway
- Permanent Stream
- Ephemeral Stream
- Drainages without Defined Channels
- Lakes and Ponds
- Beaver Ponds
- First Nations

0 0.5 1 2
Kilometres

REF: Drifter Projects Ltd., EIA Footprint REV 3.dwg; NHC hydrology Oct 2013.

Document Path: K:\Active Client\Pengrowth Lindbergh\Final Docs\11-033\Land Use\Fig D.13.3-4A Application Surface Dispositions-Mapsheet 1.mxd

PROJECT:

PENGROWTH

Lindbergh SAGD Expansion Project

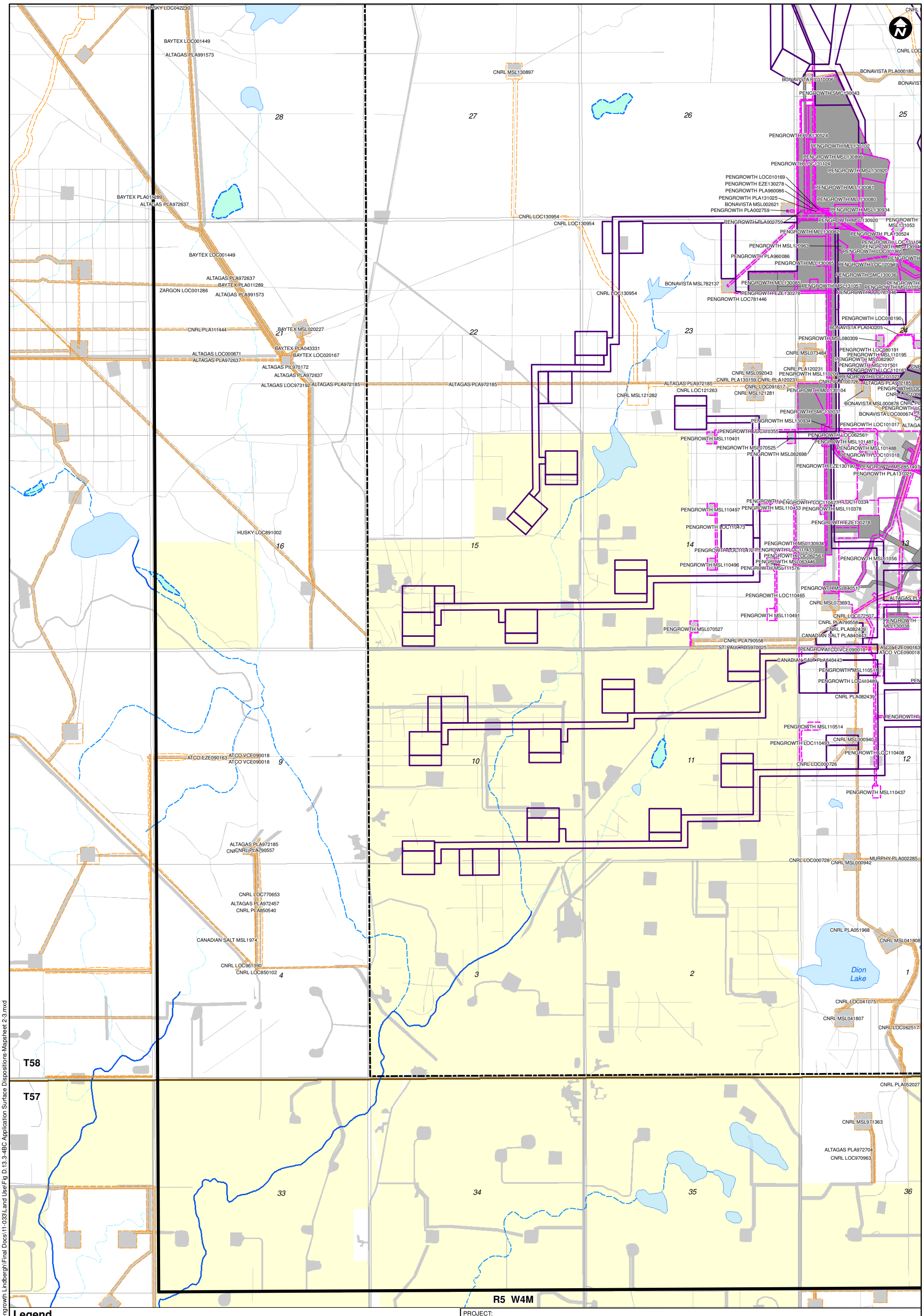
TITLE:

Application Case Surface Dispositions - Map Sheet 1

DRAWN:	SL
CHECKED:	KK
DATE:	Dec 19/13
PROJECT:	11-033

FIGURE:

D.13.3-4A



Legend

- Land Use LSA
- Pengrowth Lease
- Development Footprint
- Existing and Approved Development
- Pengrowth Disposition
- Non-Pengrowth Disposition
- Existing Human Use
- Freehold Land
- First Nations
- Secondary Highway
- Permanent Stream
- Ephemeral Stream
- Drainages without Defined Channels
- Lakes and Ponds
- Beaver Ponds

0 250 500 1,000 Metres

REF: Drifter Projects Ltd., EIA Footprint REV 3.dwg; NHC hydrology Oct 2013.

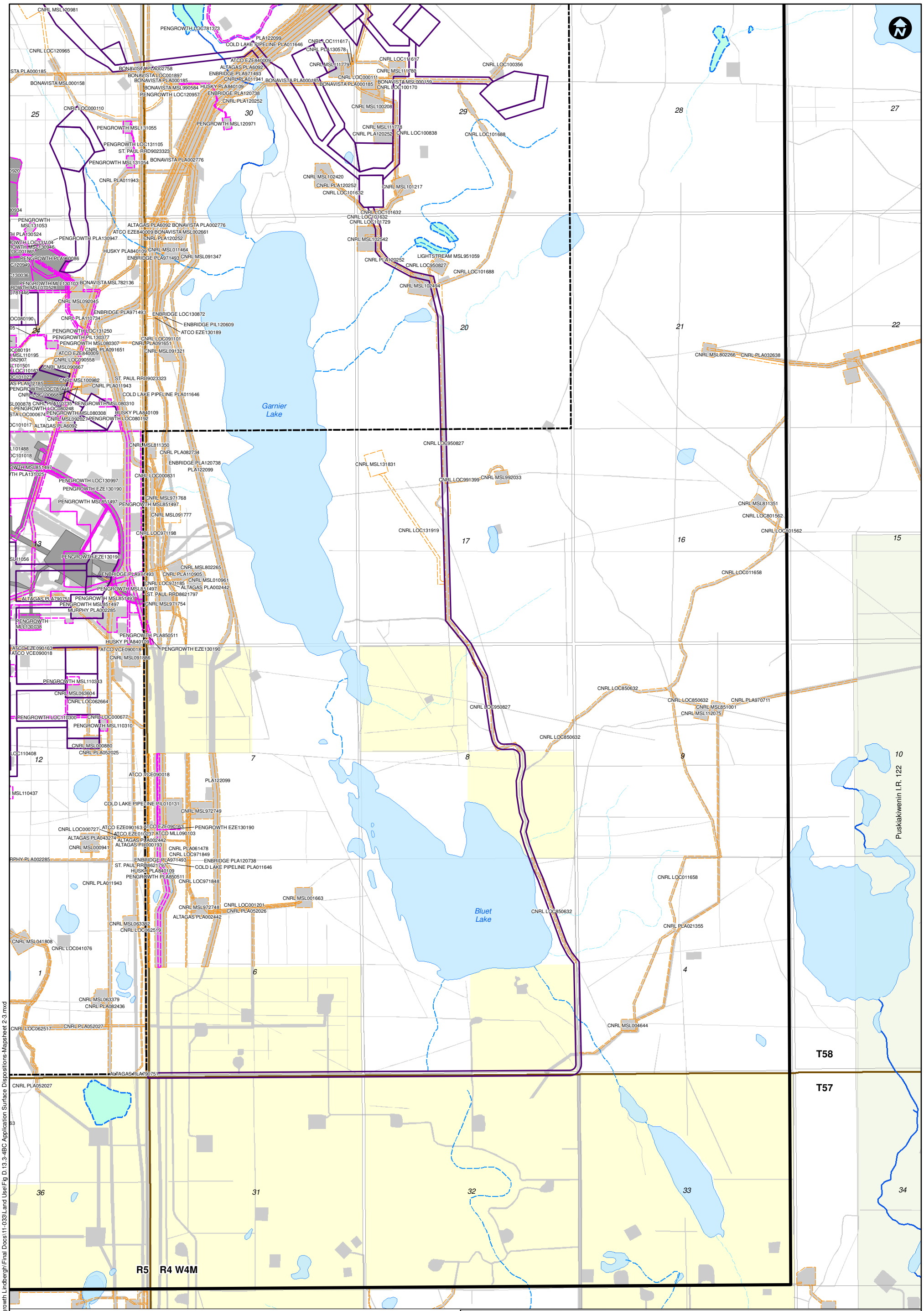
PROJECT: PENGROWTH **Lindbergh SAGD Expansion Project**

TITLE: **Application Case Surface Dispositions - Map Sheet 2**

DRAWN: SL
CHECKED: KK
DATE: Dec 19/13
PROJECT: 11-033

FIGURE: **D.13.3-4B**

Document Path: K:\Active Client\Pengrowth Lindbergh\Final Docs\11-033\Land Use\Fig D.13.3-4BC Application Surface Dispositions-Mapsheet 2-3.mxd



Legend

- Land Use LSA
- Pengrowth Lease
- Development Footprint
- Existing and Approved Development
- Pengrowth Disposition
- Non-Pengrowth Disposition
- Existing Human Use
- Freehold Land
- First Nations
- Secondary Highway
- Permanent Stream
- Ephemeral Stream
- Drainages without Defined Channels
- Lakes and Ponds
- Beaver Ponds

0 250 500 1,000
Metres

REF: Drifter Projects Ltd., EIA Footprint REV 3.dwg; NHC hydrology Oct 2013.

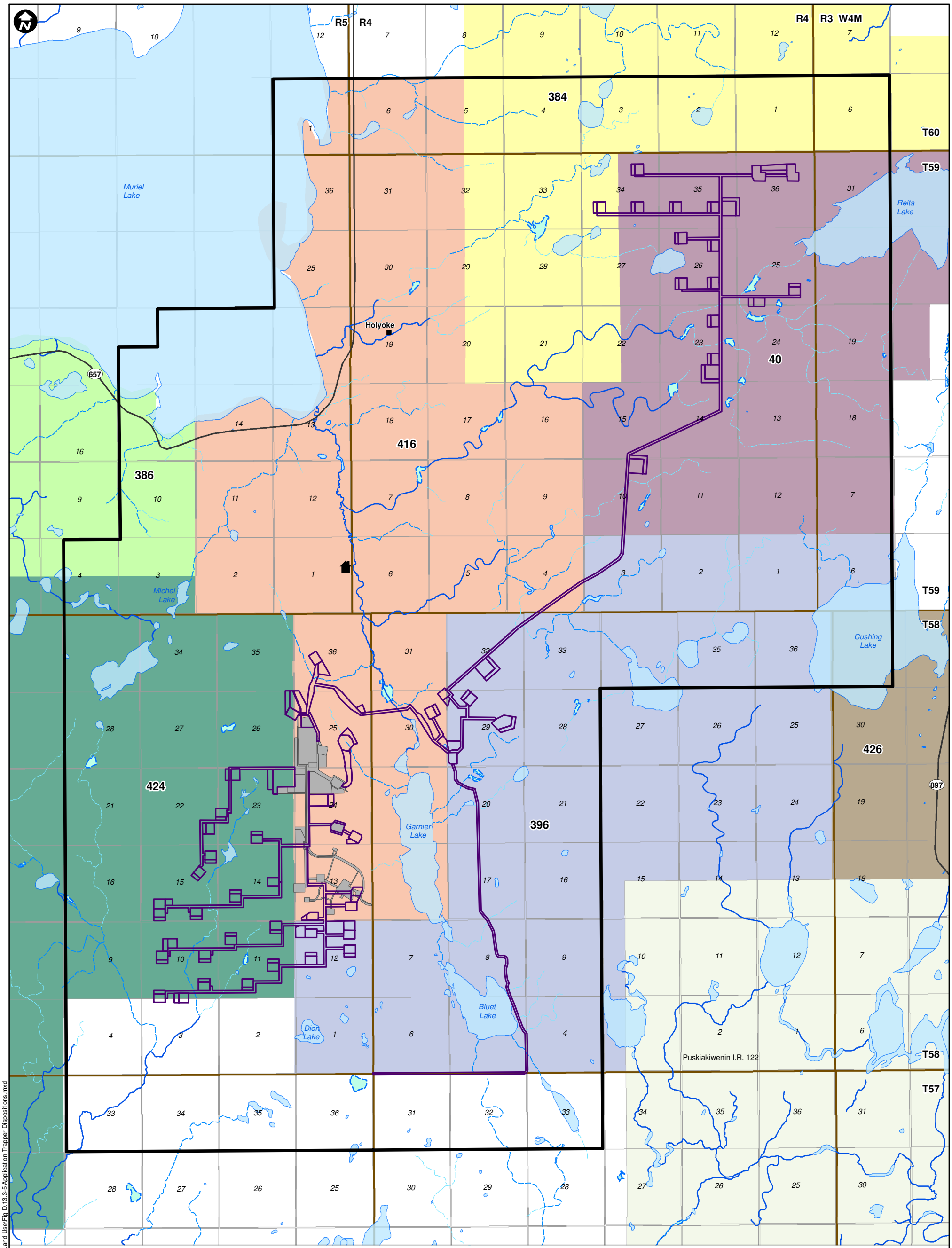
PROJECT: PENGROWTH Lindbergh SAGD Expansion Project

TITLE: Application Case Surface Dispositions - Map Sheet 3

DRAWN: SL
CHECKED: KK
DATE: Dec 19/13
PROJECT: 11-033

FIGURE: D.13.3-4C

Document Path: K:\Active Client\Pengrowth Lindbergh\Final Docs\11-033\Land Use\Fig D.13.3-4BC Application Surface Dispositions-Mapsheet 2-3.mxd



Legend

- Trapper's Cabin
- Land Use LSA
- Development Footprint
- Existing and Approved Development
- First Nations
- Secondary Highway
- Permanent Stream
- Ephemeral Stream
- Drainages without Defined Channels
- Lakes and Ponds
- Beaver Ponds

Trapline Number

- 40
- 384
- 386
- 396
- 416
- 424
- 426

0 0.75 1.5 3
Kilometres

REF: Drifter Projects Ltd., EIA Footprint REV 3.dwg; NHC hydrology Oct 2013.

PROJECT: PENGROWTH — Lindbergh SAGD Expansion Project

TITLE: **Application Case Trapper Dispositions**

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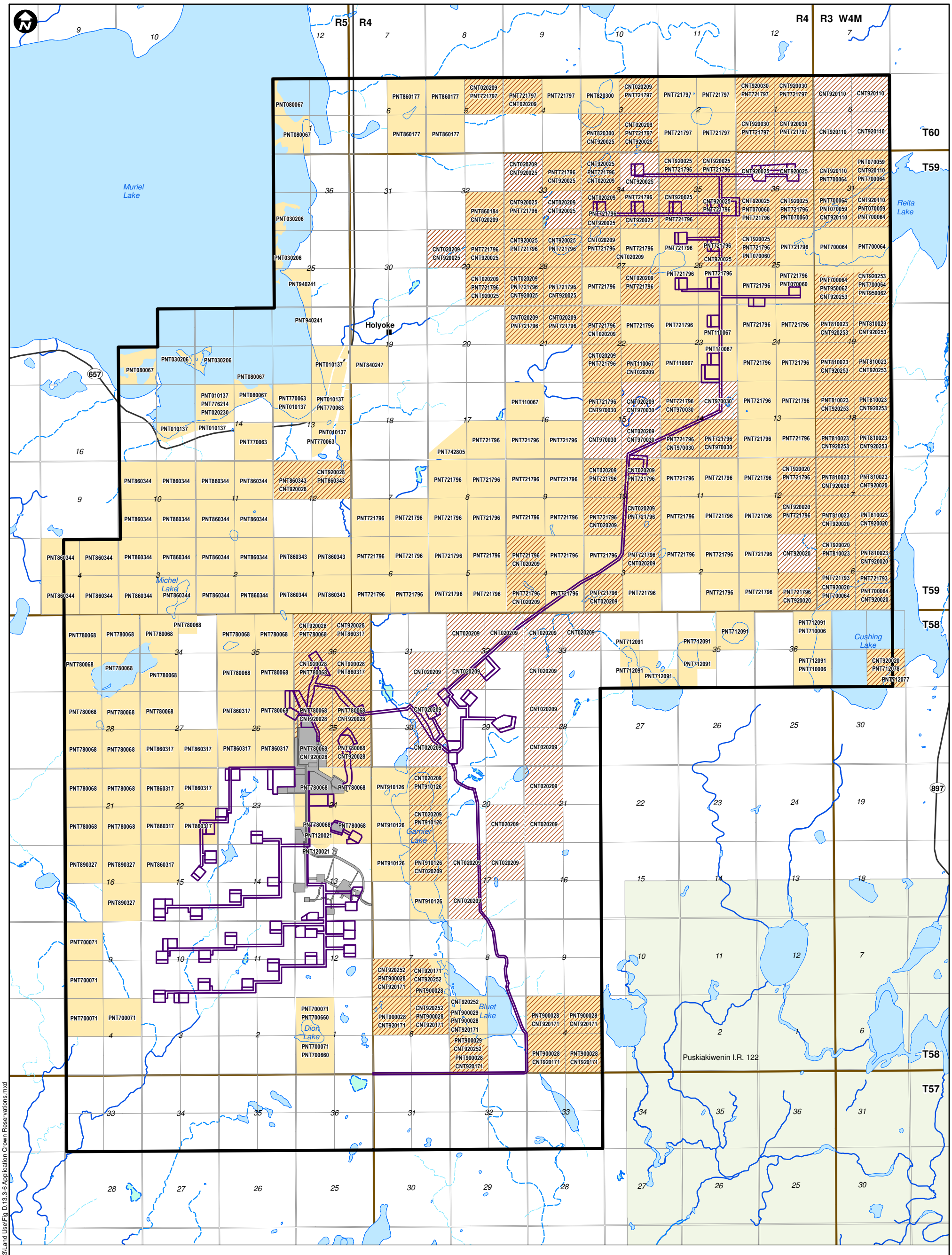
PROJECT: 11-033

FIGURE: **D.13.3-5**

Document Path: K:\Active Client\Pengrowth Lindbergh\Final Docs\11-033\Land Use\Fig D.13.3-5 Application Trapper Dispositions.mxd



Legend

- Land Use LSA
- Development Footprint
- Existing and Approved Development
- Consultative Notation
- Protective Notation
- First Nations
- Secondary Highway
- Permanent Stream
- Ephemeral Stream
- Drainages without Defined Channels
- Lakes and Ponds
- Beaver Ponds

0 0.75 1.5 3
Kilometres

PROJECT: PENGROWTH — Lindbergh SAGD Expansion Project

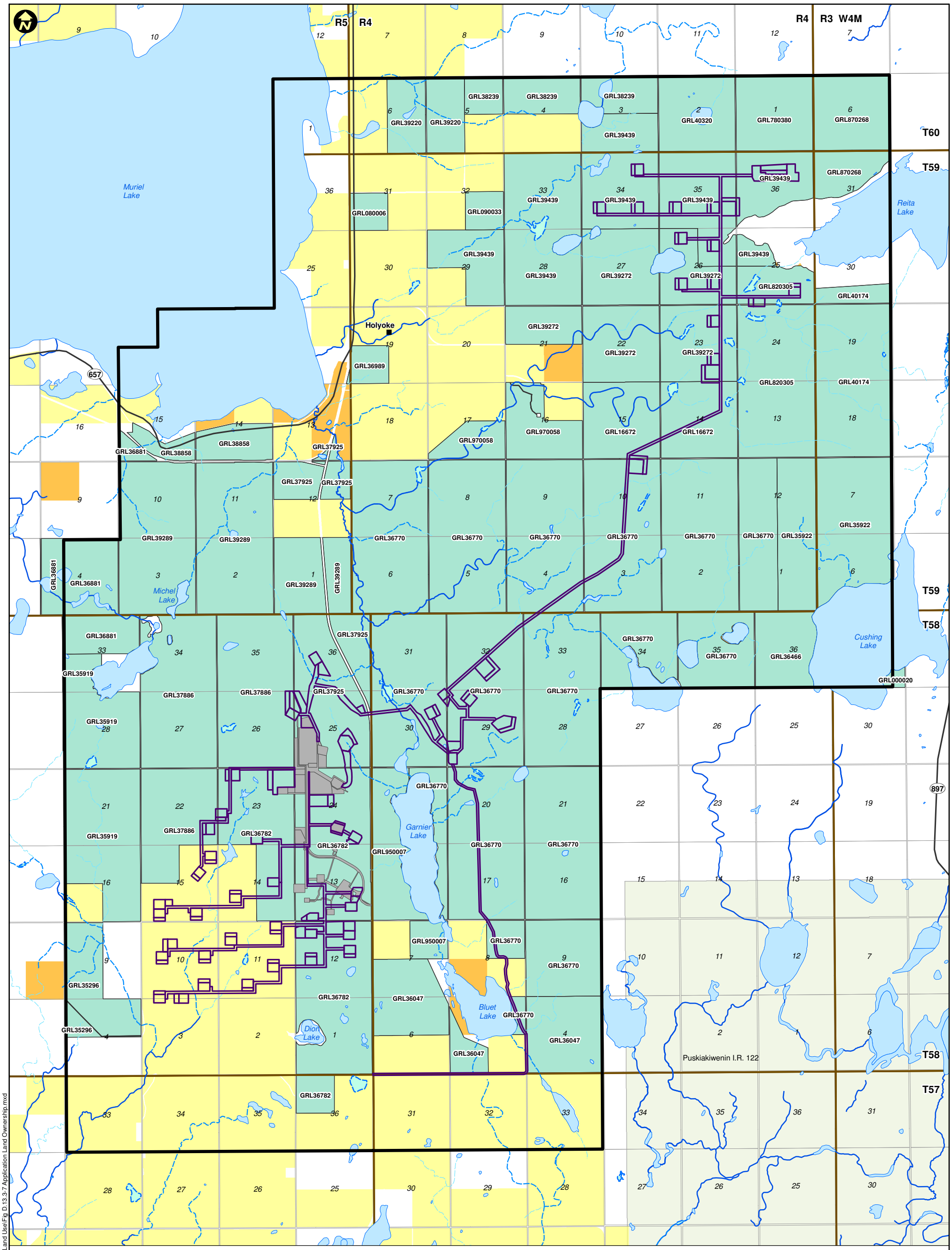
TITLE: **Application Case Crown Reservations**

DRAWN: SL
CHECKED: KK
DATE: Dec 19/13
PROJECT: 11-033

FIGURE: **D.13.3-6**

REF: Drifter Projects Ltd., EIA Footprint REV 3.dwg; NHC hydrology Oct 2013.

Document Path: K:\Active Client\Pengrowth Lindbergh\Final Docs\11-033\Land Use\Fig D.13.3-6 Application Crown Reservations.mxd



Legend

- Land Use LSA
- Development Footprint
- Existing and Approved Development
- Grazing Lease
- Crown Land
- Freehold Land
- First Nations
- Secondary Highway
- Permanent Stream
- Ephemeral Stream
- Drainages without Defined Channels
- Lakes and Ponds
- Beaver Ponds

0 0.75 1.5 3
Kilometres

PROJECT: PENGROWTH Lindbergh SAGD Expansion Project

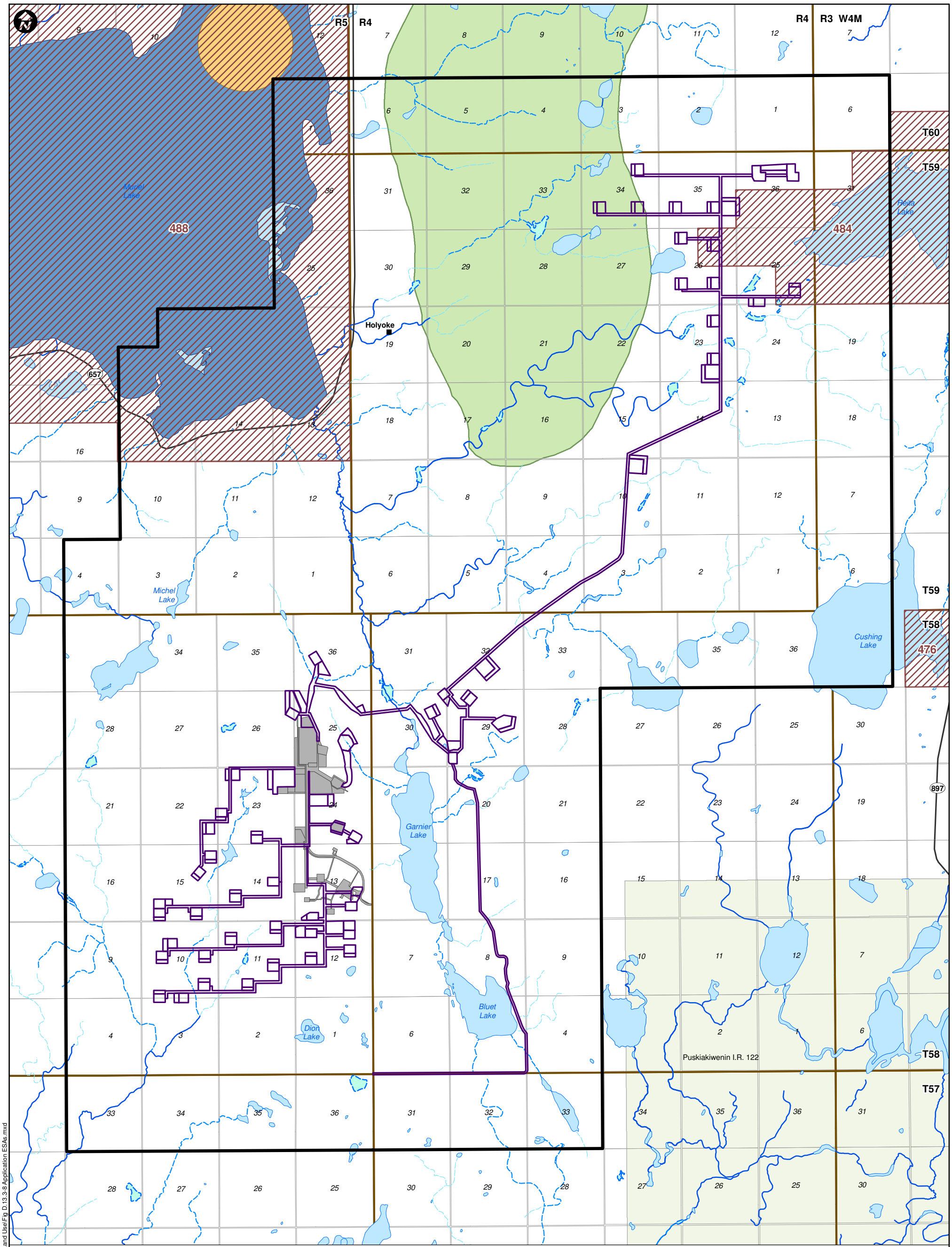
TITLE: **Application Case Land Ownership**

DRAWN: SL
CHECKED: KK
DATE: Dec 19/13
PROJECT: 11-033

FIGURE: **D.13.3-7**

REF: Drifter Projects Ltd., EIA Footprint REV 3.dwg; NHC hydrology Oct 2013.

Document Path: K:\Active Client\Pengrowth Lindbergh\Final Docs\11-033\Land Use\Fig D.13.3-7 Application Land Ownership.mxd



Legend

- Land Use LSA
- Development Footprint
- Existing and Approved Development
- First Nations
- Environmentally Significant Area (2009)
- Colonial Nesting Bird Area - American White Pelican
- Piping Plover Waterbody
- Key Wildlife and Biodiversity Zone
- Secondary Highway
- Permanent Stream
- Ephemeral Stream
- Drainages without Defined Channels
- Lakes and Ponds
- Beaver Ponds

0 0.75 1.5 3
Kilometres

REF: Drifter Projects Ltd., EIA Footprint REV 3.dwg; NHC hydrology Oct 2013.

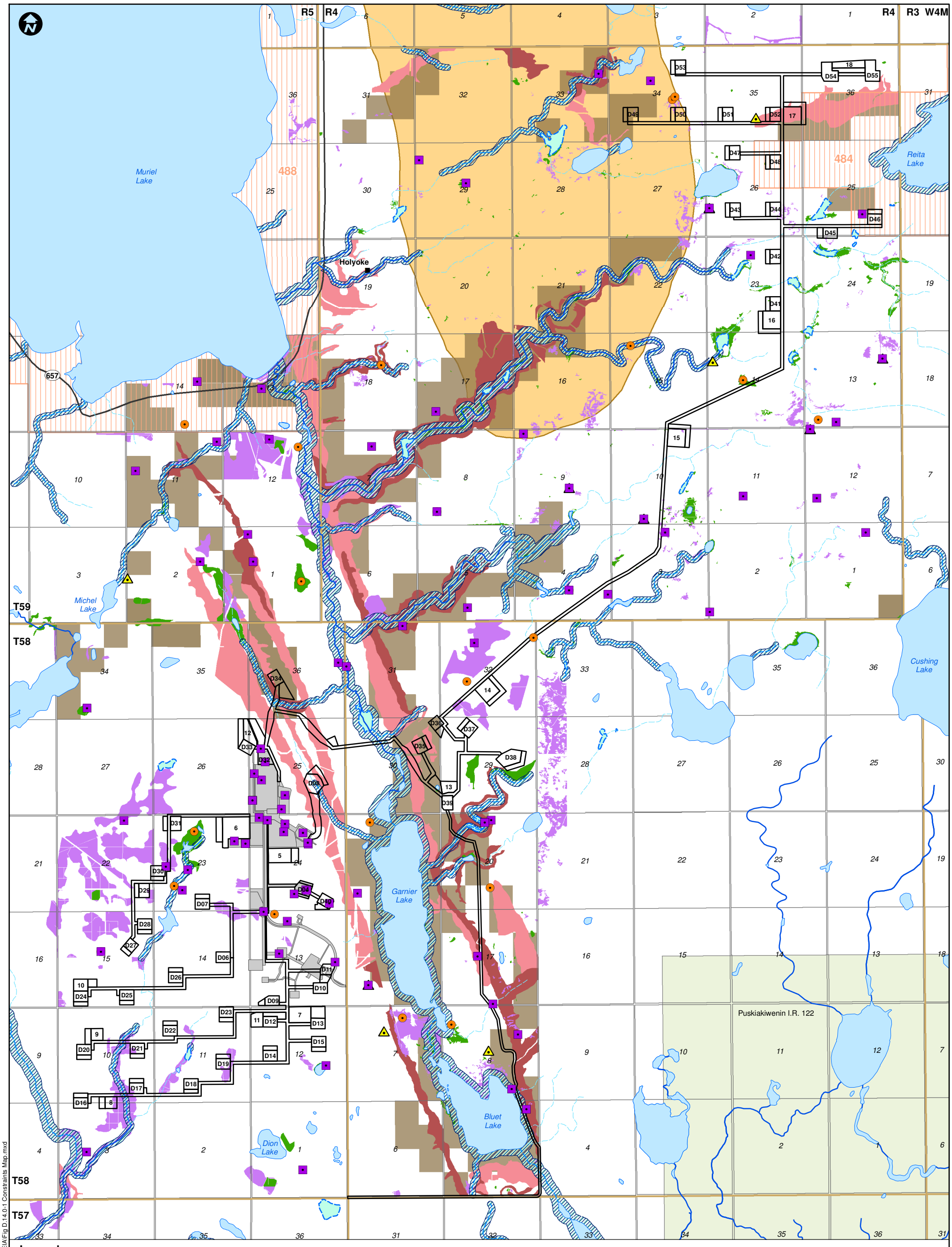
PROJECT: PENGROWTH — Lindbergh SAGD Expansion Project

TITLE: **Application Case ESAs and Wildlife Sensitivity Areas**

DRAWN: SL
CHECKED: KK
DATE: Dec 19/13
PROJECT: 11-033

FIGURE: **D.13.3-8**

Document Path: K:\Active Client\Pengrowth Lindbergh\Final Docs\11-033\Land Use\Fig D.13.3-8 Application ESAs.mxd



Legend

- Development Footprint
- Existing and Approved Development
- First Nations
- Secondary Highway
- Permanent Stream
- Ephemeral Stream
- Drainages without Defined Channels
- Lakes and Ponds
- Beaver Ponds

Aquatic
- Water Body Buffer

Historical Resources
- High Archaeological Potential

Soils
- High Water Erosion Risk
- Severe Water Erosion Risk

Vegetation

Rare Plant Location
- Bryophyte
- Lichen
- Vascular
- Wetlands with Limited Distribution
- Ecosites with Limited Distribution

Wildlife
- Environmentally Significant Area (2009)
- Key Wildlife and Biodiversity Zone

0 0.75 1.5 3
Kilometres

REF: Drifter Projects Ltd., EIA Footprint REV 3.dwg; Hatfield, 2013; Lifeways, 2013; MEMS, 2013; NHC hydrology, Oct 2013.

Document Path: K:\Active Client\Pengrowth Lindbergh\Final Docs\11-033\EIA\Fig D.14.0-1 Constraints Map.mxd

PROJECT: PENGROWTH — Lindbergh SAGD Expansion Project

TITLE: **Constraints Map**

DRAWN:	SL
CHECKED:	KK
DATE:	Dec 10/13
PROJECT:	11-033

FIGURE: **D.14.0-1**