TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

5 HYDROGEOLOGY

5.1 Introduction

This section of the EIA describes baseline hydrogeological conditions and identifies components of the Project that will potentially affect groundwater from a local and regional perspective.

5.2 Study Areas

The RSA and the LSA for the hydrogeology assessment are shown on Figure 5.2-1. For convenience, all hydrogeology figures are located at the end of this section.

The RSA was defined primarily on the basis of interpreted regional geology and groundwater flow patterns. The extent of the RSA is defined by the following:

- North – The Clearwater River, extending from the Saskatchewan border to the confluence with the Athabasca River and the eastward flowing section of the Athabasca River to the confluence with the Clearwater River;
- East – The Saskatchewan border extending north from the centre of Township 69 to the Clearwater River;
- South – The centre of Township 69 extending west from the Saskatchewan border to the Athabasca River; and
- West – The northerly flowing portion of the Athabasca River extending north from the centre of Township 69 to Township 87.

The LSA was defined to encompass the entire Project. The limits of the LSA are townships 76 to 83 and ranges 6 to 14 west of the 4th meridian.

5.3 Issues and Assessment Criteria

Through the construction, production and post-production phases of the Project, components which have the potential to affect groundwater resources include:

- Operation of surface facilities;
- Potable water withdrawal;
- Make-up water withdrawal and wastewater injection; and
- Production and steaming;

The assessment describes the potential impact to groundwater resources in terms of the following attributes:

- Direction of the impact;
- Geographic extent;
- Magnitude of impact;

- Duration of the impact;
- Confidence in the available information used to make the assessment; and
- Final impact rating.

A detailed description of the criteria for each of the attributes is located in Volume 2, Section 1. In some instances in the hydrogeology section, different criteria were used for assessing the magnitude of impact as described in the following sections.

The above attributes were used to rank the potential severity of impact to each of the following indicator resources:

- Surface Waterbodies;
- Overburden Aquifers;
- Empress Terrace Aquifer;
- Empress Channel Aquifer;
- Lower Grand Rapids Aquifer;
- Clearwater A Aquifer;
- Clearwater B Aquifer; and
- Basal McMurray Aquifer.

The potential impact to each of the above indicator resources was evaluated with respect to water quality and water levels (hydraulic head). Specific methods used to measure and evaluate the potential impacts compared to baseline conditions are discussed in the following subsections.

5.4 Methods

5.4.1 Geologic Mapping

Geologic mapping was completed in two parts. Detailed mapping of the LSA included the review of 1,635 well logs. Mapping of the RSA included the review of an additional 167 well logs. A type log illustrating how Mannville Group structure tops and isopachs were chosen is provided as Figure 5.4-1. Further details with respect to geologic mapping are provided in Appendix 5A.

5.4.2 Hydraulic Head Mapping

Hydraulic head mapping was completed for the RSA using topography, geologic subcrop and outcrop locations and several types of data sets including:

- On-site water level measurements;
- Published hydraulic heads from EIAs completed for neighboring projects;
- Published hydraulic heads from regional hydrogeologic studies; and

- Drill stem test (DST) data from the Alberta Energy and Utilities Board (EUB) database.

The data points were divided according to hydrostratigraphic units, screened for quality control and interpreted with respect to topography and geology. Appendix 5B provides background as to the data sources, describes the quality assurance/quality control (QA/QC) process employed in screening the data and includes a tabular summary of the water level and pressure data.

5.4.3 Groundwater Quality Characterization

Characterization of baseline groundwater quality in the LSA was completed to document the groundwater quality prior to project development. Data sources for the groundwater analyses included:

- Published groundwater quality results from EIAs completed for neighboring projects;
- published groundwater quality results from regional hydrogeologic studies;
- Salinity calculations from well log resistivity (Archie's Law); and
- Rakhit GeoFluids database (IHS, 2007).

Further details with respect to the salinity mapping are provided in Appendix 5C.

5.4.4 Candidate Water Supply and Disposal Aquifer Selection

The Project LSA is underlain by several water bearing formations that are candidates for use as water supply aquifers. To identify suitable candidates for use as potable (domestic) and make-up (industrial) water source aquifers, these aquifers were rated using several physical criteria. Table 5.4-1 summarizes the physical characteristics, advantages and disadvantages of using a particular aquifer as a source of industrial or domestic water for the Project.

Table 5.4-1 Advantages and Disadvantages of Aquifer Characteristics

Characteristic	Favourable Attributes	Detrimental Attributes
Depth How shallow is the aquifer?	Easier to extract water from a shallow aquifer.	The deeper the aquifer the harder it is to lift the water at a specified rate.
Thickness How thick is the aquifer? Thickness (b) is related to transmissivity (T) by T = K*b, where, K = hydraulic conductivity	Keeping K constant, a thick aquifer has a higher transmissivity and higher well yield.	Keeping K constant, a thin aquifer has a lower transmissivity and lower well yield.
Sediment Type What type of sediment is the aquifer? Sand generally has a higher permeability than finer grained sediments.	Aquifer is dominated by higher permeability sand.	Aquifer is dominated by lower permeability silt or clay.
Laterally Continuity Is the aquifer laterally continuous or isolated?	Laterally continuous aquifers are better for water supply.	Laterally isolated aquifer may not be suitable for water supply.
Aquifer Properties Does the aquifer have suitable hydraulic conductivity (K).	Aquifers with higher K values have higher well yields.	Aquifers with lower K values have lower well yields.

Characteristic	Favourable Attributes	Detrimental Attributes
Water Chemistry What is the water chemistry of the aquifer?	A TDS concentration of greater than 4,000 mg/L is considered saline. TDS concentration less than 500 mg/L and a chloride concentration less than 250 mg/L are favorable for a potable water supply.	With respect to steam generation, highly saline water would require extensive water treatment Groundwater with a TDS concentration greater than 500 mg/L and a chloride concentration greater than 250 mg/L would not be favorable for a potable water supply.
Primary Pore Contents Is the aquifer primarily water/oil/gas saturated?	An aquifer that is primarily saturated with water	An aquifer that is primarily saturated with oil and or gas.

5.4.5 Assessment of the Impact due to Make-up Water Withdrawal and Wastewater Injection

The assessment of the impact of make-up water withdrawal and wastewater injection was completed using a numerical model. This work assumes that a representative elementary volume (REV; Bear, 1972) of the porous medium exists and can represent the effective hydraulic behavior of the medium. Groundwater flow within the study area was interpreted to be normal gravity driven flow and can be represented by the fluid continuity equation:

$$\frac{\partial}{\partial x}\left(K_x \frac{\partial h}{\partial x}\right) + \frac{\partial}{\partial y}\left(K_y \frac{\partial h}{\partial y}\right) + \frac{\partial}{\partial z}\left(K_z \frac{\partial h}{\partial z}\right) = S_s \frac{\partial h}{\partial t}$$

where:

x, y, z = the principal components of space (L);
h = hydraulic head (L);
S_s = specific storage (L^{-1});
K = hydraulic conductivity (L/t); and
t = time.

The major assumptions within the continuity equation and in this application are that the fluid is incompressible, groundwater flow follows Darcy's Law and the fluid throughout the study area has a constant density.

Groundwater flow was simulated in this study using the three dimensional FEFLOW simulator developed by WASY Ltd. (2004). FEFLOW was used to solve for mass conservative groundwater flow within fully saturated porous media using finite element discretization of the media. A summary of the numerical model construction and calibration process is included in Appendix 5D.

The impact to indicator resources was predicted by inputting the projected pumping schedule into the model and simulating the change in water level and groundwater flux within the hydrogeologic system over a period of 90 years (45 years past the operational phase of the Project).

5.4.5.1 Aquifer Productivity Assessment

The simulated change in water levels as a result of make-up water withdrawal and wastewater injection was interpreted in terms of aquifer productivity. Assuming that the aquifer transmissivity does not change significantly due to drawdown, the predicted percent change in aquifer productivity (%AP) due to a change in hydraulic head (Δs) in the aquifer can be estimated as:

$$\%AP = \frac{\Delta s}{H_A} * 100$$

where:

H_A = available drawdown [L] (for a confined aquifer H_A is the difference between the hydraulic head in the aquifer and the top of the aquifer)

The magnitude of the potential impact on aquifer productivity was assessed using the following three empirical levels:

- Low Effect – If the predicted %AP is less than 15%, the effect may be detectable; however, potential conflicts with other users would likely not result.
- Medium Effect – If the predicted %AP is between 15% and 30%, the effect would likely be detectable; however, conflicts with other users would likely not result.
- High Effect – If the predicted %AP is greater than 30%, potential conflicts with other users could result.

In the instance that high effects are predicted, the lateral extent of the impact, duration of the impact and the location of other potential users need to be considered to determine the final impact rating of make-up water withdrawal and wastewater injection.

5.4.5.2 Groundwater Flux Assessment Methodology

Under baseline conditions, surface water levels in the LSA are in dynamic equilibrium with precipitation, evaporation, transpiration, groundwater recharge to overburden aquifers and surface water discharge out of the LSA. If groundwater flux to or from a surface waterbody is altered due to Project operations, there are potential impacts on that surface waterbody.

To understand the potential impact to surface waterbodies with respect to water levels, a groundwater flux assessment was completed. The induced flux normal to the ground surface is a function of the simulated drawdown and is therefore spatially dependent.

Induced flux (*IF*) is calculated as:

$$IF = q_i - q_{sim}$$

where:

q_i = steady state simulated flux in the aquifer; and
q_{sim} = simulated flux in aquifer at a specified time.

The final impact assessment of the predicted change to surface waterbodies is included in Volume 3, Section 6 (Hydrology).

5.4.5.3 Assessment of the Impact Due to Wastewater Migration

Wastewater injection into the most appropriate candidate aquifer is predicted to change water quality in that aquifer. Given that increases in hydraulic head result from wastewater injection, the potential exists for wastewater to migrate away from injection wells.

A quantitative approach was used to evaluate the potential impacts with respect to water quality. The wastewater concentration in the groundwater discharging to the nearest receptor was estimated using the one-dimensional advective-dispersive transport equation:

$$\theta \frac{\partial c}{\partial t} + \rho_b \frac{\partial s}{\partial t} = -q \frac{\partial c}{\partial x} + \theta D \frac{\partial^2 c}{\partial x^2} - \theta \lambda c - \rho_b \lambda s$$

where:

c	=	dissolved concentration (M solute / L^3)
s	=	sorbed concentration (M solute / L^3)
x	=	spatial coordinates (L)
λ	=	first order decay coefficient (T^{-1})
θ	=	saturated water content (L^3 water / L^3 porous media)
t	=	time (T)
q	=	Darcy flux (L / T)
D	=	dispersion coefficient (L^2 / T)

The program ATRANS4 (Neville, 1998) was used to solve the above equation. Two simulations were completed to illustrate the potential range in wastewater concentrations at the discharge point. The more conservative simulation assumed a porosity of 7.5% and a hydraulic conductivity of 6.0×10^{-5} m/s. The less conservative simulation assumed a porosity of 15% and a hydraulic conductivity of 2.3×10^{-5} m/s. Other parameters that were consistent between the simulations were:

- Hydraulic gradient: 8.6×10^{-4}
- Simulation period of 80,000 years
- Longitudinal dispersivity (α_L) of 1,000 m
- Effective diffusion coefficient (D*) of 0 m^2/y

The simulation assumed disposal well operation during the first 40 years of the simulation period. The simulation results are conservative as it was assumed that there was no transverse lateral or vertical dispersion and that the solutes were conservative (no degradation or retardation).

The final impact rating was assessed based on the closest receptor, travel time and breakthrough concentration.

5.4.6 Assessment of the Impact of Production Chamber Steaming

Prolonged injection of high temperature steam will increase the matrix temperature and pore fluid in close proximity to the well bore. Mineral solubility is temperature dependent. As such, an increase in matrix temperature has the potential to increase mineral solubility and, therefore, could impact groundwater quality.

For the purpose of this assessment, it was assumed that heat transport in the vicinity of the well bore can be described solely by the principles of conduction and forced convection (advection). The potential extent and magnitude of temperature change downgradient of the well bore can be described by the one dimensional conduction-convection equation:

$$\frac{\partial}{\partial \times}\left(K_e \frac{\partial T}{\partial \times}\right) - \left(\frac{n\,\rho_w\,c_w}{\rho'\,c'} V_x \frac{\partial T}{\partial x}\right) = \rho'\,c'\,\frac{\partial T}{\partial t}$$

where:

x	=	principal component of space in the direction of maximum groundwater flow (L);
T	=	temperature;
K_e	=	effective thermal conductivity (E/(LTt));
n	=	porosity (%);
ρ_w	=	density of water (M/L^3);
c_w	=	specific heat capacity of water (E/(MT));
ρ’	=	density of rock and water (M/L^3);
c’	=	specific heat capacity of rock and water (E/(MT)); and
V_x	=	groundwater velocity (in the x direction) (L/T).

For the purpose of the impact assessment, the following was assumed:

- The typical life-span of a production chamber and steam injection well is between four and eight years.
- The initial reservoir temperature is 6°C.
- The temperature of the steam and well bore reaches 265°C.
- The temperature at the edge of the wellbore is equal to the temperature of the steam (265^{o}C).
- The density of rock matrix is 2,650 kg/m^3 for all units.
- Porosity of Empress Channel and Terrace aquifers is 30%.
- Porosity of Undifferentiated Overburden Aquifer/Aquitard is 15%.

Specific heat capacities of the assessed formations were based on Dominico and Schwartz (1997; page 324):

- Undifferentiated Overburden Aquifer/Aquitard – 220 Cal/Kg.^{o}C,
- Empress Terrace Aquifer – 188 Cal/Kg.^{o}C,
- Empress Channel Aquifer – 188 Cal/Kg.^{o}C;
- Thermal conductivity of the assessed formations was based on Dominico and Schwartz (1997; page 321):
- Undifferentiated Overburden – 0.3 Cal/m.sec.^{o}C,
- Empress Terrace Aquifer – 0.9 Cal/m.sec.^{o}C,

- Empress Channel Aquifer – 0.9 Cal/m.sec.^{o}C; and

The groundwater velocities of the assessed formations were based on the results of the calibrated steady-state groundwater flow model:

- Undifferentiated Overburden – 0.000046 m/d,
- Empress Terrace Aquifer – 0.026 m/d,
- Empress Channel Aquifer – 0.043 m/d.

A finite difference approximation to this one dimensional equation was solved in order to obtain a conservative estimate of temperature change down-gradient of the well bore. For the purpose of this assessment, the following empirical levels of magnitude were used:

- Low Effect – If the predicted change in temperature is less than 10%, the change is likely too small to influence mineral solubilities; and
- High Effect – If the predicted change in temperature is greater than 10% the change could possibly have an influence on mineral solubilities and therefore mineral concentrations.

The final impact rating of high effects is then considered with respect to the initial water quality of the potential receptor.

5.5 Existing Conditions

5.5.1 Physiography

The RSA is in the Boreal Forest Natural Region (AENV, 2005). The Boreal Forest Natural Region is a vast expanse of forests comprised of white spruce, balsam fir, aspen, balsam poplar and jack pine. Lower elevations of the RSA are part of the Central Mixedwood Subregion and higher elevations of the RSA are part of the Lower Boreal Highlands Subregion. Both subregions have extensive wetland areas that make up 30% to 40% of their total area.

The climate of the Boreal Forest Natural Region is continental with short, cool summers and long, cold winters. The mean annual temperature and mean annual precipitation for the Central Mixedwood Subregion are 0.2°C and 478 mm, respectively. The mean annual temperature and mean annual precipitation for the Lower Boreal Highlands Subregion are -1.0°C and 495 mm, respectively. Approximately 70% of the precipitation accumulates during the growing season with peak precipitation occurring in July.

Topography of the RSA is illustrated on Figure 5.2-1. Surface elevations range from less than 350 metres above sea level (masl) at the confluence of the Athabasca and Clearwater rivers to over 800 masl in the May Hills.

The RSA is located within the Athabasca River Watershed. Major rivers in the RSA include the Athabasca, Clearwater, Christina and House rivers. Numerous lakes are located in the RSA, some of the larger ones include; Winefred, Gordon, Christina, Heart and Wiau lakes.

Topography of the LSA is also illustrated on Figure 5.2-1. Surface elevations range from less than 500 metres above sea level (masl) along the Christina River near Chard to over 750 masl on the Stony Mountain Uplands.

The majority of the surface water in the LSA drains toward the Christina River. The Christina River headwaters are in the Stony Mountain Uplands and the river meanders south throughout the LSA, turns and finally exits the LSA, flowing northeast, near Chard. Major tributaries of the Christina River in the LSA include May River, Jackfish River, Waddell Creek and Pony Creek. Surficial drainage of the northern and western portion of the LSA is dominated by the House, Horse and Hangingstone rivers. The largest lakes in the LSA are Christina and Egg lakes.

5.5.2 Geology

5.5.2.1 Local and Regional Geology

Stratigraphic Overview

Precambrian deposits represent the base of the geologic column for this assessment. Devonian bedrock including the Elk Point, Beaverhill Lake, Woodbend and Winterburn groups unconformably overlie the Precambrian basement. In turn, Cretaceous bedrock including the Mannville Group, the Colorado Group and Upper Cretaceous deposits unconformably overlie Devonian bedrock. Finally, unconformably overlying the Cretaceous bedrock surface are unconsolidated Tertiary and Quaternary deposits.

Geologic formations encountered below the RSA are discussed in the following sections from oldest to youngest age. Unless otherwise noted, discussion of bedrock geology and surficial geology is taken from Bachu et al. (1993) and Andriashek (2003), respectively. A stratigraphic column is illustrated on Figure 5.5-1.

Precambrian Basement

Precambrian crystalline basement below the RSA dips gently at approximately 5 m/km to the southwest and occurs between 200 masl and 900 metres below sea level (mbsl).

Elk Point Group

The Elk Point Group is divided into a succession of red bed/evaporitics of the Lotsberg, Ernestina Lake, and Cold Lake formations, followed by a succession of clastics, platform carbonates, evaporites and clastics of the Contact Rapids, Winnipegosis, Prairie Evaporite and Watt Mountain formations. As mapped by Bachu (1993) formations in the Elk Point Group dip to the southwest at a slope of approximately 3 m/km in the RSA.

Lotsberg Formation

Regionally, the Lotsberg Formation is a complex wedge of red bed and evaporite deposits consisting of the Basal Red Beds unit overlying the Precambrian basement, followed by the Lower Lotsberg Salt, an unnamed red bed and the Upper Lotsberg Salt. The Lower Lotsberg Salt is present throughout the RSA except in the extreme northeast and the Upper Lotsberg salt is present south of approximately Township 75 (Mossop and Shetsen, 1994). The Lotsberg Formation thickens in the southern portion of the RSA.

Ernestina Formation

The Ernestina Lake Formation conformably overlies the Lotsberg Formation and consists of a basal red dolomitic shale, a middle anhydrytic calcareous shale and an upper anhydrite bed. In the RSA, the Ernestina Formation has a “remarkably consistent average thickness of 17 m” (page 13, Bachu et al., 1993).

Cold Lake Formation

The Cold Lake Formation consists of a basal red bed unit overlain by salt deposits interbedded with dolomitic shale. In the RSA, the salt deposits thicken to the south.

Contact Rapids Formation

The Contact Rapids Formation consists of interbedded argillaceous dolostone and shale.

Keg River Formation

The Contact Rapids Formation is conformably overlain by reef and non-reef carbonates of the Keg River Formation (Winnipegosis equivalent). In the RSA, the Keg River Formation varies in thickness from 10 m to 150 m. Variation in Keg River Formation thickness is due in part to reef buildups.

Prairie Formation

The Prairie Formation is the most extensive evaporitic unit in the region and it is predominantly made up of halite and anhydrite (Hitchon et al., 1989). Wightman et al. (1995), Mossop and Shetsen (1994), and Bachu et al. (1993) suggest salt dissolution of the Prairie Formation has occurred since Devonian time. The effects of salt dissolution and subsequent collapse can be seen in regional structure maps of the overlying formations. The salt dissolution scarp is prominent in the east portion of the RSA. In the RSA, the top of the Prairie Formation ranges in elevation from 400 mbsl to 100 masl and the thickness of the Prairie Formation ranges from 0 m to 250 m.

Watt Mountain Formation

The Watt Mountain Formation consists of interbedded shale, sandstone, anhydrite, dolomite and limestone. In the RSA, the top of the Watt Mountain Formation ranges from 350 mbsl to 250 masl and ranges in thickness from approximately 15 m to 20 m.

Beaverhill Lake Group

The Beaverhill Lake Group is a wide carbonate platform that represents a ‘major back-stepping and onlap of shallow marine carbonate platforms toward the interior of the continent’ (Hitchon et al., 1989). In the RSA, the Beaverhill Lake Group ranges in thickness from 0 m to 250 m, and it consists of the Fort Vermillion, Slave Point and Waterways formations. The Beaverhill Lake Group represents the uppermost Devonian deposits for the eastern portion of the RSA (Figure 5.5-2).

Fort Vermillion and Slave Point Formations

In the RSA, the anhydrite-dominated Fort Vermillion Formation and the limestone dominated Slave Point Formation occur as thin southerly tapering wedges.

Waterways Formation

The Waterways Formation is an alternating succession of calcareous shales and carbonates.

Woodbend Group

The Woodbend Group consists of two stacked carbonate platforms, the Cooking Lake Formation and the Grosmont Formation, which are separated by limestone shales of the Ireton Formation. The Woodbend Group represents the uppermost Devonian deposits for the western portion of the RSA (Figure 5.5-2).

Cooking Lake Formation

Within the RSA, the Cooking Lake Formation ranges in thickness from 0 m to 100 m. Near the subcrop edge, the formation locally thickens due to the presence of carbonate build-ups.

Ireton Formation

The Ireton Formation is comprised of limestone shales that range in thickness from 0 m to 150 m in the RSA.

Grosmont Formation

The Grosmont Formation carbonate platform ranges in thickness from 0 m to 170 m in the RSA and is believed to have high permeability.

Winterburn Group

The Winterburn Group mainly consists of dolomitic rocks that have a maximum thickness of 125 m. The Winterburn Group represents the uppermost Devonian deposits for the extreme southwest portion of the RSA (Figure 5.5-2).

Mannville Group

The top of the Devonian deposits is a major erosional surface and represents an angular unconformity, referred to as the sub-Cretaceous Unconformity. Sub-areal erosion responsible for this unconformity has resulted in a series of ridges and valleys that trend north-northwest. These valleys developed into northerly flowing river systems during the early Cretaceous. Within the LSA, the top of Devonian deposits are between 140 to 250 masl (Figure 5.5-3). Three valley features are recognized in the LSA; a north-south trending valley from Township 75 – Range 14 to Township 82 – Range 13, a northeast-southwest trending valley from Township 75 – Range 12 to Township 82 – R9 and a large valley along the east edge of the LSA in Range 6.

The Cretaceous Mannville Group unconformably overlies Devonian deposits. In general, the Mannville Group represents a major subsidence and sedimentation followed by a long period of uplift and erosion (Mossop and Shetsen, 1994). The Mannville Group consists of the McMurray, Clearwater and Grand Rapids formations.

McMurray Formation

The lowermost deposits of the Mannville Group are the sands and shales of the McMurray Formation that were deposited in the valleys of the sub-Cretaceous Unconformity surface (Hitchon et al., 1989). The lower sediments of the McMurray Formation are fluvial in nature while the upper sediments are deposited in estuarine and interdistributary bay environments. The basic regional sequence, consistent with EUB (2003), consists of stacked progradational parasequences designated, from top down, A1, A2, B1, B2 and an underlying C Channel. A variety of estuarine channels occur within the McMurray stratigraphic section. The McMurray

Formation outcrops along the Athabasca and Clearwater rivers near the north boundary of the RSA.

Within the RSA, the top of the McMurray Formation occurs at elevations between 150 masl and 350 masl and the formation ranges in thickness from roughly 10 m to over 100 m. Within the LSA, the top of the McMurray Formation occurs at elevations between 180 masl and 300 masl and ranges in thickness from 10 m to 100 m (Figures 5.5-4 and 5.5-5). A comparison of Figures 5.5-3 and 5.5-5, illustrates how the sub-Cretaceous Unconformity surface impacted McMurray Formation deposition. Low areas of the sub-Cretaceous Unconformity resulted in thick accumulations of McMurray sediments and, in contrast, high areas of the sub-Cretaceous Unconformity resulted in thin accumulations of McMurray sediments.

The McMurray Formation hosts the majority of the bitumen reserves in the RSA. Coarse-grained sediments of the McMurray Formation are typically bitumen saturated; however, in some instances, coarse-grained fluvial sediments at the base of the McMurray Formation can be saturated with water instead.

An isopach map of the water-saturated fluvial sands of the McMurray Formation, in the LSA, is provided as Figure 5.5-6. The water-saturated fluvial sands are somewhat discontinuous with thicknesses generally less than 10 m. However, east of Range 7, the water-saturated fluvial sands are regional in extent and have a thickness of up to 40 m. Comparing Figures 5.5-3 and 5.5-6, it becomes apparent that there is a correlation between the occurrence of sub-Cretaceous surface valleys and the presence of water-saturated fluvial sands.

Clearwater Formation

The Clearwater Formation is composed of several thick, coarsening-upwards, sand successions each separated by thin shale layers (Hitchon et al., 1989). The Clearwater Formation outcrops along the Athabasca and Clearwater rivers near the north boundary of the RSA.

For the purposes of this assessment, the Clearwater Formation was subdivided into five separate units (from oldest to youngest): the Wabiskaw Member, Clearwater C unit, Clearwater B unit, Clearwater A unit and the Clearwater Shale.

In general, the lower Clearwater/Upper McMurray interval comprises a transgressive system tract. The point of the maximum transgression is marked by a low resistivity shale layer. The sediments between the top of the McMurray Formation and the point of maximum transgression are commonly separated from the remainder of the Clearwater Formation and are referred to as the Wabiskaw Member. The Wabiskaw Member is generally comprised of sandy to silty shales with occasional thin, clean sand buildups. In the RSA, the top of the Wabiskaw Member occurs at elevations between 200 masl and 400 masl and can reach thicknesses of up to 40 m. Within the LSA, the Wabiskaw Member occurs at elevations between 205 masl and 305 masl, and its thickness generally ranges from 4 m to 12 m (Figures 5.5-7 and 5.5-8).

Within the LSA, the Clearwater C unit consists of a coarsening upwards sequence containing a wide range of grain sizes; the Clearwater B unit consists of one to two coarsening upwards, stacked sandstones bounded on the top by silty shale; and the Clearwater A unit consists of a coarsening upwards sequence containing a wide range of grain sizes bounded at the top by the Clearwater Shale.

Within the RSA, the Clearwater A, B and C units can contain a considerable amount of sand, referred to as the Clearwater A,B and C Sand units (Maher, 1989). Only the Clearwater A and B Sand units are present in the LSA.

The Clearwater B Sand unit (greater than 5 m thick) is restricted to the southern portion of the LSA at an elevation ranging from 250 masl to 305 masl and a thickness up to 40 m (Figure 5.5-9). In the central and northern part of the LSA, the Clearwater B unit becomes predominantly a silty shale unit.

The Clearwater A Sand unit (greater than 5 m thick) is restricted to the northern portion of the LSA at an elevation ranging from 335 masl to 365 masl and a thickness up to 30 m (Figure 5.5-10). There is a small amount of the Clearwater A Sand unit in the southeast portion of the LSA but its thickness is less than 15 m. In the central and southern part of the LSA, the Clearwater A unit becomes predominantly a silty shale unit.

The Clearwater Shale unit (top unit of the Clearwater Formation) overlies the top of the Clearwater A unit and represents a minor transgressive pulse. Within the LSA, the Clearwater Shale occurs at elevations between 300 masl and 380 masl (Figure 5.5-11).

Grand Rapids Formation

The Grand Rapids Formation of the upper Mannville Group represents a regional regression event and consists dominantly of thick sandstones. Deposition of these sandstones was in a pattern of northwesterly prograding sand bodies (Cant and Abramson, 1997). The Grand Rapids Formation outcrops along the Athabasca and Clearwater and Christina rivers (along the northwest and north boundaries of the RSA).

For the purposes of this assessment, the Grand Rapids Formation was subdivided into three major units: the Grand Rapids C unit, the Grand Rapids B unit and the Grand Rapids A unit.

The Grand Rapids C unit is a laterally continuous coarsening-upwards sand succession consisting primarily of sandstone. The coarse-grained upper portion of the Grand Rapids C unit reaches a substantial thickness for most of the RSA and is referred to as the Grand Rapids C Sand unit. In some areas, the finer grained lower portion of the Grand Rapids C unit can also reach substantial thicknesses. Within the LSA, the top of the Grand Rapids C porous sand occurs between 335 masl and 405 masl and ranges in thickness from 10 m to 45 m (Figures 5.5-12 and 5.5.13).

The Grand Rapids A and B units are laterally continuous coarsening-upwards sand successions that are bounded by shales and silty beds.

Structure of the top of the Grand Rapids Formation (and Mannville Group) is illustrated on Figure 5.5-14. The top of the Grand Rapids Formation occurs between 380 masl and 460 masl.

Colorado Group

The Cretaceous Colorado Group is the uppermost bedrock group for the majority of the RSA. Within the RSA, the Colorado Group consists of the La Biche, Viking (Pelican equivalent) and Joli Fou formations. The stratigraphic thickness of the Colorado Group in the RSA is a function of pre-glacial and glacial erosion.

Joli Fou Formation

The Joli Fou Formation was deposited in a marine environment and is a dark grey non-calcareous marine shale (Mossop and Shetsen, 1994). Regionally, the Joli Fou Formation is eroded away north and east of the Stony Mountain Uplands and along stretches of the Athabasca River. Locally, the top of the Joli Fou Formation is encountered at elevations ranging between 401 masl and 492 masl and where it is not eroded, the thickness of the Joli Fou Formation ranges from 20 m to 34 m (North American, 2006).

Viking Formation

The Viking Formation was deposited in a shallow epicontinental sea environment (Mossop and Shetsen, 1994). Regionally, the Viking Formation is eroded away north and east of the Stony Mountain Uplands and along stretches of the Athabasca River. In addition, the Viking Formation subcrops beneath channel deposits in the Wiau, Leismer and Christina channels (Figure 5.5-15).

Where present, the top of the Viking Formation is encountered at elevations ranging between 350 masl and 500 masl.

Locally, the Viking Formation occurs at elevations ranging between 433 masl and 460 masl, and its thickness ranges from 6 m to 11 m (North American, 2006).

La Biche Formation

The La Biche Formation was deposited in a marine environment. The formation is composed of dark grey shale and silty shale with ironstone partings and concretions, with the lower layers containing fish-scales (Hamilton et al., 1999). Three regional geologic markers are present in the La Biche Formation. These are (in ascending order) the Fish Scale Zone, the Second White Speckeled Shale and the First White Speckeled Shale. The Fish Scale Zone demarcates the boundary between Lower and Upper Cretaceous sediments (Mossop and Shetsen, 1994).

The La Biche Formation is eroded away north and east of the Stony Mountain Uplands and subcrops beneath thick quaternary sediments for the majority of the LSA. Where present, the La Biche Formation ranges in thickness from 3 m to over 140 m (North American, 2006).

Upper Cretaceous Deposits

In the RSA, Upper Cretaceous deposits consist of the uppermost La Biche Formation (above the Fish Scale Zone as discussed above), the Lea Park Formation and the Wapiti Formation. The Lea Park and Wapiti formations are found only marginally in the RSA and are present in the May Hills area (Andriashek, 2003).

Lea Park Formation

The Lea Park Formation consists of fine-grained sediments consisting of dark grey to brown mudstone and siltstone (Rosenthal et al., 1984). The Lea Park Formation is present near May Hills but is not found in the LSA.

Wapiti Formation

The Wapiti Formation (Belly River to Battle succession equivalent; Dawson et al., 1992) was deposited in a fluvial environment with local lacustrine influences (Mossop and Shetsen, 1994). The formation consists of interbedded sandstone and siltstone with minor mudstone and coal (Rahmani and Lerbekmo, 1975). The Wapiti Formation outcrops along the May Hills and is not present in the LSA.

Tertiary and Quaternary Deposits

The bedrock surface in the RSA is a major unconformable surface, also known as the pre-Quaternary Unconformity. The pre-Quaternary Unconformity represents a period of erosion from the Late Cretaceous to the Early Tertiary continuing to the onset of glaciation in the Early Quaternary. This period of erosion of the exposed bedrock resulted in deep incised valleys or channels and remnant bedrock uplands.

In the RSA, numerous bedrock channels have been identified. They include the Amesbury, Imperial Mills, Wiau, Christina, Kirby, Sunday Creek, Leismer and Gregoire Bedrock channels. Some of these channels erode deeply into the bedrock. For example, the Sunday Creek Channel erodes down into the Grand Rapids C unit and the Gregoire Channel erodes down into the McMurray Formation.

In the LSA, there are three prominent bedrock channels, and they are called the Wiau, Christina and Leismer channels (Figure 5.5-15). The Wiau and Leismer bedrock channels erode through the La Biche Formation leaving the Viking Formation to subcrop. The Christina bedrock channel erodes through the Colorado Group leaving the Grand Rapids Formation to subcrop. Large deposits of permeable unconsolidated coarse-grained material inhabit the talwegs of these bedrock channels making them important aquifers in the region.

Andriashek (2003) identified eight glacial formations within the overburden. These include, from oldest to youngest, the Empress, Bronson Lake, Muriel Lake, Bonnyville, Ethel Lake, Marie Creek, Sand River and Grand Centre formations. It should be noted that wire line log information is not common for the overburden material above the Empress Formation. As such, the occurrence and distribution of most of these glacial formations are speculative within the RSA.

Empress Formation

The Empress Formation is defined as all unconsolidated, stratified sediments that rest on bedrock and are covered by the first occurrence of glacial till in the area. These drift sediments consist of Tertiary age “stratified gravel, sand, silt and clay of fluvial, lacustrine, and colluvial origin” (Whitaker and Christiansen, 1972) and exist within bedrock channels (channel deposits) and on bedrock terraces or interfluve benches (terrace deposits).

Three units of the Empress Formation are identified by Andriashek (2003) on the basis of lithological and petrological properties. The lowermost Unit 1 refers to pre-glacial sand and gravel which characteristically fines upward into Unit 2. The silt and clay of Unit 2 is interpreted to be fluvial and lacustrine in origin and is evidence of the first glaciation in the region. It is interpreted that glacial ice dammed eastward flowing rivers creating a lacustrian environment for fine grain deposition of Unit 2. Unit 3 consists of glaciofluvial and outwash deposits (sand and gravel) which overlie Unit 2.

These three units are identified by Andriashek (2003) in the Wiau Channel. However, the Empress deposits in the Christina Channel are classified as “undifferentiated” by Andriashek (2003) owing to the uncertainty regarding the age and origin of the sediments on the channel floor.

Locally, Andriashek (2003) identified Empress Channel deposits in the Leismer, Christina and Wiau bedrock channels. Empress Channel deposits reach a thickness of approximately 30 m, 40 m and 70 m in the Leismer, Christina and Wiau channels, respectively (Figure 5.5-16).

Locally, Andriashek (2003) identified Empress Terrace deposits south of the Christina bedrock channel, north of the Leismer bedrock channel and between the Christina and Leismer bedrock channels. Empress Terrace Sands reach a maximum thickness of approximately 30 m (Figure 5.5-17).

There has been some disagreement on the topic of lateral continuity between the Empress Channel and Terrace deposits. The Empress Terrace Sands were interpreted by Golder (2002) and Andriashek (2003) to be laterally discontinuous with the Empress Channel deposits. However, Stein et al. (1993) interpreted the Empress Unit 3 sediments of the Wiau Channel to be laterally continuous with the Empress Terrace deposits.

Bronson Lake Formation

The Bronson Lake Formation is a clay-rich glacial till unit that overlies the Empress Formation. The Bronson Lake Formation is currently mapped within the Wiau, Christina and Leismer Channels. Within the Leismer channel the Bronson Lake Formation appears to be relatively thin (approximately 10 m). A possible explanation for the thinning of the Bronson Lake Formation is glacial meltwater erosion that later deposited the relatively thick sand and gravel deposits of the Muriel Lake Formation (Andriashek, 2003).

Muriel Lake Formation

The Muriel Lake Formation is a course-grained sand and gravel formation that overlies the Bronson Lake Formation; however, it may overlie the Empress Formation in areas where the Bronson Lake Formation is completely eroded. It consists primarily of sand and gravel of glaciofluvial origin and it is currently interpreted to be extensive and continuous along the Leismer Channel (Andriashek, 2003).

Bonnyville Formation

Andriashek (2003) describes two distinct units in the Bonnyville Formation: a lower unit of clay-rich till (Unit 1) and an upper unit of sandier till (Unit 2). These two units are separated in some areas by a stratified sand and gravel unit. This sand and gravel unit is approximately 10 m to 15 m thick and is laterally extensive along the eastern segment of the Wiau Channel and along the western segment of the Leismer Channel. Andriashek's (2003) mapping of the stratigraphic succession above the Bonnyville Formation is speculative because most oil and gas wells are cased at least to this depth.

Ethel Lake Formation

The Ethel Lake Formation consists of stratified clay, silt, sand and gravel that lie on the surface of the Bonnyville Formation (Andriashek, 2003). This formation is interpreted to have been deposited by glacial melt water, either in proglacial lakes or in glacial melt water channels. The glacial melt water runoff likely cut into the underlying Bonnyville Formation, resulting in deposition of the melt water sediments into the incised surface. Ethel Lake Formation deposits have the potential to be widespread if not continuous. At this time, the lateral extent of the Ethel Lake Formation in the LSA is unknown.

Marie Creek Formation

The Marie Creek Formation consists primarily of glacial till with a relative abundance of carbonates. It has a buried oxidized profile on the till surface, indicating that the till was exposed to sub-aerial weathering, but is less clayey than the overlying Grand Centre Formation (Andriashek, 2003). In addition, it has been observed to contain numerous interbeds of sand in outcrop. At this time, the lateral extent of the Marie Creek Formation in the LSA is unknown.

Sand River Formation

The coarse-grained sediments of the Sand River Formation have limited extent but may have relatively thick stratified deposits in a buried glacial channel setting (Andriashek, 2003). Based on the current level of information available, it is anticipated that there are very few occurrences of the Sand River Formation in the LSA.

Grand Centre Formation

The Grand Centre Formation is the uppermost till deposit mapped by Andriashek (2003). As such, the Grand Centre Formation outcrops on the present land surface. However, Andriashek (2003) notes that there is some uncertainty in the distribution and extent of the Grand Centre Formation. In the LSA, it is possible that the Marie Creek Formation is the uppermost glacial formation present in some areas. The most likely occurrence of the Marie Creek Formation as the uppermost formation is in the southeast portion of the LSA.

Recent Deposits

Recent deposits in the LSA include fluvial deposits along the Christina River and fairly widespread organic deposits. Andriashek (2003) identified that a good portion of the LSA is underlain by thick (>1 m) continuous organic deposits or thin (<1 m) discontinuous organic deposits.

5.5.3 Hydrogeology

5.5.3.1 Hydrostratigraphy

Hydrostratigraphy provides a classification of the geological units according to hydrogeological characteristics. The geological column for the region (Figure 5.5-18) has been arranged into a series of aquifers and aquitards, based on the relative hydraulic characteristics of each unit or adjacent units. A total of 26 hydrostratigraphic units were identified in the RSA in this assessment. Schematic cross-sections are provided as Figures 5.5-19 and 5.5-20. Hydraulic parameters for hydrostratigraphic units are summarized on Tables 5.5-1 through 5.5-6.

Table 5.5-1 Characterization of Hydraulic Parameters: Overburden

Project	Comments	Test	# of Observation Wells	Hydraulic Conductivity Kh - min m/s	Kh - max m/s	Kv m/s	Kh* m/s	Porosity %	Specific Storage m^{-1}	Reference
Empress Unit 1										
RAX Kirby	WSW 11-21	pump test					5.8E-04			Golder, 2000
Tucker	Twp 64; Rge 4 & 5	pump test					2.0E-06			Husky, 2003
Tucker	Twp 64; Rge 4 & 5	pump test					1.0E-05			Husky, 2003
Jackfish I	12-1-73-6 W4M	pump test		6.0E-05	1.0E-04		1.0E-04			Stein et al., 1993
Nabiye and Mahikan North	Regional study area	12 tests		2.7E-06	3.7E-04		8.8E-05			Imperial Oil, 2003
PanCanadian	9-17-76-6 W4M	pump test					3.0E-04			Van Horne, 1998
MEG Christina Lake	MW06	---					4.0E-04			MEG Energy, 2004
MEG Christina Lake	OBW 09-17	pump test					9.0E-02			MEG Energy, 2004
MEG Christina Lake	MW12	---					1.0E-04			MEG Energy, 2004
EnCana Christina Lake	WSW 9-17	pump test	1				7.6E-04		2.0E-04	CH2M Gore & Storrie, 1998
Terrace Sand										
Jackfish I	12-28-75-6 W4M (PW1 and 2)	2 tests					1.9E-04			Matrix, 2005
North American	11-14-78-9 W4M	pump test	1				2.2E-05		2.5E-05	Westwater, 2006
Till										
MEG Christina Lake	Grand Centre - MW05	---					4.0E-06			MEG Energy, 2004
MEG Christina Lake	Marie Crk / Bonnyville Unit 2-MW10	---					7.0E-04			MEG Energy, 2004
MEG Christina Lake	Sand River - MW11	---					8.0E-05			MEG Energy, 2004
MEG Christina Lake	Shallow Till - PSB 03A	slug	NA				3.5E-07			MEG Energy, 2004
MEG Christina Lake	Shallow Till - PSB 04	slug	NA				7.8E-07			MEG Energy, 2004
Devon Jackfish Project	Shallow Till	7 slug tests	NA	8.4E-08	2.8E-07		3.6E-07			Stantec, 2005
Tucker	Grand Centre	1 well					8.5E-09			Husky, 2003
Connacher Oil and Gas Ltd.	Shallow Till (sand seams)	4 slug tests	NA	3.1E-07	3.6E-06		1.2E-06			Westwater, 2005
RAX Kirby	01-2	slug test	NA				1.3E-06			Matrix, 2002
RAX Kirby	01-6	slug test	NA				1.1E-06			Matrix, 2002
Sand										
Well test	14-31-76-7 W4M	slug	NA				1.4E-04			Ozoray, 1974
Obs Site 11a	16-2-87-9 W4M	pump test					4.6E-07			Hackbarth and Nastasa, 1979
Devon Jackfish Project	shallow sand	slug test	NA				3.6E-05			
Foster Creek	Basal	MW09					2.3E-05			CG&S, 1999
Foster Creek	Basal	MW13					1.0E-04			CG&S, 1999
Tucker	Bonnyville Unit 1 and Unit 2	6 wells		3.4E-05	8.5E-04					Husky, 2003
Tucker	Empress Unit 3	4 wells		2.8E-07	3.9E-05					Husky, 2003
Tucker	Ethel Lake	1 well					1.0E-04			Husky, 2003
Foster Creek	Ethel Lake	PW01					2.8E-04		9.4E-06	AEC, 1999
Foster Creek	Ethel Lake	PW02					3.7E-04		7.0E-06	AEC, 1999
Foster Creek	Ethel Lake	PW05					5.3E-04		1.9E-05	AEC, 1999
Foster Creek	Ethel Lake	MW11					4.5E-05			CG&S, 1999
Foster Creek	Ethel Lake	MW14					5.3E-04			CG&S, 1999
Tucker	Muriel Lake	4 wells		2.7E-06	3.0E-04					Husky, 2003
MEG Christina Lake	PSB 01						3.0E-04			
Foster Creek	Sand River	MW10					1.7E-05			CG&S, 1999
Foster Creek	Sand River	MW12					1.6E-05			CG&S, 1999
Bulk										
Regional		slug*	NA				2.1E-07			Bachu et al., 1996

Notes:
* - Representative value; average or geometric mean
blank - not reported
NA - Not applicable

Table 5.5-2 Characterization of Hydraulic Parameters: Colorado Group

Project	Comments	Test	# of Observation Wells	Hydraulic Conductivity					Porosity	Specific Storage	Reference
				Kh - min m/s	Kh - max m/s	Kh/Kv	Kv m/s	Kh * m/s	%	m^{-1}	
Bulk											
Nabiye and Mahihkan North	Regional study area	7 wells		3.4E-11	4.5E-07			2.8E-08			Imperial Oil, 2003
Tucker	Twp 62 to 67; Rge 2 to 6	model calibration	NA			300	3.0E-10	1.0E-07			Husky, 2003
Viking Formation											
Core analyses	Twp 70 to 103; Rge 1 W4 to 1 W5	12 tests**		2.6E-07	6.0E-05	1		7.0E-06	33		Bachu et al., 1993
Drill-stem tests	Twp 70 to 103; Rge 1 W4 to 1 W5	51 tests**		4.6E-10	5.2E-05			1.9E-07			Bachu et al., 1993
Core analyses	Twp 50 to 70; Rge 15 W3 to 17 W4	158 tests**		4.9E-10	9.6E-05			3.2E-06		4.4E-03	Hitchon et al., 1989
Drill-stem tests	Twp 50 to 70; Rge 15 W3 to 17 W4	1167 tests**		1.2E-11	8.0E-04			2.4E-07		2.3E-03	Hitchon et al., 1989
Joli Fou Formation											
Regional		estimate	NA				4.6E-14				Basin Analysis Group, 1985

Notes:
* - Representative value; average or geometric mean
** - Number of tests used to estimate hydraulic conductivity
blank - not reported
NA - not applicable

Table 5.5-3 Characterization of Hydraulic Parameters: Grand Rapids Formation

Project	Comments	Test	# of Observation Wells	Hydraulic Conductivity Kh - min m/s	Kh - max m/s	Kh/Kv	Kv m/s	Kh * m/s	Porosity %	Specific Storage m^{-1}	Reference
Undifferentiated Colony and Grand Rapids											
Core analyses	Twp 50 to 70; Rge 15 W3M to 17 W4M	8832 tests**		6.8E-08	1.7E-04	82	4.5E-08	3.7E-06		5.5E-03	Hitchon et al., 1989
Drill-stem	Twp 50 to 70; Rge 15 W3M to 17 W4M	1497 tests**		1.0E-11	1.0E-05			2.6E-08		4.5E-04	Hitchon et al., 1989
Jackfish	characterization							1.0E-05		1.0E-04	Devon, 2003
Foster Creek	DST analyses	34 tests		4.3E-09	1.8E-05			3.3E-06		---	EBA, 1999
Core analyses	Twp 70 to 103; Rge 1 W4M to 1 W5M	101 tests**		4.0E-10	6.3E-05	2		4.9E-06	35	---	Bachu et al., 1993
Drill-stem tests	Twp 70 to 103; Rge 1 W4M to 1 W5M	416 tests**		8.0E-11	6.7E-05			4.2E-07		---	Bachu et al., 1993
Tucker Lake	DST analyses; Twp 63 to 66, Rge 3 to 5	10 wells		3.8E-09	5.8E-06			1.9E-07		---	Matrix, 2003
Grand Rapids Aquifer											
Jackfish I	characterization	drill stem						2.0E-05		1.0E-04	Devon, 2003
Jackfish I	characterization	core analyses						4.0E-05		1.0E-04	Devon, 2003
Jackfish I	100/12-15-075-6 W4M	pump test (72 hr)	1					2.3E-05		4.3E-06	Westwater, 2004
Surmont In-Situ Oil Sands	8-25-083-7 W4M	pump test (24 hr)						1.1E-05		8.6E-06	Sentar, 1997
Surmont In-Situ Oil Sands	2-18-083-6 W4M	pump test (72 hr)	3					5.0E-05		2.5E-06	Matrix, 2003
Surmont In-Situ Oil Sands	4-18-083-6 W4M	pump test (72 hr)	3					5.0E-05		5.0E-06	Matrix, 2003
Surmont In-Situ Oil Sands	1-19-083-6 W4M	pump test (72 hr)	4					5.0E-05		2.5E-06	Matrix, 2003
Surmont In-Situ Oil Sands	2-21-083-7 W4M	pump test (72 hr)						6.7E-06		1.7E-05	Matrix, 2003
Surmont In-Situ Oil Sands	2-26-083-6 W4M	pump test (72 hr)						5.7E-05		8.6E-07	Matrix, 2003
Surmont In-Situ Oil Sands	7-36-085-7 W4M	pump test (72 hr)						1.8E-05		---	Golder, 2000
Surmont In-Situ Oil Sands	15-6-085-6 W4M	pump test						1.5E-05		7.5E-08	Stanley, 1982
Surmont In-Situ Oil Sands	6-32-084-6 W4M	pump test						1.8E-05		5.0E-06	Stanley, 1982
Surmont In-Situ Oil Sands		short pump test						6.0E-05		7.2E-05	Stantec, 1998
Surmont In-Situ Oil Sands		recovery test						3.7E-05			Stantec, 1998
Petro-Canada Meadow Creek								5.0E-05			Komex, 2001
Obs Site 10d	9-24-085-9 W4M	drill stem or pump						1.1E-08		---	Hackbarth and Nastasa, 1979
Obs Site 11b	16-2-087-9 W4M	pump test						3.8E-05			Hackbarth and Nastasa, 1979
North American	13-22-078-10 W4M	air lift						1.5E-05			North American, 2006
North American	9-21-081-09 W4M	pump test						8.2E-06			Westwater, 2007
North American	3-2-079-10 W4M	pump test						1.7E-05			Westwater, 2007

Notes:
* - Representative value; average or geometric mean
** - Number of tests used to estimate hydraulic conductivity
blank - not reported
NA - not applicable

Table 5.5-4 Characterization of Hydraulic Parameters: Clearwater Formation

Project	Comments	Test	# of Observation Wells	Hydraulic Conductivity Kh - min m/s	Kh - max m/s	Kh/Kv	Kv m/s	Kh * m/s	Porosity %	Specific Storage m^{-1}	Reference
Undifferentiated Clearwater Formation											
Regional		drill stem & pumping		1.0E-09	1.0E-06			1.5E-07			Hackbarth and Nastasa, 1979
Core analyses	Twp 70 to 103; Rge 1 W4M to 1 W5M	30 tests**		4.8E-09	4.7E-05	2		1.8E-06	31		Bachu et al., 1993
Core analyses	Twp 50 to 70; Rge 15 W3M to 17 W4M	2549 tests		9.7E-10	1.4E-04	2222	8.1E-09	1.8E-05		8.0E-04	Hitchon et al., 1989
Drill-stem	Twp 50 to 70; Rge 15 W3M to 17 W4M	96 tests**		2.0E-10	1.1E-05			1.6E-07		4.5E-04	Hitchon et al., 1989
Foster Creek	DST analyses	8 tests		2.6E-07	1.1E-05			2.5E-06			EBA, 1999
Tucker	DST analyses; Twp 64 to 68, Rge 3 to 6	9 wells**		4.3E-08	7.0E-06			8.0E-07			Husky, 2003
Tucker	16-20-064-04 W4M	5 day pump test						1.0E-06			Husky, 2003
Clearwater 'B' Unit											
Christina Lake	F2/11-09-076-06 W4M	3 day pump test						3.3E-05			EnCana, 2005
Christina Lake	F2/09-19-076-06 W4M	3 day pump test						4.3E-05			EnCana, 2005
Christina Lake	F2/13-16-076-06 W4M	4 day pump test						6.6E-05			EnCana, 2005
North American	12-02-078-10 W4M	air lift		5.1E-07	3.2E-05						Westwater, 2007
Wabiskaw Member											
AOSTRA	10-23-072-07 W4M	core analysis		1.0E-06	1.8E-05			6.4E-05	36		AOSTRA, 1995
Foster Creek	DST analyses	3 tests		9.0E-10	2.1E-07			8.0E-08			EBA, 1999
Core analyses	Twp 70 to 103; Rge 1 W4M to 1 W5M	269 tests**		1.0E-09	6.9E-05	2		2.5E-06	31		Bachu et al., 1993
Drill-stem tests	Twp 70 to 103; Rge 1 W4M to 1 W5M	200 tests**		9.0E-11	5.5E-05			8.4E-08			Bachu et al., 1993

Notes:
* - Representative value; average or geometric mean
** - Number of tests used to estimate hydraulic conductivity
blank - not reported
NA - not applicable

Table 5.5-5 Characterization Hydraulic Parameters: McMurray Formation

Project	Comments	Test	# of Observation Wells	Hydraulic Conductivity Kh - min	Kh - max	Kh/Kv	Kv	Kh *	Porosity	Specific Storage	Reference
				m/s	m/s		m/s	m/s	%	m^{-1}	
Undifferentiated											
Foster Creek	DST analyses	1 tests						2.1E-07			EBA, 1999
Core analyses	Twp 70 to 103; Rge 1 W4M to 1 W5M	382 tests**		1.0E-10	1.0E-04	7		2.6E-06	32		Bachu et al., 1993
Drill-stem tests	Twp 70 to 103; Rge 1 W4M to 1 W5M	365 tests**		2.0E-11	8.1E-05			1.4E-07			Bachu et al., 1993
Water Sands											
Obs Site 10e	9-24-085-9 W4M	drill stem or pump						4.1E-09			Hackbarth and Nastasa, 1979
Obs Site 10f	9-24-085-9 W4M	drill stem or pump						1.3E-08			Hackbarth and Nastasa, 1979
Obs Site 11d	16-2-087-9 W4M	drill stem or pump						1.9E-07			Hackbarth and Nastasa, 1979
AOSTRA	10-23-072-7 W4M	core analysis	NA	1.9E-05	8.8E-05			6.2E-05	37		AOSTRA, 1995
Core analyses	Twp 50 to 70; Rge 15 W3M to 17 W4M	482 tests**		1.3E-09	1.1E-04	63	8.6E-08	5.4E-06		7.7E-03	Hitchon et al., 1989
Drill-stem	Twp 50 to 70; Rge 15 W3M to 17 W4M	137 tests**		6.5E-10	3.1E-04			3.5E-07			Hitchon et al., 1989
Jackfish	characterization							3.0E-07			Devon, 2003
Tucker	DSTs; Twp 68, Rge 3 to 4	3 tests		2.5E-07	3.3E-06			8.2E-07			Husky, 2003
Tucker	14D-29-066-4 W4M	step injection test						7.0E-05			Husky, 2003
Tucker	13A-20-064-4 W4M	step injection test						1.0E-04			Husky Oil, 1984
Orion (Well 11-16)	11-16-063-3 W4M	slug test	NA					7.6E-06			BlackRock, 2001
MEG Christina Lake	10-29-077-5 W4M	pump and injection tests						2.0E-05			MEG Energy, 2004
North American	01-28-078-10 W4M	injection test						7.0E-05			North American, 2006
North American	09-02-078-10 W4M	pump / injection test						2.1E-05			Westwater, 2007
North American	07-03-081-9 W4M	injection test						5.5E-05			Westwater, 2007
North American	13-33-078-10 W4M	pump / injection test						2.0E-05			Westwater, 2007
Regional				5.0E-08	3.0E-05						Wallick and Dabrowski, 1982
OSLO Lease 31				6.2E-08	2.5E-04			3.3E-07			Korol, 1985
Oil Sands											
Agar		geotechnical investigation						1.00E-10			AGAR, 1985
RAX Kirby		average range		2.9E-05	6.7E-05				33		RAX, 2000
Muskeg River		tritium isotopes	NA				4.0E-08			3.0E-05	Wallick and Dabrowski, 1982
Regional		laboratory	NA	3.2E-08	1.0E-05						Hackbarth and Nastasa, 1979

Notes:
* - Representative value; average or geometric mean
** - Number of tests used to estimate hydraulic conductivity
blank - not reported
NA - not applicable

Table 5.5-6 Characterization of Hydraulic Parameters: Devonian Formations

Project	Comments	Test	Observation Wells	Hydraulic Conductivity Kh - min m/s	Kh - max m/s	Kh/Kv	Kv m/s	Kh * m/s	Porosity %	Specific Storage m^{-1}	Reference
Beaverhill Lake											
Core analyses	Twp 50 to 70; Rge 15 W3M to 17 W4M	173 tests**		2.0E-10	9.1E-07	0.4	5.8E-09	2.3E-09		4E-04	Hitchon et al., 1989
Drill-stem	Twp 50 to 70; Rge 15 W3M to 17 W4M	44 tests**		1.6E-10	1.0E-05			8.4E-08			Hitchon et al., 1989
Obs Site 10g	9-24-085-9 W4M	drill stem						1.4E-08			Hackbarth and Nastasa, 1979
Obs Site 10h	9-24-085-9 W4M	drill stem						2.6E-08			Hackbarth and Nastasa, 1979
Obs Site 11e	16-2-087-9 W4M	drill stem						3.5E-10			Hackbarth and Nastasa, 1979
Obs Site 11f	16-2-087-9 W4M	drill stem						5.5E-08			Hackbarth and Nastasa, 1979
Obs Site 11g	16-2-087-9 W4M	drill stem						1.6E-08			Hackbarth and Nastasa, 1979
Obs Site 11h	16-2-087-9 W4M	drill stem						5.5E-10			Hackbarth and Nastasa, 1979
Obs Site 11i	16-2-087-9 W4M	drill stem or pump						3.8E-09			Hackbarth and Nastasa, 1979
Obs Site 12e	8-27-088-9 W4M	drill stem						3.9E-09			
Obs Site 12f	8-27-088-9 W4M	drill stem						1.4E-09			
Core analyses	Twp 70 to 103; Rge 1 W4M to 1 W5M	34 tests**		1.0E-10	1.0E-04	33		4.0E-07	31		Bachu et al., 1993
Drill-stem tests	Twp 70 to 103; Rge 1 W4M to 1 W5M	22 tests**		3.6E-10	1.1E-05			9.1E-07			Bachu et al., 1993
Prairie Evaporite											
ARC Site 7		drill-stem						3.0E-09			Hackbarth and Nastasa, 1979
Core analyses	Twp 70 to 103; Rge 1 W4M to 1 W5M	9 tests**		1.0E-10	9.0E-08	2		2.0E-09	8		Bachu et al., 1993

Notes:
* - Representative value; average or geometric mean
** - Number of tests used to estimate hydraulic conductivity
blank - not reported
NA - not applicable

Aquifers in the LSA that are of most interest, to the Project include the Empress Terrace, Empress Channel, Lower Grand Rapids, Clearwater A, Clearwater B and Basal McMurray aquifers.

Undifferentiated Overburden Aquifer/Aquitard

For the purpose of this assessment and because of the scarcity of data for the overburden, all of the Tertiary and Quaternary deposits are grouped together and called the Undifferentiated Overburden Aquifer/Aquitard. Two notable exceptions are the Empress channel and terrace aquifers.

The dominant lithology of the Undifferentiated Overburden Aquifer/Aquitard is clayey till; however, local deposits of sand and gravel are found within the till units (Andriashek, 2003) and may represent important local aquifers. Glacial formations that may represent locally important aquifers include the Sand River, Ethel Lake, Bonnyville and Muriel Lake formations.

Based on the abundance of muskeg and small lakes in this area, the groundwater table is interpreted to be near the ground surface. Some shallow groundwater discharges to springs and surface waterbodies and some groundwater recharges the underlying bedrock aquifers (Ozoray, 1974). Shallow groundwater flow is interpreted to be influenced primarily by topography and in the LSA is anticipated to flow northwest and southwest away from the Stony Mountain Uplands (Figure 5.5-21).

Estimates of Undifferentiated Overburden Aquifer/Aquitard horizontal hydraulic conductivities have been compiled throughout the RSA and are summarized in Table 5.5-1. The measured horizontal hydraulic conductivity of till deposits range from 9×10^{-9} m/s to 7×10^{-4} m/s with a geometric mean value of 1×10^{-6} m/s. The measured horizontal hydraulic conductivity of sand deposits range from 5×10^{-7} m/s to 5×10^{-4} m/s with a geometric mean value of 4×10^{-5} m/s.

Groundwater flow in the Undifferentiated Overburden Aquifer/Aquitard in the LSA is interpreted to be, more or less, a muted representation of surface topography (Figure 5.5-21). As such, the horizontal groundwater flow direction in the shallow Undifferentiated Overburden Aquifers typically flow toward surface drainage features, such as, the Christina River and its tributaries. Vertical groundwater flow in the Undifferentiated Overburden Aquitards is interpreted to be generally downward. However, the complex nature of the glacial deposition of the Undifferentiated Overburden Aquifer/Aquitard resulted in an amalgamation of aquifers and aquitards with hydraulic conductivities of varying magnitudes. Therefore, local vertical gradients in the Undifferentiated Overburden Aquifer/Aquitard can be directed upward, as evidenced by springs and flowing shot holes identified in the LSA (GIC, 2006, Figure 5.5-21).

Undifferentiated Overburden Aquifer/Aquitard pore water is typically considered non-saline (i.e., TDS concentration less than 4,000 mg/L). Regionally, Ozoray (1974) estimated the TDS concentration of groundwater in the Undifferentiated Overburden Aquifer/Aquitard to be less than 1,000 mg/L. Actual TDS concentrations documented by AENV groundwater information system range from 39 mg/L to 1,424 mg/L (GIC, 2005; Table 5.5-8)

Empress Terrace Aquifer

The Empress Terrace Sand deposits are referred to as the Empress Terrace Aquifer. This aquifer overlies bedrock and occurs on the bedrock highs between channel lows (Figure 5.5-22). The Empress Terrace Aquifer is interpreted to be laterally discontinuous with the Empress Channel deposits and is overlain by clay till.

In the RSA, a horizontal hydraulic conductivity of 2 x 10^{-4} m/s was measured for the Empress Terrace Aquifer (Table 5.5-1).

Hydraulic head and conductivity values for the Empress Terrace Aquifer are plotted on Figure 5.5-22. Groundwater flow is expected to be predominantly horizontal and influenced by regional topography. Due to the paucity of hydraulic head data, the flow direction is more or less speculative.

Empress Terrace Aquifer pore water is believed to be non-saline (i.e., TDS concentration less than 4,000 mg/L). Testing of the North American 11-14-78-9 W4M camp supply well identified TDS concentrations of 748 mg/L and 816 mg/L (Westwater, 2006).

Empress Channel Aquifer

The Empress Channel Sand deposits are referred to as the Empress Channel Aquifer. This aquifer is present in the Wiau, Christina and Leismer bedrock channels, including tributaries, mapped in the LSA (Figures 5.5-15 and 5.5-16).

Numerous horizontal hydraulic conductivity measurements have been obtained for the Empress Channel Aquifer in the RSA. The estimated hydraulic conductivity of the Empress Channel Aquifer ranges from to 2 x 10^{-6} m/s to 9 x 10^{-2} m/s, with a geometric mean value of 2 x 10^{-4} m/s (Table 5.5-1).

Hydraulic head values for the Empress Channel Aquifer are currently not available for the LSA. However, there are some hydraulic heads reported for the Empress Channel Aquifer in the RSA (Figure 5.5-23). Hydraulic head elevations in the Leismer Channel decrease toward the confluence with the Wiau Channel. Hydraulic heads reported for the Wiau Channel decrease towards the west where a series of springs discharge along the Athabasca River (approximately 25 km west of the LSA) (Stewart, 2003). Conversely, hydraulic heads reported for the Christina Channel decrease toward the east. In areas below the Empress Channel Aquifer where the Colorado Group has been eroded (i.e., in the Christina Channel), it is likely that increased recharge to the Grand Rapids Formation occurs resulting in low hydraulic heads in the Empress Channel Aquifer. Groundwater flow in the Empress Channel aquifer is expected to be predominately horizontal from higher head to lower head values.

The Leismer Channel is likely recharged beneath the high topography of the Stony Mountain Uplands (i.e., higher hydraulic heads). As seen on Figure 5.5-23, the Leismer channel is present mainly to the south of the Stony Mountain Uplands but there is a small portion of the channel that lies to the north. A groundwater divide is anticipated to exist in this area of the channel. For this reason, a portion of groundwater flow in the Leismer Channel is expected to be to the north.

Empress Channel Aquifer pore water is typically considered non-saline (i.e., TDS concentration less than 4,000 mg/L). Actual TDS concentrations from the MEG Christina Lake Regional Project (MEG, 2005) and the Petro-Canada Meadow Creek Project (Petro-Canada, 2001) are 737 mg/L and 573 mg/L, respectively.

La Biche Aquitard

The La Biche, Lea Park and Wapiti formations are lumped together and referred to as the La Biche Aquitard in this assessment. Regionally, the La Biche Aquitard is eroded away north and east of the Stony Mountain Uplands. Locally, the La Biche Aquitard is eroded away in the talwegs of the Leismer, Wiau and Christina bedrock channels (Figure 5.5-15).

Hydraulic conductivity values specific to the La Biche Aquitard are not available. However, hydraulic conductivity estimates for the undifferentiated Colorado Group are summarized on

Table 5.5-2. Horizontal hydraulic conductivity estimates range from 3×10^{-11} m/s to 5×10^{-7} m/s and vertical hydraulic conductivity was estimated at 3×10^{-10} m/s.

Hydraulic head values for the La Biche Aquitard are currently not available for the LSA but groundwater flow is expected to predominantly vertical and downward.

Viking Aquifer

For the purposes of this assessment the Viking Formation is referred to as the Viking Aquifer. Regionally, the Viking Aquifer is eroded away north and east of the Stony Mountain uplands and along stretches of the Athabasca River. Locally, the Viking Aquifer is eroded away in the talweg of the Christina bedrock channel and subcrops in the Wiau and Leismer Channels.

Several hydraulic conductivity estimates of the Viking Aquifer are available. Bachu et al. (1993) and Hitchon et al. (1989) both published regional data sets of hydraulic conductivity measurements from drill stem test (DST) and core analyses (Table 5.5-2). Representative Viking Aquifer hydraulic conductivity values from those data sets range from 1×10^{-11} m/s to 8×10^{-4} m/s.

Bachu et al. (1993) notes that hydraulic head values in the Viking Aquifer are mounded below the Stony Mountain Uplands and radially decrease to the north, west and south toward the Clearwater, Athabasca and Beaver rivers. As such, groundwater flow in the Viking Aquifer is expected to be predominantly horizontal and radial away from the Stony Mountain Uplands towards aquifer outcrop.

Joli Fou Aquitard

For the purposes of this assessment the Joli Fou Formation is referred to as the Joli Fou Aquitard. Regionally, the Joli Fou Aquitard is eroded away north and east of the Stony Mountain Uplands and along stretches of the Athabasca River. Locally, the Joli Fou Aquitard is eroded away in the talweg of the Christina bedrock channel (Figure 5.5-15).

Hydraulic conductivity estimates for the undifferentiated Colorado Group are summarized on Table 5.5-2. Horizontal hydraulic conductivity estimates range from 3×10^{-11} m/s to 5×10^{-7} m/s. Horizontal hydraulic conductivity values specific to the Joli Fou Aquitard are not available. However, the Basin Analysis Group (1985) estimated the vertical permeability of the Joli Fou Formation to be 5×10^{-14} m/s.

Hydraulic head values for the Joli Fou Aquitard are currently not available for the LSA but groundwater flow is expected to predominantly vertical and downward. Where the Joli Fou aquitard is thinned or absent increased recharge from the Empress Channel Aquifer to the Upper Grand Rapids Aquifer is expected to occur.

Upper Grand Rapids Aquifer/Aquitard

The Upper Grand Rapids Aquifer/Aquitard consists of the Grand Rapids A and B units. Regionally, the Upper Grand Rapids Aquifer/Aquitard outcrops along the Athabasca and Clearwater and Christina rivers (along the northwest and north boundaries of the RSA). Locally, the Upper Grand Rapids Aquifer/Aquitard subcrops in the talweg of the Christina bedrock channel.

Hydraulic conductivity values specific to the Upper Grand Rapids Aquifer/Aquitard are not available. However, hydraulic conductivity estimates for the undifferentiated Grand Rapids Formation are summarized on Table 5.5-3. Horizontal hydraulic conductivity estimates range from 1×10^{-11} m/s to 2×10^{-4} m/s and vertical hydraulic conductivity was estimated at 5×10^{-8} m/s.

Hydraulic head values specific to the Upper Grand Rapids Aquifer/Aquitard are not available. However, hydraulic head values for the undifferentiated Grand Rapids Formation are presented on Figure 5.5-24. Groundwater mounding is evident below the Stony Mountain Uplands and in the area of the Christina and Wiau channels. Groundwater flow in the Upper Grand Rapids Aquifer/Aquitard is believed to be mainly horizontal and directed north and west towards the Clearwater and Athabasca rivers.

Lower Grand Rapids Aquifer

The Lower Grand Rapids Aquifer consists of the porous sands of the Grand Rapids C unit. Regionally, the Lower Grand Rapids Aquifer outcrops along the Athabasca and Clearwater and Christina rivers (along the northwest and north boundaries of the RSA).

Hydraulic conductivity estimates for the Lower Grand Rapids Aquifer are summarized in Table 5.5-3. Estimated horizontal hydraulic conductivity values for the Lower Grand Rapids Aquifer range from 1×10^{-8} m/s to 6×10^{-5} m/s. A transmissivity of 16 m^2/d and a hydraulic conductivity of 1×10^{-5} m/s has been reported for the Lower Grand Rapids Aquifer (North American, 2006). Recent well testing conducted by North American (winter 2007) suggests the hydraulic conductivity of the Lower Grand Rapids Aquifer ranges from 8.2×10^{-6} m/s to 1.7×10^{-5} m/s with a capacity of greater than 400 m^3/d in areas (Westwater, 2007).

Hydraulic head values specific to the Lower Grand Rapids Aquifer are sporadic. Hydraulic head values for the undifferentiated Grand Rapids Formation are presented on Figure 5.5-24. Groundwater mounding is evident below the Stony Mountain Uplands and in the area of the Christina and Wiau channels. Groundwater flow in the Lower Grand Rapids Aquifer is expected to be predominately horizontal and directed north and west towards the Clearwater and Athabasca rivers.

Lower Grand Rapids Aquifer pore water is typically considered non-saline (i.e., TDS concentration less than 4,000 mg/L). Regionally, Ozoray (1974) estimated the TDS concentration of groundwater in the Lower Grand Rapids Aquifer to range from 500 mg/L to 3,000 mg/L. In the LSA, estimates of Lower Grand Rapids Aquifer salinity range from 750 mg/L to 5,000 mg/L TDS (Figure 5.5-25). Actual TDS concentrations from the Connacher Great Divide Project (Westwater, 2005), Petro-Canada Meadow Creek Project (Petro-Canada, 2001) and test well 13-22 (North American, 2006) are 1,800 mg/L, 1,340 mg/L and 1,400 mg/L, respectively. Recent well testing conducted by North American (winter 2007) identified TDS concentration in the Lower Grand Rapids Aquifer ranging from 1,340 mg/L to 1,520 mg/L (Westwater, 2007).

Lower Grand Rapids Aquifer/Aquitard

The Lower Grand Rapids Aquifer/Aquitard consists of the finer-grained deposits of the Grand Rapids C coarsening-upwards sequence.

Hydraulic conductivity values specific to the Lower Grand Rapids Aquifer/Aquitard are not available. However, hydraulic conductivity estimates for the undifferentiated Grand Rapids Formation are summarized on Table 5.5-3. Horizontal hydraulic conductivity estimates range from 1×10^{-11} m/s to 2×10^{-4} m/s and vertical hydraulic conductivity was estimated at 5×10^{-8} m/s.

Hydraulic head values specific to the Lower Grand Rapids Aquifer/Aquitard are not available. However, hydraulic head values for the undifferentiated Grand Rapids Formation are presented on Figure 5.5-24. Groundwater mounding is evident below the Stony Mountain Uplands and in the area of the Christina and Wiau channels. Groundwater flow in the Lower Grand Rapids Aquifer/Aquitard is believed to be mainly horizontal and directed north and west towards the Clearwater and Athabasca rivers.

Clearwater Shale Aquitard

The Clearwater Shale unit is referred to as the Clearwater Shale Aquitard. The Clearwater Formation, including all of its individual hydrostratigraphic units, outcrops along the Athabasca and Clearwater rivers near the north boundary of the RSA.

Hydraulic conductivity values specific to the Clearwater Shale Aquitard are not available. However, hydraulic conductivity estimates for the undifferentiated Clearwater Formation are summarized on Table 5.5-4. Horizontal hydraulic conductivity estimates range from 2×10^{-10} m/s to 5×10^{-5} m/s and vertical hydraulic conductivity was estimated at 8×10^{-9} m/s. DST and pumping test data are likely biased towards the Clearwater aquifers; therefore, this range in values may overestimate the hydraulic conductivity of the Clearwater Shale Aquitard.

Hydraulic head values specific to the Clearwater Shale Aquitard are not available. Groundwater flow in the Clearwater Shale Aquitard is expected to be predominantly vertical and downward.

Clearwater A Aquifer

The Clearwater A sand unit is referred to as the Clearwater A Aquifer. The Clearwater A Aquifer is located in the northern portion of the LSA. Accumulations of gas may exist in the northern up-dip portions of the Clearwater A sand body, Maher (1989) referred to this gas pool as the Hangingstone gas field.

Hydraulic conductivity values specific to the Clearwater A Aquifer are not available. However, hydraulic conductivity estimates for the Clearwater B Aquifer (believed to be comparable) are summarized on Table 5.5-4. Horizontal hydraulic conductivity estimates range from 3×10^{-5} m/s to 7×10^{-5} m/s.

Hydraulic head values specific to the Clearwater A Aquifer are not available. However, hydraulic head values for the undifferentiated Clearwater Formation are presented on Figure 5.5-26. Hydraulic heads reflect the general distribution of pressures in the overlying Grand Rapids Formation. Groundwater flow in the Clearwater A Aquifer is expected to be predominantly horizontal and north toward the Athabasca and Clearwater rivers.

Clearwater A Aquifer pore water is transitional between non-saline and saline (i.e., TDS concentration less than and greater than 4,000 mg/L). In the LSA, estimates of Clearwater A Aquifer salinity range from 2000 mg/L to 6,000 mg/L TDS (Figure 5.5-27).

Clearwater B Aquifer

The Clearwater B sand unit is referred to as the Clearwater B Aquifer. The Clearwater B Aquifer is located in the southern portion of the LSA. Accumulations of gas may exist in the northern up-dip portions of the Clearwater B sand body, Maher (1989) referred to this gas pool as the Leismer gas field

Hydraulic conductivity estimates for the Clearwater B Aquifer are summarized in Table 5.5-4. Representative horizontal hydraulic conductivity values for the Clearwater B Aquifer range from 3×10^{-5} m/s to 7×10^{-5} m/s. Recent well testing conducted by North American (winter 2007) suggests the hydraulic conductivity of the Clearwater B Aquifer ranges from 5.1×10^{-7} m/s to 3.2×10^{-5} m/s (Westwater, 2007). Authigenic swelling clays were identified in the Clearwater B Aquifer and were found to effectively reduce the permeability of the aquifer (North American, 2006).

Hydraulic head values specific to the Clearwater B Aquifer are not available. However, hydraulic head values for the undifferentiated Clearwater Formation are presented on Figure 5.5-26. Hydraulic heads reflect the general distribution of pressures in the overlying Grand Rapids Formation. Groundwater flow in the Clearwater B Aquifer is expected to be predominantly horizontal and west toward the Athabasca River.

Clearwater B Aquifer pore water is typically considered saline (i.e., TDS concentration greater than 4,000 mg/L). In the LSA, estimates of Clearwater B Aquifer salinity range from 4000 mg/L to 6,000 mg/L TDS (Figure 5.5-28). Actual TDS concentrations reported in the EnCana Christina Lake Project range from 3,840 mg/L to 4,640 mg/L (EnCana, 2005). Recent well testing conducted by North American (winter 2007) identified TDS concentrations in the Clearwater B Aquifer ranging from 6,340 mg/L to 7,610 mg/L (Westwater, 2007).

Clearwater C Aquifer

The Clearwater C sand unit is referred to as the Clearwater C Aquifer. The Clearwater C Aquifer is not located in the LSA.

Clearwater Aquifer/Aquitard

All sediments of the Clearwater A, B and C units that are not considered a sand unit are referred to as the Clearwater Aquifer/Aquitard. The Clearwater Formation, including its hydrostratigraphic units, outcrops along the north boundary of the RSA.

Hydraulic conductivity values specific to the Clearwater Aquifer/Aquitard are not available. However, hydraulic conductivity estimates for the undifferentiated Clearwater Formation are summarized on Table 5.5-4. Horizontal hydraulic conductivity estimates range from 2×10^{-10} m/s to 5×10^{-5} m/s and vertical hydraulic conductivity was estimated at 8×10^{-9} m/s. DST and pumping test data are likely biased towards the Clearwater aquifers; therefore, this range in values may overestimate the hydraulic conductivity of the Clearwater Aquifer/Aquitard.

Hydraulic head values specific to the Clearwater Aquifer/Aquitard are not available. Groundwater flow in the Clearwater Aquifer/Aquitard is expected to be predominantly vertical and downward.

Wabiskaw Bitumen Aquitard

The Wabiskaw Member of the Clearwater Formation may be partially bitumen saturated within portions of the RSA. Areas with a high degree of bitumen saturation likely have decreased hydraulic conductivity and these areas are referred to as the Wabiskaw Bitumen Aquitard.

Hydraulic conductivity values specific to the Wabiskaw Bitumen Aquitard are not available. However, hydraulic conductivity estimates for the undifferentiated Wabiskaw Member are summarized on Table 5.5-4. Horizontal hydraulic conductivity estimates range from 9×10^{-11} m/s to 2×10^{-5} m/s.

Hydraulic head values specific to the Wabiskaw Bitumen Aquitard are not available. Groundwater flow in the Wabiskaw Bitumen Aquitard is expected to be predominantly vertical and downward.

Wabiskaw Aquifer/Aquitard

The portion of the Wabiskaw Member that is not bitumen saturated is referred to as the Wabiskaw Aquifer/Aquitard. In the RSA, the Wabiskaw Aquifer/Aquitard generally consists of shale with discontinuous sand units that may be gas saturated.

Hydraulic conductivity values specific to the Wabiskaw Aquifer/Aquitard are not available. However, hydraulic conductivity estimates for the undifferentiated Wabiskaw Member are summarized on Table 5.5-4. Horizontal hydraulic conductivity estimates range from 9 x 10^{-11} m/s to 2 x 10^{-5} m/s.

Hydraulic head values specific to the Wabiskaw Aquifer/Aquitard are not available. Groundwater flow in the Wabiskaw Aquifer/Aquitard is expected to be predominantly vertical and downward.

McMurray Bitumen Aquitard

The middle portion of the McMurray Formation is typically bitumen saturated and is referred to as the McMurray Bitumen Aquitard. Similar to the Wabiskaw Member, areas in the McMurray Formation with a high degree of bitumen saturation are likely to have decreased hydraulic conductivity. The McMurray Formation, including its individual hydrostratigraphic units, outcrops along the Athabasca and Clearwater rivers near the north boundary of the RSA.

Hydraulic conductivity estimates for the McMurray Bitumen Aquitard are summarized in Table 5.5-5. Horizontal hydraulic conductivity estimates for the McMurray Bitumen Aquitard range from 3 x 10^{-8} m/s to 1 x 10^{-5} m/s and the vertical hydraulic conductivity was estimated at 4 x 10^{-8} m/s.

Hydraulic head values specific to the McMurray Bitumen Aquitard are not available. Groundwater flow in the McMurray Bitumen Aquitard is expected to be predominantly vertical and downward.

Basal McMurray Aquifer

Water-saturated fluvial sands that occur at the base of the McMurray Formation are referred to as the Basal McMurray Aquifer. The Basal McMurray Aquifer is thin and discontinuous in the LSA but it is much thicker and laterally extensive to the east of the LSA.

Hydraulic conductivity estimates for the Basal McMurray Aquifer are summarized in Table 5.5-5. Horizontal hydraulic conductivity estimates for the Basal McMurray Aquifer range from 7 x 10^{-10} m/s to 3 x 10^{-4} m/s and the vertical hydraulic conductivity was estimated at 9 x 10^{-8} m/s. A transmissivity of 60 m^2/d and a hydraulic conductivity of 7 x 10^{-5} m/s were reported for the Basal McMurray Aquifer (North American, 2006). Recent well testing conducted by North American (winter 2007) suggests the hydraulic conductivity of the Basal McMurray Aquifer ranges from 2.0 x 10^{-5} m/s to 5.5 x 10^{-5} m/s (Westwater, 2007).

Hydraulic head values specific to the Basal McMurray Aquifer are not available. However, hydraulic head values for the undifferentiated McMurray Formation are presented on Figure 5.5-29. Hydraulic heads decrease radially from the Stony Mountain Uplands. Groundwater flow in the Basal McMurray Aquifer is expected to be predominantly horizontal and away from the Stony Mountain Uplands toward the Clearwater and Athabasca rivers. The apparent decrease in hydraulic heads to the west is likely controlled by the presence of the Grosmont Aquifer where it subcrops beneath the Basal McMurray Aquifer. Groundwater is interpreted to drain from the Basal McMurray Aquifer vertically into the Grosmont Aquifer and ultimately discharge to the Peace River (Bachu et al., 1993).

Basal McMurray Aquifer pore water is typically considered saline (i.e., TDS concentration greater than 4,000 mg/L). Regionally, Bachu et al. (1993) estimated the TDS concentration of groundwater in the Basal McMurray Aquifer to range from 5,000 mg/L to 15,000 mg/L. In the LSA, estimates of Basal McMurray Aquifer salinity range from 5,000 mg/L to more than 20,000 mg/L TDS (Figure 5.5-30). Actual TDS concentrations from the AA/01-28-078-10W4/0 injection well was 13,000 mg/L (North American, 2006), EnCana reported a concentration of

12,000 mg/L (EnCana, 2005) and MEG reported a concentrations ranging from 10,300 mg/L to 11,000 mg/L (MEG, 2005). Recent well testing conducted by North American (winter, 2007) identified TDS concentrations in the Basal McMurray Aquifer ranging from 10,700 mg/L to 13,500 mg/L (Westwater, 2007).

McMurray Aquifer/Aquitard

The remainder of the McMurray deposits are grouped together and referred to as the McMurray Aquifer/Aquitard.

Hydraulic conductivity values specific to the McMurray Aquifer/Aquitard are not available. However, hydraulic conductivity estimates for the undifferentiated McMurray Formation are summarized on Table 5.5-5. Horizontal hydraulic conductivity estimates range from 2×10^{-11} m/s to 1×10^{-4} m/s.

Hydraulic head values specific to the McMurray Aquifer/Aquitard are not available. Groundwater flow in the McMurray Aquifer/Aquitard is expected to be predominantly vertical and downward.

Winterburn Aquifer/Aquitard

The Winterburn Group is referred to as the Winterburn Aquifer/Aquitard. The Winterburn Aquifer/Aquitard is present only in the extreme southwest part of the RSA and is not in the LSA (Figure 5.5-2).

Grosmont Aquifer

The Grosmont Formation is referred to as the Grosmont Aquifer. The Grosmont Aquifer is present beneath the western portion of the RSA and the zero edge of the unit trends in a north-northwest direction (Figure 5.5-2).

Hydraulic head data from the Grosmont Formation is presented on Figure 5.5-31. Hydraulic heads decrease to the west. Groundwater flow is expected to be predominantly horizontal and to the west. On a regional scale, groundwater flow in the Grosmont Aquifer is to the north toward its outcrop along the Peace River. Given the permeability of the Grosmont Aquifer, Bachu et al. (page 30, 1993) postulates that if there is hydraulic continuity between the Grosmont Aquifer and aquifers located above it, the Grosmont Aquifer may act as a “drain.”

Grosmont Aquifer pore water is typically considered saline (i.e., TDS concentration greater than 4,000 mg/L). Regionally, Bachu et al. (1993) estimated the TDS concentration of groundwater in the Grosmont Aquifer to be approximately 10,000 mg/L.

Ireton Aquitard

The Ireton Formation is referred to as the Ireton Aquitard. The Ireton Aquitard is present beneath the western portion of the RSA and zero edge of the unit trends in a north-northwest direction (Figure 5.5-2).

Both Bachu et al. (1993) and Hitchon et al. (1990) consider the Ireton Aquitard a strong barrier to flow. Therefore, it is anticipated that groundwater flow is vertical and downward in the Ireton Aquitard.

Cooking Lake/Beaverhill Lake Aquifer/Aquitard

The Cooking Lake Formation and the Beaverhill Lake Group are lumped together and referred to as the Cooking Lake/Beaverhill Lake Aquifer/Aquitard. The Cooking Lake/Beaverhill Lake

Aquifer/Aquitard subcrops along the sub-Cretaceous unconformity beneath the eastern portion of the RSA (Figure 5.5-2). As mapped by Bachu et al. (1993), the Cooking Lake/Beaverhill Lake Aquifer/Aquitard hydraulic heads decrease from south to north.

Hydraulic conductivity estimates for the Cooking Lake/Beaverhill Lake Aquifer/Aquitard are summarized in Table 5.5-6. Horizontal hydraulic conductivity estimates for the Cooking Lake/Beaverhill Lake Aquifer/Aquitard range from 1 x 10^{-10} m/s to 1 x 10^{-4} m/s and the vertical hydraulic conductivity was estimated at 6 x 10^{-9} m/s.

Bachu et al. (1993) mapped groundwater flow in the Cooking Lake/Beaverhill Lake Aquifer/Aquitard to the east, beyond the dissolution boundary of the Prairie Evaporite. Groundwater flow is then believed to drain downward into the Keg River/Winnipegosis Aquifer. Due to the extremely low permeability of the Prairie Evaporite, very little vertical flux from the Beaverhill Lake Aquifer is expected to occur on the west side of the dissolution boundary.

Watt Mountain Aquitard

The watt Mountain Formation is referred to as the Watt Mountain Aquitard. The Watt Mountain Aquitard is present beneath the majority of the RSA. As discussed by Bachu et al. (1993), where the Prairie Aquiclude is absent, the Watt Mountain Formation has weak aquitard characteristics.

Groundwater flow in the Watt Mountain Aquitard is anticipated to be vertical and downward.

Prairie Aquiclude

The Prairie Formation is referred to as the Prairie Aquiclude. The Prairie Aquiclude is present beneath the western portion of the RSA.

Hydraulic conductivity estimates for the Prairie Aquiclude are summarized in Table 5.5-6. Horizontal hydraulic conductivity estimates for the Prairie Aquiclude range from 1 x 10^{-10} m/s to 9 x 10^{-8} m/s.

Both Hitchon et al. (1989) and Bachu et al. (1993) consider the Prairie Aquiclude to be a significant barrier to flow based on formation water analyses and hydraulic head distributions above and below the Prairie Aquiclude.

Keg River/Winnepegosis Aquifer

The Keg River (Winnepegosis equivalent) is referred to as the Keg River/Winnepegosis Aquifer. The Keg River/Winnipegosis Aquifer is present beneath the entire RSA.

As mapped by Bachu et al. (1993), the distribution of hydraulic head values within the Keg River/Winnipegosis Aquifer indicates that, where the Prairie Aquiclude is present, horizontal groundwater flow is directed to the northeast. Where the Prairie Aquiclude is absent, horizontal groundwater flow is directed north where it discharges in the Clearwater River valley.

Keg River/Winnepegosis Aquifer pore water is typically considered saline (i.e., TDS concentration greater than 4,000 mg/L). Regionally, Bachu et al. (1993) estimated the TDS concentration of groundwater in the Keg River/Winnepegosis Aquifer to be greater than 350,000 mg/L.

5.5.4 Evolution of Groundwater Chemistry

Groundwater quality changes with depth in the RSA. There is an evolution of major ions and an increase in TDS with depth (Ozoray, 1974). Ozoray (1974) noted that major anions and cations evolve from a calcium-bicarbonate ($CaHCO_3$) type water in the shallow overburden to a sodium-bicarbonate ($NaHCO_3$) type water in the deeper overburden deposits and portions of the Grand Rapids Formation. The evolution of the major ions continues to the Clearwater Formation and deeper bedrock units where the groundwater changes to sodium-chloride (NaCl) type water (Ozoray, 1974). An increase in groundwater salinity (TDS) with depth is present within the RSA and LSA (Figures 5.5-25, 5.5-27, 5.5-28 and 5.5-30) and has also been mapped by Bachu et al. (1993). This salinity trend is interpreted to be the result of two main factors: 1) an increase in temperature with depth (Bachu et al., 1993); and 2) horizontal and vertical groundwater flow patterns acting to mix meteoric water with deeper saline water.

An evolution of groundwater chemistry with depth is consistent with a downward flow of groundwater. Pressure mapping completed for this project and regional mapping completed by Ozoray (1974), Hitchon et al. (1989) and Bachu et al. (1993) suggest that a downward directed flow potential from ground surface to Devonian bedrock is present throughout the RSA. However, comparison of Figures 5.5-24, 5.5-26 and 5.5-29 indicates there is potential for upward flow of groundwater beneath the LSA in the Mannville Group. In the vicinity of the Stony Mountain Uplands, the hydraulic head in the undifferentiated McMurray Formation is estimated to be 475 masl and higher, whereas the hydraulic head in the shallower undifferentiated Clearwater Formation is estimated to be between 450 masl and 475 masl. Similarly, in between Conklin and Chard the hydraulic head in the undifferentiated Clearwater Formation is estimated to be higher than 500 masl and the hydraulic head in the shallower undifferentiated Grand Rapids Formation are estimated to be between 450 masl and 475 masl. An explanation for the existence of this apparent anomaly is unknown, but Tóth and Millar (1983) showed that Pliocene erosion changes of the topographic relief could feasibly impact pore pressures at depth resulting in current local pressure anomalies. Tóth and Millar (1983) studied similar deposits west of the RSA but at much greater depths.

5.5.5 Local Water Users

According to the AENV Groundwater Information Centre (GIC) database accessed in February 2007, there are 335 drilling records registered within the LSA (GIC, 2006). Of the 335 records, 206 records are not considered water wells. Therefore, there are 129 existing or potential water wells in the LSA, most of which are completed in the Undifferentiated Overburden Aquifer/Aquitard. A table listing the 129 water wells along with 33 flowing shot holes identified in the LSA is presented as Table 5.5-7. Figure 5.5-21 illustrates the distribution of water wells in the LSA. Most of the water wells are located in and around Conklin. Springs and flowing shot holes are generally located in areas of steeply sloping topography along stream valleys.

Table 5.5-7 Groundwater Users within the LSA

Well ID *	LSD	Section	TWP	Range	Meridian	Easting (27)	Northing (27)	Well Owner	Ground Surface (masl)	Static Water Level (mbgs)	Water Level (masl)	Total Depth (mbgs)	Top of Screen (mbgs)	Bottom of Screen (mbgs)	Hydrostratigraphic* Unit	Date of Information mm/dd/yyyy	Type of Work	Proposed Use for Well
279038		31	76	8	4	485323.31	6164481.87	Conklin School	629	4.57	624.43	42.06	25.91	27.43	Undifferentiated Overburden Aquifer/Aquitard	1/1/1984	new well	Domestic
279044		33	76	8	4	488582.45	6164473.85	Thomas, Fred	637	NA	NA	0	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	7/15/1987	chemistry	Domestic
101264	SE	36	76	8	4	493471.29	6164461.39	Ledcor Ind	594	NA	NA	0	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	3/1/1989	chemistry	Domestic
101265	SE	36	76	8	4	493471.29	6164461.39	Constr Consulting SVCS	594	22.86	571.14	60.96	33.53	36.58	Undifferentiated Overburden Aquifer/Aquitard	3/16/1986	new well	Domestic
279046	NE	36	76	8	4	493471.29	6164461.39	Cooper, Bob	584	6.1	577.9	12.19	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	4/17/1980	chemistry	Domestic
279048		36	76	8	4	493471.29	6164461.39	Alta Housing Corp.	609	10.67	598.33	18.29	16.76	18.29	Undifferentiated Overburden Aquifer/Aquitard	8/18/1972	new well	Domestic
256375	11	11	76	10	4	472246.86	6158071.58	Paramount#South (Leismer)	662	12.98	649.02	79.25	18.29	24.38	Undifferentiated Overburden Aquifer/Aquitard	11/19/1994	new well	Domestic
256454	SE	24	76	10	4	473897.31	6161297	Paramount Res #Base Camp	662	5.03	656.97	15.24	13.11	15.24	Undifferentiated Overburden Aquifer/Aquitard	12/21/1994	new well	Domestic
279197	NE	23	77	9	4	482090.46	6170970.16	Liemer base	585	NA	NA	30.48	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	7/25/1984	chemistry	Domestic
153805	N	2	77	8	4	491844.73	6166084.3	PTI Camp SVC	576	11.28	564.72	54.86	33.83	36.88	Undifferentiated Overburden Aquifer/Aquitard	11/16/1990	new well	Domestic
279190	SW	11	77	8	4	491847.81	6167703.07	Emarce Mercede & Sons	582	18.9	563.1	45.11	43.59	45.11	Undifferentiated Overburden Aquifer/Aquitard	10/13/1980	new well	Domestic
154762	11	31	79	11	4	455383.94	6193818.02	Logan Res	685	7.92	677.08	60.96	28.65	31.7	Undifferentiated Overburden Aquifer/Aquitard	2/7/1991	new well	Domestic
230555	10	14	80	8	4	491309.75	6198453.82	Universal Expl	646	15.85	630.15	115.82	32	35.05	Undifferentiated Overburden Aquifer/Aquitard	12/6/1993	new well	Domestic
101323		19	80	13	4	435890	6200538.79	Marianna Lakes Restaurant	686	NA	NA	0	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	3/22/1983	chemistry	Domestic
101324	NE	19	80	13	4	435890	6200538.79	Marianna Lakes Investments	688	24.38	663.62	100.58	56.39	60.96	Undifferentiated Overburden Aquifer/Aquitard	7/4/1979	new well	Domestic
279465	NE	19	80	13	4	435890	6200538.79	Marianna Lake Lodge	688	NA	NA	6.1	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	5/12/1975	chemistry	Domestic
279466	NE	19	80	13	4	435890	6200538.79	Marianna Lake Campsite	688	11.89	676.11	49.38	46.02	47.55	Undifferentiated Overburden Aquifer/Aquitard	NA	well inventory	Domestic
279468	NW	20	80	13	4	437519.73	6200516.26	Marianna Lakes Settlement	693	42.67	650.33	48.77	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	7/21/1980	chemistry	Domestic
279469	NW	20	80	13	4	437519.73	6200516.26	Marianna Lakes Settlement	693	48.77	644.23	54.86	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	9/9/1980	chemistry	Domestic
42462	SE	4	81	13	4	439218.13	6205349.5	P.T.I. Camp SVC	696	9.36	686.64	45.72	39.01	40.54	Undifferentiated Overburden Aquifer/Aquitard	11/21/2000	new well	Domestic
287973	SE	9	81	13	4	439240.99	6206968.23	Carrier Lumber	690	10.97	679.03	18.59	15.54	18.59	Undifferentiated Overburden Aquifer/Aquitard	1/2/1997	new well	Domestic
230558	14	4	81	9	4	478297.73	6204975.07	Paramount Res	700	3.35	696.65	76.2	36.58	39.62	Undifferentiated Overburden Aquifer/Aquitard	12/8/1993	new well	Domestic
193583	NE	17	82	8	4	486479.27	6217890.67	North Star Energy	737	1.65	735.35	60.96	43.89	46.94	Undifferentiated Overburden Aquifer/Aquitard	2/3/1995	new well	Domestic
150374	NE	22	82	12	4	450782.6	6219771.77	Alta Forestry	746	29.57	716.43	60.96	53.34	54.86	Undifferentiated Overburden Aquifer/Aquitard	3/7/1990	new well	Domestic
1827829	SE	20	83	11	4	456412.36	6229438.12	Alta Env.	658	NA	NA	9.14	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	7/20/1994	new well	Monitoring
212764	N	2	77	8	4	491844.73	6166084.3	Skatering, Karen	576	8.84	567.16	48.77	35.05	38.1	Undifferentiated Overburden Aquifer/Aquitard	6/27/1993	new well	Municipal
153797	15	34	83	11	4	459710.04	6232643.94	PetroCan#Obs Well 1	648	4.57	643.43	28.35	16.15	20.73	Undifferentiated Overburden Aquifer/Aquitard	10/24/1990	new well	Observation
279218		24	82	12	4	454028.62	6219733.72	Alta Land & Forest#Algar	743	NA	NA	0	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	10/22/1968	chemistry	Unknown
279219		24	82	12	4	454028.62	6219733.72	Alta Lands#Spring	743	0	743	0	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	10/22/1968	chemistry	Unknown
279050	5	20	76	9	4	477158.53	6161280.94	Amoco Can#325	665	0	665	18.29	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	2/1/1978	Flowing shot hole	Industrial
279053	7	21	76	9	4	478789.34	6161273.27	Amoco Can#257	682	0	682	18.29	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	2/1/1978	Flowing shot hole	Industrial
279055	7	21	76	9	4	478789.34	6161273.27	Amoco Can#253	682	0	682	12.19	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	2/1/1978	Flowing shot hole	Industrial
279057	7	21	76	9	4	478789.34	6161273.27	Amoco Can#249	682	0	682	18.29	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	2/1/1978	Flowing shot hole	Industrial
279063	5	19	76	11	4	455968.08	6161441.8	Amoco Can#965	655	0	655	18.29	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	2/5/1978	Flowing shot hole	Industrial
279067	13	7	76	13	4	436357.14	6158450.87	Western Geoph#91080	650	0	650	18.29	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	NA	Flowing shot hole	Industrial
279066	12	8	76	13	4	437988.83	6158427.73	Can Superior Oil #924	649	0	649	13.72	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	3/14/1965	Flowing shot hole	Industrial
279196	5	13	77	8	4	493478.74	6169317.84	PetroCan Expl #1084	556	0	556	17.98	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	2/21/1982	Flowing shot hole	Industrial
279194	7	18	77	8	4	485339.71	6169337.97	Kenting Expl#335	567	0	567	0	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	1/13/1982	Flowing shot hole	Industrial
279195	7	18	77	8	4	485339.71	6169337.97	Kenting Expl#336	567	0	567	0	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	1/13/1982	Flowing shot hole	Industrial
279926	10	4	78	9	4	478860.19	6175841.43	Amoco Can#753	590	0	590	17.98	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	1/24/1996	Flowing shot hole	Industrial
279315	12	12	79	13	4	443871.38	6187476.45	Marigold Oils Ltd. #8	702	0	702	184.71	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	3/8/1957	Flowing shot hole	Industrial
279177	7	27	81	13	4	440935.06	6211801.39	#SP 853	681	0	681	4.57	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	4/6/1988	Flowing shot hole	Unknown
279174	4	14	81	12	4	452279.69	6208422.18	Anderson Expl#SP 503	714	0	714	11.89	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	4/2/1987	Flowing shot hole	Industrial
279220	16	34	82	12	4	450819.79	6223012.33	Anderson Expl#SP 301	676	0	676	11.89	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	3/26/1987	Flowing shot hole	Industrial
279042	1	33	76	8	4	488582.45	6164473.85	ARC #23	673	0	673	0	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	1/1/1971	spring	Unknown
190188	14	10	80	10	4	470100.11	6196930.75	Paramount Res	692	18.29	673.71	34.14	27.43	30.48	Undifferentiated Overburden Aquifer/Aquitard	1/14/1993	new well	Industrial
162308	4	20	80	12	4	447299.63	6200385.94	Atco Drlg Rig 3	696	0	696	36.58	29.57	31.09	Undifferentiated Overburden Aquifer/Aquitard	12/12/1991	new well	Industrial
279216	7	9	82	12	4	449121.54	6216553.52	Denmar Oilfield Const	742	17.37	724.63	79.25	56.08	59.13	Undifferentiated Overburden Aquifer/Aquitard	5/14/1988	new well	Industrial
150679	5	34	83	11	4	459710.04	6232643.94	PetroCan	643	6.71	636.29	23.47	10.67	14.63	Undifferentiated Overburden Aquifer/Aquitard	2/21/1990	new well	Industrial
279254	5	34	83	11	4	459710.04	6232643.94	PetroCan	643	7.32	635.68	25.6	9.75	15.24	Undifferentiated Overburden Aquifer/Aquitard	3/11/1989	new well	Industrial
279212	NW	5	77	14	4	428333.47	6166686.12	Alta Forestry	643	2.44	640.56	30.48	28.96	30.48	Undifferentiated Overburden Aquifer/Aquitard	8/5/1986	New Well	Domestic
279215	NW	8	77	14	4	428360.06	6168304.81	Alta Highways	686	0	686	0	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	12/23/1974	spring	Domestic
279470	NE	13	80	14	4	434235.29	6198944.97	Triton Can Res Ltd.	690	19.51	670.49	54.86	46.94	49.99	Undifferentiated Overburden Aquifer/Aquitard	10/3/1988	New Well	Domestic
1500078	10	8	76	6	4	506518.07	6157988.35	Pan Canadian	577	0	577	86.56	77.72	81.08	Undifferentiated Overburden Aquifer/Aquitard	11/1/2006	New Well	Domestic
1500085	10	8	76	6	4	506518.07	6157988.35	Pan Canadian	577	NA	NA	42.06	29.87	32.92	Undifferentiated Overburden Aquifer/Aquitard	11/1/2006	New Well	Domestic
278940	0	31	76	6	4	504878.72	6164459.42	Alta Housing	558	18.29	539.71	44.2	19.81	21.34	Undifferentiated Overburden Aquifer/Aquitard	9/5/1984	New Well	Domestic
278941	0	31	76	6	4	504878.72	6164459.42	Alta Housing	558	12.8	545.2	54.86	22.86	24.38	Undifferentiated Overburden Aquifer/Aquitard	9/5/1984	New Well	Domestic
278944	0	1	76	7	4	503255.16	6156364.79	Alta Housing	586	NA	NA	12.19	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	6/15/1981	chemistry	Domestic
278945	0	1	76	7	4	503255.16	6156364.79	# Bunk House	586	NA	NA	45.72	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	6/15/1981	chemistry	Domestic
278951	6	31	76	7	4	495101.1	6164459.2	Northern Alta Railways	560	NA	NA	15.24	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	12/8/1972	chemistry	Domestic
278952	NW	31	76	7	4	495101.1	6164459.2	Alta Housing	574	4.57	569.43	14.33	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	NA	New Well	Domestic
278958	11	31	76	7	4	495101.1	6164459.2	Alta Housing Corp.	565	NA	NA	12.8	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	NA	well inventory	Domestic
278968	11	31	76	7	4	495101.1	6164459.2	Northland School Div	565	4.51	560.49	15.85	12.5	14.33	Undifferentiated Overburden Aquifer/Aquitard	NA	New Well	Domestic

Well ID *	LSD	Section	TWP	Range	Meridian	Easting (27)	Northing (27)	Well Owner	Ground Surface (masl)	Static Water Level (mbgs)	Water Level (masl)	Total Depth (mbgs)	Top of Screen (mbgs)	Bottom of Screen (mbgs)	Hydrostratigraphic* Unit	Date of Information mm/dd/yyyy	Type of Work	Proposed Use for Well
278974	11	31	76	7	4	495101.1	6164459.2	Northland School Div	565	5.49	559.51	15.24	12.5	14.33	Undifferentiated Overburden Aquifer/Aquitard	NA	New Well	Domestic
278977	11	31	76	7	4	495101.1	6164459.2	Northland School Div	565	NA	NA	13.11	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	NA	well inventory	Domestic
278981	12	31	76	7	4	495101.1	6164459.2	Alta Housing Corp.	577	10.67	566.33	18.29	16.76	18.29	Undifferentiated Overburden Aquifer/Aquitard	NA	well inventory	Domestic
278985	13	31	76	7	4	495101.1	6164459.2	Alta Housing Corp.	574	9.75	564.25	17.07	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	12/4/1972	chemistry	Domestic
279001	9	31	76	7	4	495101.1	6164459.2	Alta Housing #Cabin 106	559	3.96	555.04	5.49	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	12/8/1972	chemistry	Domestic
279005	9	31	76	7	4	495101.1	6164459.2	Tremblay, Dumas	559	5.58	553.42	12.8	9.75	11.58	Undifferentiated Overburden Aquifer/Aquitard	NA	well inventory	Domestic
279007	10	31	76	7	4	495101.1	6164459.2	Conklin Metis Group	559	2.71	556.29	12.19	9.14	10.97	Undifferentiated Overburden Aquifer/Aquitard	NA	well inventory	Domestic
279013	0	31	76	7	4	495101.1	6164459.2	Conklin Hamlet of #Community well	559	NA	NA	9.14	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	5/12/1975	chemistry	Domestic
279017	0	31	76	7	4	495101.1	6164459.2	Conklin School	559	NA	NA	45.72	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	1/25/1984	chemistry	Domestic
279019	0	31	76	7	4	495101.1	6164459.2	Handy Andy Constr	559	8.53	550.47	68.58	27.43	33.53	Undifferentiated Overburden Aquifer/Aquitard	8/15/1985	New Well	Domestic
279021	0	31	76	7	4	495101.1	6164459.2	Karen's Camp Catering	559	NA	NA	0	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	12/18/1987	chemistry	Domestic
279022	0	31	76	7	4	495101.1	6164459.2	Conklin Fire Hall	559	NA	NA	0	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	6/18/1988	chemistry	Domestic
279023	0	31	76	7	4	495101.1	6164459.2	Northland School Div 61	559	5.79	553.21	30.78	26.52	27.74	Undifferentiated Overburden Aquifer/Aquitard	11/7/1988	New Well	Domestic
279024	12	32	76	7	4	496730.47	6164459.06	McCallum, D.	556	5.52	550.48	11.28	9.14	10.97	Undifferentiated Overburden Aquifer/Aquitard	NA	well inventory	Domestic
279025	NE	32	76	7	4	496730.47	6164459.06	Moller, Gary	556	6.4	549.6	64.01	60.96	62.48	Undifferentiated Overburden Aquifer/Aquitard	1/15/1988	New Well	Domestic
279026	NE	32	76	7	4	496730.47	6164459.06	Ledcor Const	556	6.1	549.9	45.11	33.53	36.58	Undifferentiated Overburden Aquifer/Aquitard	1/15/1988	New Well	Domestic
279028	SW	33	76	7	4	498360.1	6164458.84	Thom's Camping	552	NA	NA	0	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	7/8/1987	chemistry	Domestic
279029	NW	33	76	7	4	498360.1	6164458.84	Christina Lake Ent Ltd.	556	4.88	551.12	20.73	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	4/13/1987	New Well	Domestic
279031	NW	33	76	7	4	498360.1	6164458.84	Christina Lake Ent Ltd.	556	10.67	545.33	18.29	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	4/13/1987	New Well	Domestic
279032	NW	33	76	7	4	498360.1	6164458.84	Christina Lake Ent Ltd.	556	1.52	554.48	4.57	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	4/13/1987	New Well	Domestic
279033	NW	33	76	7	4	498360.1	6164458.84	Christina Lake Ent Ltd.	556	2.13	553.87	6.71	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	4/13/1987	New Well	Domestic
279034	NW	33	76	7	4	498360.1	6164458.84	Thom, Donald	556	NA	NA	12.19	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	11/2/1987	chemistry	Domestic
279035	0	33	76	7	4	498360.1	6164458.84	Christina Lake Lodge	548	NA	NA	0	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	6/30/1988	chemistry	Domestic
279036	0	33	76	7	4	498360.1	6164458.84	Christina Lake Lodge	548	NA	NA	0	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	6/30/1988	chemistry	Domestic
279037	0	36	76	7	4	503249.15	6164457.89	Conklin Fire Hall	566	NA	NA	0	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	2/6/1987	chemistry	Domestic
292381	3	7	77	7	4	495104.76	6167696.8	Anderson Expl	567	12.5	554.5	42.67	34.14	35.66	Undifferentiated Overburden Aquifer/Aquitard	6/17/1999	New Well	Domestic
279364	NE	1	79	6	4	512545.03	6185515.39	Barry's Plumbing	545	NA	NA	36.58	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	5/3/1982	chemistry	Domestic
279366	SW	17	79	6	4	505998.63	6188737.28	Catholic Church	505	4.88	500.12	6.1	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	9/11/1972	chemistry	Domestic
256456	6	18	79	7	4	494558.48	6188734.9	Rio Alta Expl C/O Tundra Eng	568	2.35	565.65	79.25	40.84	42.37	Undifferentiated Overburden Aquifer/Aquitard	1/24/1995	New Well	Domestic
279462	10	2	80	6	4	510885.03	6195223.21	Petro Can	486	43.59	442.41	146.3	107.9	110.95	Undifferentiated Overburden Aquifer/Aquitard	9/25/1987	New Well	Domestic
254297	15	2	81	6	4	510860.66	6204935.04	Paramount #Kettle River	481	27.43	453.57	55.78	45.72	54.86	Undifferentiated Overburden Aquifer/Aquitard	2/23/1995	New Well	Domestic
279173	5	5	81	6	4	505976.31	6204924.09	CNR # Campsite	512	NA	NA	4.57	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	1/17/1986	chemistry	Domestic
279214	13	27	82	6	4	509198.03	6221118.97	NAR Railway	496	3.05	492.95	17.98	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	1/25/1983	New Well	Domestic
279250	NE	17	83	6	4	505417.72	6227596.93	Engstrom Lk Guide/Scout Camp	566	NA	NA	0	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	6/8/1989	chemistry	Domestic
279251	9	25	83	7	4	502146.67	6230830.27	Gulf Can	560	12.19	547.81	103.63	17.68	18.9	Undifferentiated Overburden Aquifer/Aquitard	11/26/1980	New Well	Domestic
279365	NE	20	79	6	4	505996.46	6190356.26	Petro Can #Chard Compressor	493	NA	NA	79.25	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	11/2/1987	chemistry	Industrial
92288	10	32	79	7	4	496197.2	6193590.31	Richfield Oil Corp	584	NA	NA	240.79	NA	NA	Lower Grand Rapids Aquifer	4/8/1960	chemistry	Industrial
92289	1	33	79	7	4	497829.92	6193589.78	Unknown	578	NA	NA	319.74	NA	NA	Lower Grand Rapids Aquifer	1/2/1958	chemistry	Industrial
162384	12	36	76	6	4	513027.1	6164476.04	Venture Seismic Ltd#SP416	556	0	556	9.75	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	4/3/1991	Flowing shot hole	Industrial
162385	12	36	76	6	4	513027.1	6164476.04	Venture Seismic Ltd	556	0	556	9.75	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	4/3/1991	Flowing shot hole	Industrial
279273	7	26	78	6	4	511351.01	6182278.38	Amoco Can Ltd #113	544	0	544	15.24	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	3/9/1977	Flowing shot hole	Industrial
279276	7	26	78	6	4	511351.01	6182278.38	Amoco Petro#109	544	0	544	15.24	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	3/9/1977	Flowing shot hole	Industrial
279278	9	27	78	6	4	509727.92	6182275.22	Amoco Can #85	536	0	536	15.24	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	5/30/1977	Flowing shot hole	Industrial
279282	16	31	78	7	4	495123.11	6183882.94	Amoco Can #341	546	0	546	15.24	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	3/9/1977	Flowing shot hole	Industrial
279283	16	31	78	7	4	495123.11	6183882.94	Amoco Can #345	546	0	546	18.29	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	5/30/1977	Flowing shot hole	Industrial
279368	3	5	79	7	4	496189.65	6185498.44	Amoco Can #329	553	0	553	15.24	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	5/30/1977	Flowing shot hole	Industrial
279369	4	5	79	7	4	496189.65	6185498.44	Amoco Can Ltd #337	556	0	556	15.24	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	5/30/1977	Flowing shot hole	Industrial
279371	10	22	79	7	4	499461.61	6190352.11	Amoco Can Ltd #125	566	0	566	15.24	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	5/30/1977	Flowing shot hole	Industrial
279373	10	22	79	7	4	499461.61	6190352.11	Amoco Can Ltd #129	566	0	566	15.24	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	5/30/1977	Flowing shot hole	Industrial
162528	11	31	79	7	4	494564.74	6193590.8	Alta Energy CO#SP251	595	0	595	17.98	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	2/10/1992	Flowing shot hole	Industrial
162529	10	31	79	7	4	494564.74	6193590.8	Alta Energy CO#SP226	588	0	588	17.98	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	2/10/1992	Flowing shot hole	Industrial
162530	10	31	79	7	4	494564.74	6193590.8	Alta Energy CO#SP209	588	0	588	17.98	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	2/10/1992	Flowing shot hole	Industrial
162531	10	31	79	7	4	494564.74	6193590.8	Alta Energy CO#SP240	588	0	588	17.98	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	2/10/1992	Flowing shot hole	Industrial
279374	4	32	79	7	4	496197.2	6193590.31	Amoco Can Ltd #441	582	0	582	15.24	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	5/30/1977	Flowing shot hole	Industrial
279463	13	14	80	7	4	501093.2	6198444.87	Amoco Can Ltd #201	600	0	600	15.24	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	5/30/1977	Flowing shot hole	Industrial
279464	13	24	80	7	4	502723	6200063.31	Amoco Can Ltd #125	552	0	552	15.24	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	5/30/1977	Flowing shot hole	Industrial
1420120	NW	14	78	9	4	482124.01	6179063.58	North American Oil Sands Corp.	608	3.61	604.39	96.62	90.53	96.62	Empress Terrace Aquifer	11/2/2006	New Well	Industrial
1420525	4	17	83	11	4	456395.79	6227819.44	Burnco Rock Products	695	61.57	633.43	134.11	86.56	92.66	Undifferentiated Overburden Aquifer/Aquitard	11/27/2006	New Well	Industrial
279319	EH	33	79	14	4	429264.54	6194170.44	Simmons Pipeline	677	3.66	673.34	64.01	9.14	10.36	Undifferentiated Overburden Aquifer/Aquitard	3/7/1989	New Well	Industrial
298114	9	17	76	6	4	506515.62	6159606.79	Pan Can	563	2.99	560.01	143.26	127.41	139.6	Empress Channel Aquifer	12/31/2001	New Well	Industrial
298237	9	17	76	6	4	506515.62	6159606.79	Pan Can (C.S. Res)	563	3.51	559.49	143.26	127.41	139.6	Empress Channel Aquifer	6/30/1998	New Well	Industrial
289512	8	25	83	7	4	502146.67	6230830.27	Gulf Res Can Ltd	553	106.25	446.75	198.12	146.91	193.24	Lower Grand Rapids Aquifer	10/28/1996	New Well	Industrial
1911634	NE	25	83	7	4	502146.67	6230830.27	Inland Concrete	569	6.89	562.11	24.38	18.29	24.38	Undifferentiated Overburden Aquifer/Aquitard	11/13/2006	New Well	Industrial
278956	NW	31	76	7	4	495101.1	6164459.2	Alta Municipal Affairs ID 18 N	574	NA	NA	33.53	NA	NA	Undifferentiated Overburden Aquifer/Aquitard	2/27/1986	chemistry	Municipal
278986	14	31	76	7	4	495101.1	6164459.2	ARC	566	11.13	554.87	131.06	NA	NA	Empress Channel Aquifer	9/22/1971	Test Hole	Municipal
279249	0	16	83	6	4	507052.08	6227600.01	Alta Forestry	568	29.87	538.13	36.58	35.05	36.58	Undifferentiated Overburden Aquifer/Aquitard	9/25/1987	New Well	Municipal
1420423	NW	14	78	9	4	482124.01	6179063.58	North American Oil Sands Corp.	608	3.52	604.48	95.71	89.61	95.71	Empress Terrace Aquifer	11/9/2006	New Well	Observation

Well ID *	LSD	Section	TWP	Range	Meridian	Easting (27)	Northing (27)	Well Owner	Ground Surface (masl)	Static Water Level (mbgs)	Water Level (masl)	Total Depth (mbgs)	Top of Screen (mbgs)	Bottom of Screen (mbgs)	Hydrostratigraphic* Unit	Date of Information mm/dd/yyyy	Type of Work	Proposed Use for Well
40913	10	8	76	6	4	506518.07	6157988.35	Pan Canadian #TH 1	577	NA	NA	152.4	132.89	138.99	Empress Channel Aquifer	2/15/2002	New Well	Observation
40914	10	8	76	6	4	506518.07	6157988.35	Pan Canadian #TH 2	577	NA	NA	83.52	77.42	83.52	Undifferentiated Overburden Aquifer/Aquitard	2/15/2002	New Well	Observation
40915	10	8	76	6	4	506518.07	6157988.35	Pan Canadian #TH 3	577	NA	NA	53.64	47.55	53.64	Undifferentiated Overburden Aquifer/Aquitard	2/15/2002	New Well	Observation
40916	10	8	76	6	4	506518.07	6157988.35	Pan Canadian #TH 4	577	NA	NA	24.38	18.29	24.38	Undifferentiated Overburden Aquifer/Aquitard	2/15/2002	New Well	Observation
40917	10	8	76	6	4	506518.07	6157988.35	Pan Canadian #TH 5	577	NA	NA	6.71	3.66	6.71	Undifferentiated Overburden Aquifer/Aquitard	2/15/2002	New Well	Observation
40918	7	16	76	6	4	508146.98	6159610.09	Pan Canadian #TH 21	567	NA	NA	158.19	143.87	154.53	Empress Channel Aquifer	2/15/2002	New Well	Observation
40919	7	16	76	6	4	508146.98	6159610.09	Pan Canadian #TH 17	567	NA	NA	118.87	112.78	118.87	Empress Channel Aquifer	2/15/2002	New Well	Observation
40920	7	16	76	6	4	508146.98	6159610.09	Pan Canadian #TH 18	567	NA	NA	24.08	17.98	24.08	Undifferentiated Overburden Aquifer/Aquitard	2/15/2002	New Well	Observation
40921	7	16	76	6	4	508146.98	6159610.09	Pan Canadian #TH 19	567	NA	NA	12.19	6.1	12.19	Undifferentiated Overburden Aquifer/Aquitard	2/15/2002	New Well	Observation
40922	8	17	76	6	4	506515.62	6159606.79	Pan Canadian #TH 7	565	NA	NA	148.44	137.16	143.26	Empress Channel Aquifer	2/15/2002	New Well	Observation
40923	8	17	76	6	4	506515.62	6159606.79	Pan Canadian #TH 9	565	NA	NA	116.43	110.34	116.43	Empress Channel Aquifer	2/15/2002	New Well	Observation
40924	8	17	76	6	4	506515.62	6159606.79	Pan Canadian #TH 10	565	NA	NA	76.2	70.1	76.2	Undifferentiated Overburden Aquifer/Aquitard	2/15/2002	New Well	Observation
40925	8	17	76	6	4	506515.62	6159606.79	Pan Canadian #TH 11	565	NA	NA	62.48	56.39	62.48	Undifferentiated Overburden Aquifer/Aquitard	2/15/2002	New Well	Observation
40926	8	17	76	6	4	506515.62	6159606.79	Pan Canadian #TH 12	565	NA	NA	45.72	39.62	45.72	Undifferentiated Overburden Aquifer/Aquitard	2/15/2002	New Well	Observation
40927	8	17	76	6	4	506515.62	6159606.79	Pan Canadian #TH 13	565	NA	NA	22.86	16.76	22.86	Undifferentiated Overburden Aquifer/Aquitard	2/15/2002	New Well	Observation
298238	9	17	76	6	4	506515.62	6159606.79	Pan Can (C.S. Res)	563	1.28	561.72	140.21	126.8	138.99	Empress Channel Aquifer	6/30/1998	New Well	Observation
1500992	8	17	76	6	4	506515.62	6159606.79	EnCana	565	NA	NA	12.19	8.53	10.06	Undifferentiated Overburden Aquifer/Aquitard	11/26/2006	New Well	Observation
1500993	9	17	76	6	4	506515.62	6159606.79	EnCana	563	NA	NA	11.58	5.49	8.53	Undifferentiated Overburden Aquifer/Aquitard	11/26/2006	New Well	Observation
1500994	9	17	76	6	4	506515.62	6159606.79	EnCana	563	NA	NA	28.96	18.29	22.86	Undifferentiated Overburden Aquifer/Aquitard	11/26/2006	New Well	Observation
1420514	1	13	83	7	4	502148.34	6227593.01	Conoco Phillips Canada	623	NA	NA	41.15	38.1	41.15	Undifferentiated Overburden Aquifer/Aquitard	11/27/2006	New Well	Observation
1420515	1	13	83	7	4	502148.34	6227593.01	Conoco Phillips Canada	623	NA	NA	24.83	19.81	22.86	Undifferentiated Overburden Aquifer/Aquitard	11/27/2006	New Well	Observation
1420516	1	13	83	7	4	502148.34	6227593.01	Conoco Phillips Canada	623	NA	NA	4.57	1.52	4.57	Undifferentiated Overburden Aquifer/Aquitard	11/27/2006	New Well	Observation
286008	8	25	83	7	4	502146.67	6230830.27	Gulf Res Can Ltd	553	NA	NA	198.73	150.57	188.98	Lower Grand Rapids Aquifer	10/28/1996	Reconditioned	Observation
1420099	15	12	77	9	4	483705.91	6167724.74	Whitesands Insitu Ltd.	609	23.58	585.42	120.7	116.13	120.7	Empress Channel Aquifer	11/1/2006	New Well	Other
1501044	9	17	76	6	4	506515.62	6159606.79	Pan Canadian	563	NA	NA	136.25	103.63	136.25	Empress Channel Aquifer	11/27/2006	New Well	Other
40928	2	18	83	6	4	503783.12	6227593.81	Conoco	626	179.83	446.17	265.18	249.94	262.13	Lower Grand Rapids Aquifer	2/15/2002	New Well	Other
40929	2	18	83	6	4	503783.12	6227593.81	Conoco	626	179.83	446.17	265.18	230.12	262.43	Lower Grand Rapids Aquifer	2/15/2002	New Well	Other
1500097	4	18	83	6	4	503783.12	6227593.81	Conoco Phillips Canada Res Corp	637	187.45	449.55	263.04	247.8	263.04	Lower Grand Rapids Aquifer	11/1/2006	New Well	Other
1500277	1	19	83	6	4	503781.65	6229212.47	Conoco Phillips Canada Res Corp	611	NA	NA	250.24	244.14	237.74	Lower Grand Rapids Aquifer	11/3/2006	New Well	Other
1500271	2	26	83	6	4	510313.55	6230843.35	Conoco Phillips Canada Res Corp	553	NA	NA	188.06	172.82	188.06	Lower Grand Rapids Aquifer	11/3/2006	New Well	Other
1500092	2	21	83	7	4	497245.71	6229215.72	Conoco Phillips Canada Res Corp	685	NA	NA	305.71	290.17	305.71	Lower Grand Rapids Aquifer	11/1/2006	New Well	Other

Notes:

Alberta Environment, Alberta Groundwater Data on CD-ROM, Groundwater Information Centre, April 2003;

*elevation estimated from digital elevation model (DEM)

Three water wells completed in the Undifferentiated Overburden Aquifer/Aquitard are located within the boundaries of the Project. The well ID for these wells are #154762 (11-31-79-11 W4M), #162308 (4-20-80-12 W4M) and #230558 (14-4-81-9 W4M).

Groundwater chemistry data supplied by GIC is summarized on Table 5.5-8. Generally speaking, groundwater in the Undifferentiated Overburden Aquifer/Aquitard has concentrations of dissolved iron above the aesthetic object outlined by the Canadian Drinking Water Quality Guidelines (CDWQ). Occasionally, TDS concentrations also exceed the aesthetic objective of the CDWQ for the Undifferentiated Overburden Aquifer/Aquitard. TDS concentrations identified in the Empress Channel Aquifer also can exceed the CDWQ aesthetic objectives. TDS concentrations posted on Table 5.5-8 are consistent with the TDS estimations put forth by Ozoray (1974) and described in Section 5.5.3.1.

Table 5.5-8 Undifferentiated Overburden Aquifer/Aquitard: Groundwater Quality Results

Well Name	Sample Date	Well ID	Total Depth or Screen Interval (mbgs)	Hydrostratigraphic Unit[#]	Lab pH	Lab EC uS/cm	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Fe mg/L	Cl mg/L	HCO_3 as $CaCO_3$ mg/L	SO_4 mg/L	F mg/L	NO_2-N mg/L	NO_3-N mg/L	Hardness mg/L	TDS mg/L	SiO_2 mg/L
Conklin School	22-Jan-87	0279038	26-27	Undifferentiated Overburden Aquifer/Aquitard	8.0	693	79.8	25.0	39	4.85	0.22	<1	463	<5	0.22	<0.05	---	303	391	21.5
ARC #23	---	0279042	NA	Undifferentiated Overburden Aquifer/Aquitard	7.2	---	28.9	8.9	9	1.72	0.06	2.5	120	3	<0.05	---	2.0	218	214	---
Fred Thomas	4-Jun-87	0279044	NA	Undifferentiated Overburden Aquifer/Aquitard	8.0	785	105.8	28.0	19	6.47	*0.54*	10	500	22	0.11	<0.005	---	380	437	18.2
Construction Consult	30-May-86	0101265	34-37	Undifferentiated Overburden Aquifer/Aquitard	7.7	766	87.8	26.0	47	5.05	*1.93*	<1	488	20	0.28	<0.05	---	327	427	22
Bob Cooper	16-Apr-80	0279046	12	Undifferentiated Overburden Aquifer/Aquitard	8.4	581	68.9	27.0	14	3.03	*3.6*	2.0	392	<5	0.26	<0.05	---	281	316	19.8
Leismer Base	19-Jun-84	0279197	30	Undifferentiated Overburden Aquifer/Aquitard	7.7	658	60.9	20.0	46	4.95	*0.45*	9.0	416	20	0.20	<0.05	---	235	366	20.4
Marianna Lake Lodge	15-Jul-71	0279465	6	Undifferentiated Overburden Aquifer/Aquitard	*6.3*	990	11.0	60.8	---	---	---	14	---	80	---	---	0.3	50	*695*	---
Marianna Lake Lodge	8-May-75	0279465	6	Undifferentiated Overburden Aquifer/Aquitard	7.8	46	11.0	1.0	1	0.40	<0.1	4.0	24	<10	0.50	<0.1	---	31	39	---
Marianna Lake Camp	15-May-70	0279466	46-48	Undifferentiated Overburden Aquifer/Aquitard	---	520	---	---	---	---	*4.95*	4.0	---	64	---	---	---	268	426	---
Marianna Lake Camp	-	0279466	46-48	Undifferentiated Overburden Aquifer/Aquitard	---	---	---	---	---	---	*10.8*	2.0	---	19	---	---	---	290	396	---
Marianna Lakes STLMN	15-Jul-80	0279468	49	Undifferentiated Overburden Aquifer/Aquitard	7.8	683	73.9	24.0	37	4.24	*3.52*	<1	345	95	0.50	<0.05	---	283	408	19.6
Marianna Lakes STLMN	26-Aug-80	0279469	55	Undifferentiated Overburden Aquifer/Aquitard	8.0	739	88.8	27.0	36	3.94	*1.26*	<1	331	123	0.53	<0.05	---	333	446	20.1
Land & Serv./Algar	-	0279218	NA	Undifferentiated Overburden Aquifer/Aquitard	---	---	---	---	---	---	*1.95*	4.0	---	10	---	---	---	30	106	---
Highways, Dept of	18-Dec-74	0279215	NA	Undifferentiated Overburden Aquifer/Aquitard	7.8	180	25.0	3.0	4	9.9	0.1	8.0	61	39	0.17	<0.1	<0.1	78	122	---
Alberta Housing	10-Jun-81	0278944	12	Undifferentiated Overburden Aquifer/Aquitard	8.3	201	20.0	7.0	6	0.7	0.04	1.0	125	<5.0	0.09	<0.05	---	81	102	6.4

Well Name	Sample Date	Well ID	Total Depth or Screen Interval (mbgs)	Hydrostratigraphic Unit#	Lab pH	Lab EC uS/cm	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Fe mg/L	Cl mg/L	HCO_3 as $CaCO_3$ mg/L	SO_4 mg/L	F mg/L	NO_2-N mg/L	NO_3-N mg/L	Hardness mg/L	TDS mg/L	SiO_2 mg/L
Bunk House	10-Jun-81	0278945	46	Undifferentiated Overburden Aquifer/Aquitard	8.3	662	78.8	29.0	3	1.3	0.05	2.0	425	18	1.17	<0.05	---	318	346	12.6
NAR Well	4-Dec-72	0278951	15	Undifferentiated Overburden Aquifer/Aquitard	6.6	210	13.0	4.0	---	---	*1.8*	19.0	---	---	0.06	<1.0	3.8	53	121	---
Alberta Housing	-	278952	14	Undifferentiated Overburden Aquifer/Aquitard	7.8	565	72.9	26.0	13	2.7	*1.6*	<1.0	389	<5.0	0.27	<0.05	---	289	312	19.2
Municipal Affairs	6-Feb-86	0278956	34	Undifferentiated Overburden Aquifer/Aquitard	7.8	609	77.8	26.0	19	3.2	*1.4*	<1.0	420	6	0.28	<0.05	---	302	340	21.3
Northlands Schl Div	23-Oct-72	0278968	13-14	Undifferentiated Overburden Aquifer/Aquitard	7.4	580	61.9	25.0	---	---	0.1	<1.0	---	52	---	---	---	529	*529*	---
Northlands Schl Div	5-Dec-72	0278968	13-14	Undifferentiated Overburden Aquifer/Aquitard	7.6	370	21.0	25.0	---	---	0.1	7.0	---	<10	---	---	---	162	298	---
Northlands Schl Div	2-Jul-85	0278968	13-14	Undifferentiated Overburden Aquifer/Aquitard	7.9	728	81.8	28.0	41	6.3	*3.3*	5.0	483	<5	0.21	<0.05	---	320	405	20.4
Northlands Schl Div	2-Jul-85	0278968	13-14	Undifferentiated Overburden Aquifer/Aquitard	7.9	735	85.8	28.0	45	6.2	*1.2*	5.0	487	<5	0.21	<0.05	---	330	415	20.7
Northlands Schl Div	21-Aug-86	0278968	13-14	Undifferentiated Overburden Aquifer/Aquitard	7.9	714	83.8	27.0	41	6.6	*0.5*	4.0	480	10	0.21	<0.05	---	321	418	24
Northlands Schl Div	8-Apr-87	0278968	13-14	Undifferentiated Overburden Aquifer/Aquitard	7.8	608	78.8	26.0	17	3.2	*1.9*	<1.0	405	9	0.27	0.07	---	304	335	22
Northlands Schl Div	8-Apr-87	0278968	13-14	Undifferentiated Overburden Aquifer/Aquitard	7.7	638	79.8	25.0	20	5.6	<0.02	<1.0	424	8	0.32	<0.05	---	302	348	34
Northlands Schl Div	2-Dec-87	0278977	13	Undifferentiated Overburden Aquifer/Aquitard	8.2	689	79.8	26.0	35	4.4	*0.32*	<1.0	462	6	0.22	<0.005	---	307	387	22
Northlands Schl Div	18-May-88	0278977	13	Undifferentiated Overburden Aquifer/Aquitard	7.6	796	77.8	24.0	65	4	<0.02	33.0	464	<5	0.22	<0.005	---	293	444	22.3
Alberta Housing Corp	18-Aug-72	0278981	17-18	Undifferentiated Overburden Aquifer/Aquitard	7.7	480	24.0	41.0	---	---	*4*	8.0	---	<10	---	---	---	232	390	---
Alberta Housing Corp	4-Dec-72	0278985	17	Undifferentiated Overburden Aquifer/Aquitard	7.9	400	21.0	33.0	---	---	0.1	2.0	---	33	0.32	---	---	191	377	---
ARC	16-Sep-71	0278986	131	Empress Channel Aquifer	*8.8*	---	9.4	3.4	*203*	4.2	0.27	5.0	392	19	0.6	---	6	38	*642*	8
ARC	-	0278986	131	Empress Channel Aquifer	---	840	---	---	---	---	*0.67*	6.0	---	14	---	---	1	36	*574*	---

Well Name	Sample Date	Well ID	Total Depth or Screen Interval (mbgs)	Hydrostratigraphic Unit[#]	Lab pH	Lab EC uS/cm	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Fe mg/L	Cl mg/L	HCO_3 as $CaCO_3$ mg/L	SO_4 mg/L	F mg/L	NO_2-N mg/L	NO_3-N mg/L	Hardness mg/L	TDS mg/L	SiO_2 mg/L
ARC	-	0278986	131	Empress Channel Aquifer	---	300	---	---	---	---	0.12	2.0	---	15	---	---	0.3	147	208	---
ARC	-	0278986	131	Empress Channel Aquifer	---	860	---	---	---	---	*0.49*	2.0	---	120	---	---	---	55	*614*	---
ARC	-	0278986	131	Empress Channel Aquifer	---	360	---	---	---	---	0.01	4.0	---	43	---	---	1.4	162	260	---
ARC	-	0278986	131	Empress Channel Aquifer	---	530	---	---	---	---	*0.34*	2.0	---	53	---	---	2.5	229	380	---
Alberta Hsng #106	4-Dec-72	0279001	5	Undifferentiated Overburden Aquifer/Aquitard	7.8	420	21	33	---	---	*1.2*	8.0	---	<10	0.53	---	---	194	349	---
Conklin Metis Group	-	0279007	11-Sep	Undifferentiated Overburden Aquifer/Aquitard	7.5	650	46.9	35	---	---	0.2	1.0	---	348	---	---	---	266	*545*	---
Conklin Community	8-May-75	0279013	9	Undifferentiated Overburden Aquifer/Aquitard	7.3	500	82.8	21	3	1.7	0.1	5.0	263.9	61	0.05	<0.1	---	294	316	---
Conklin School	19-Jan-84	0279017	46	Undifferentiated Overburden Aquifer/Aquitard	7.4	744	77.8	21.0	53	4.3	*0.35*	2.0	363	109	0.26	<0.05	---	281	446	21.1
Karen's Camp Catering	2-Dec-87	0279021	NA	Undifferentiated Overburden Aquifer/Aquitard	7.9	601	73.9	24.0	24	4.3	*2.03*	<1.0	399	9	0.16	<0.005	---	283	328	22.1
Conklin Fire Hall	18-May-88	0279022	NA	Undifferentiated Overburden Aquifer/Aquitard	7.5	616	77.8	25.0	20	3	0.15	<1.0	413	<5	0.26	0.06	---	298	336	22
Thom's Camp	11-Jun-87	0279028	NA	Undifferentiated Overburden Aquifer/Aquitard	7.2	206	25.9	8.0	---	0.71	0.19	19.0	---	---	0.15	0.38	<0.005	98	111	10.6
Thom, Donald	13-Oct-87	0279034	12	Undifferentiated Overburden Aquifer/Aquitard	7.9	655	95.8	24.0	9	1.9	*0.89*	6.0	430	22	0.15	<0.005	---	338	371	---
Christina Lake Lodge	-	0279035	NA	Undifferentiated Overburden Aquifer/Aquitard	8	741	96.8	30.0	18	5.4	0.12	4.0	480	24	0.1	0.07	---	366	415	14.6
Christina Lake Lodge	-	0279036	NA	Undifferentiated Overburden Aquifer/Aquitard	7.9	447	55.9	19.0	6	2.9	*0.31*	<1.0	294	<5	0.52	<0.005	---	218	---	17.4
Conklin Fire Hall	22-Jan-87	0279037	NA	Undifferentiated Overburden Aquifer/Aquitard	7.8	613	73.9	25.0	22	7.1	0.1	<1.0	407	7	0.36	<0.05	---	288	337	24
Barry's Plumbing	27-Apr-82	0279364	37	Undifferentiated Overburden Aquifer/Aquitard	7.6	1167	67.9	22.0	172	3.3	*2.16*	3.0	432	250	0.36	<0.05	---	260	*731*	21.1
Catholic Church	-	0279366	6	Undifferentiated Overburden Aquifer/Aquitard	7.8	420	51.9	11.0	---	---	0.1	4.0	---	11	---	---	---	178	349	---

Well Name	Sample Date	Well ID	Total Depth or Screen Interval (mbgs)	Hydrostratigraphic Unit#	Lab pH	Lab EC uS/cm	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Fe mg/L	Cl mg/L	HCO_3 as $CaCO_3$ mg/L	SO_4 mg/L	F mg/L	$N0_2$-N mg/L	$N0_3$-N mg/L	Hardness mg/L	TDS mg/L	SiO_2 mg/L
Petro Canada #Chard	-	0279365	79	Undifferentiated Overburden Aquifer/Aquitard	*8.8*	2410	2.0	<1.0	*595*	2.6	*3.54*	*305.4*	951	<5	*2.4*	0.02	---	9	*1424*	6.7
CNR campsite	14-Jan-86	0279173	5	Undifferentiated Overburden Aquifer/Aquitard	7.1	312	36.9	9.0	16	1.30	*12.9*	4	192	6	0.11	<0.05	---	129	168	11.5
Gulf Can	20-Nov-80	0279251	18-19	Undifferentiated Overburden Aquifer/Aquitard	7.9	565	77.8	22.0	11	1.60	*0.37*	2.0	327	47	0.3	<0.05	---	285	322	18.4
Canadian Drinking Water Guidelines*					**6.5-8.5(AO)**	**NS**	**NS**	**NS**	**200(AO)**	**NS**	**0.3(AO)**	**250(AO)**	**NS**	**500(AO)**	**1.5(MAC)**	**1(MAC)**	**10(MAC)**	**NS**	**500(AO)**	**NS**

Notes:
Information accessed through the Groundwater Information website available at http://www3.gov.ab.ca/env/water/groundwater/index.html
--- - not analyzed
NS - not specified
AO - aesthetic objective
MAC - maximum acceptable concentration based on health effects
* - Summary of Guidelines for Canadian Drinking Water Quality (Health Canada, 2004)
\# - not confirmed
Italics - indicates values do not meet drinking water guidelines

Table 5.5-9 summarizes current groundwater diversion licenses issued in the LSA along with reported diversions near the LSA. Groundwater diversions in the LSA have been issued for such purposes as municipal water use, camp supply, aggregate washing and industrial steam injection.

Table 5.5-9 Current Groundwater Diversions within the LSA and Reported Diversions near the LSA

Producer	Project	Location	Source Aquifer	Production Interval (mbgs)	Average Daily Water Diversion (m^3/d)	Maximum Daily Water Diversion (m^3/d)	Maximum Annual Water Diversion (m^3/y)	Expiry Date	Reference	Comments
Japan Canada Oil Sands Ltd.	Hangingstone One	SE-11-84-11 W4M	Undifferentiated Overburden Aquifer/Aquitard	64.6 - 82.9	1,127	1,200	438,000	May 3, 2007	AENV, 2007j	industrial steam injection
Stony Valley Contracting Ltd.	---	NE-25 & SE 36-83-11 W4M	Undifferentiated Overburden Aquifer/Aquitard	10.0 - 30.0	---	7,855	125,000	May 8, 2010	AENV, 2006a	dewatering and aggregate washing
Whitesands Insitu Ltd.	Whitesands	15-12-77-9 W4M	Empress Channel Aquifer	116.1 - 120.7	---	250	2,000	Nov 20, 2006	AENV, 2006b	temporary diversion for drilling
Whitesands Insitu Ltd.	Whitesands	10-12-77-9 W4M	Empress Channel Aquifer	174.3 - 178.9	---	292	107,180	Mar 12, 2012	AENVm, 2007	industrial steam injection
Whitesands Insitu Ltd.	Whitesands	---	Empress Channel Aquifer	---	575	---	---	NA	Orion, 2003	industrial steam injection
Connacher Oil and Gas Ltd.	Great Divide Project	9-17-82-12 W4M	Lower Grand Rapids Aquifer	386.0 - 329.0	500	3,000	180,000	NA	Connacher, 2005	industrial steam injection
Connacher Oil and Gas Ltd.	Great Divide Project	13-16-82-12 W4M	Undifferentiated Overburden Aquifer/Aquitard	---	4.5	45	1,657	NA	Connacher, 2005	domestic and construction supply
Alberta Municipal Affairs	---	8-36-76-8 W4M	Undifferentiated Overburden Aquifer/Aquitard	33.5 - 36.6	---	130	1,364	No expiry	AENV, 2006c	Conklin municipal water supply
EnCana Corporation	Christina Lake	NE-8-76-6 W4M	Undifferentiated Overburden Aquifer/Aquitard	30.0 - 36.0 & 79.2 - 84.1	---	36.3	31,500	Dec 13, 2015	AENV, 2007b	camp supply
EnCana Corporation	Christina Lake	9-17-76-6 W4M	Empress Channel Aquifer	127.4 - 139.6	600	5,000	1,825,000	Aug 30, 2025	AENV, 2007c	industrial steam injection
EnCana Corporation	Christina Lake	8-17-76-6 W4M	Clearwater B Aquifer	---	3,900	---	---	NA	EnCana, 2005	horizontal well (3 more proposed)
Regional Municipality of Wood Buffalo	---	NE-32-76-7 W4M	Christina Lake	---	---	164	50,000	Oct 6, 2030	AENV, 2007d	municipal water supply
North American	Kai Kos Dehseh	11-14-78-9 W4M	Empress Terrace Aquifer	90.5 - 96.6	---	102	37,230	Apr 18, 2017	AENV, 2007a	camp supply
Ledcor Pipeline Inc.	---	1-9-81-13 W4M	Undifferentiated Overburden Aquifer/Aquitard	17.1 - 21.6	---	140	51,100	Dec 12, 2026	AENV, 2007e	camp supply
Alberta Infrastructure	---	14,15 & 16-30-82-6 W4M	Undifferentiated Overburden Aquifer/Aquitard	1.0 - 3.0	---	---	---	Oct 29, 2011	AENV, 2007f	dewatering
ConocoPhilips Canada Corporation	Surmont	8-25-83-7 W4M	Lower Grand Rapids Aquifer	173.7 - 193.2	---	202	73,750	Dec 31, 2007	AENV, 2007g	industrial steam injection
ConocoPhilips Canada Corporation	Surmont	2-18-83-6 W4M	Lower Grand Rapids Aquifer	249.9 - 262.4	---	970	231,240	Feb 9, 2014	AENV, 2007n	industrial steam injection
ConocoPhilips Canada Corporation	Surmont	4-18-83-6 W4M	Lower Grand Rapids Aquifer	247.8 - 263.0	---	1,220	231,240	Feb 9, 2014	AENV, 2007n	industrial steam injection
ConocoPhilips Canada Corporation	Surmont	1-19-83-6 W4M	Lower Grand Rapids Aquifer	228.3 - 250.2	---	1,220	231,240	Feb 9, 2014	AENV, 2007n	industrial steam injection

Producer	Project	Location	Source Aquifer	Production Interval (mbgs)	Average Daily Water Diversion (m^3/d)	Maximum Daily Water Diversion (m^3/d)	Maximum Annual Water Diversion (m^3/y)	Expiry Date	Reference	Comments
ConocoPhillips Canada Corporation	Surmont	---	Lower Grand Rapids Aquifer	---	6,616	7,162	---	NA	Gulf, 2001	industrial injection (16 wells)
ConocoPhillips Canada Corporation	Surmont	---	Basal McMurray Aquifer	---	9,820	---	---	NA	Conoco, 2006	industrial injection (4 wells)
Burnco Rock Products Ltd.	---	SW-17-83-11 W4M	Surface Water	---	---	---	25,227	Jul 10, 2010	AENV, 2007h	aggregate washing
Burnco Rock Products Ltd.	---	4-17-83-11 W4M	Undifferentiated Overburden Aquifer/Aquitard	86.6 - 92.7	---	287	73,000	Jan 24, 2017	AENV, 2007i	aggregate washing
Petro-Canada Oil and Gas	Meadow Creek	15-27-84-9 W4M	Lower Grand Rapids Aquifer	308.0 - 328.3	2,172	4,000	---	NA	Petro-Canada, 2001	industrial steam injection
Nexen/OPTI	Long Lake	---	Lower Grand Rapids Aquifer, Empress Channel Aquifer and storm water runoff	---	9,000	---	---	NA	OPTI/Nexen, 2002	industrial steam injection
Nexen/OPTI	Long Lake South	---	Basal McMurray Aquifer	---	17,800	---	---	NA	Nexen/OPTI, 2006	industrial steam injection
MEG Energy Corp.	Christina Lake	8-16 & 2-16-77-5 W4M	Clearwater A Aquifer	275 - 300	1,025	3,200	766,500	Oct 16, 2011	AENV, 2007k	industrial steam injection
MEG Energy Corp.	Christina Lake	---	Undifferentiated Overburden Aquifer/Aquitard	---	210	---	---	NA	MEG, 2006	camp supply
MEG Energy Corp.	Christina Lake	NE-9-77-5 W4M	Undifferentiated Overburden Aquifer/Aquitard (Ethel Lake)	52.5 - 57.4	195	400	---	Feb 12, 2010	MEG, 2006	domestic and utility
Devon Canada Corporation	Jackfish 1	12-28-75-6 W4M	Empress Terrace Aquifer	123.1 - 129.5	30	150	54,750	NA	Devon, 2006	domestic supply (PW1 and PW2)
Devon Canada Corporation	Jackfish 1	3-27, 11-22 & 12-15-75-6 W4M	Lower Grand Rapids Aquifer	---	1,200	5,000	---	NA	Devon, 2006	industrial steam injection
Devon Canada Corporation	Jackfish 2	3-27, 11-22 & 12-15-75-6 W4M	Lower Grand Rapids Aquifer	---	1,200	5,000	---	NA	Devon, 2006	industrial steam injection
Canadian Natural Resources Ltd.	Kirby	13-21-73-7 W4M	Empress Channel Aquifer	292.7 - 302.2	---	1,355	483,000	Jun 21, 2021	AENV, 2007l	industrial steam injection

Table 5.5-10 summarizes the publicly known water strategies for the other in-situ oil sands operators in the RSA. The main groundwater supply target aquifers for these projects include the Undifferentiated Overburden Aquifer/Aquitard, Empress Terrace Aquifer, Empress Channel Aquifer, Lower Grand Rapids Aquifer, Clearwater A Aquifer, Clearwater B Aquifer and Basal McMurray Aquifer. The target disposal aquifers include the Clearwater A Aquifer, Clearwater B Aquifer, Basal McMurray Aquifer and the Keg River Aquifer.

Table 5.5-10 Publicly Known In-Situ Oil Sands Operator Water Strategies in the Vicinity of the Kai Kos Dehseh Project

Project	Groundwater Withdrawal		Liquid Waste Injection		Literature Cited
	Withdrawal Rate (m^3/d)	Withdrawal Source	Injection Rate (m^3/d)	Injection Aquifer	
CNRL Kirby Pilot	1,355	Empress Channel Aquifer	1,355*	Basal McMurray Aquifer	AENV, 2001
EnCana Christina Lake Thermal Project Phase 1A and 1B	3,900	Clearwater B Aquifer	2,500	Basal McMurray Aquifer	EnCana, 2005
	600	Empress Channel Aquifer			
MEG Christina Lake Regional Project Pilot and Phase 2	195	Quaternary Aquifer	1,141	Basal McMurray Aquifer	MEG, 2006
	1,025	Clearwater A Aquifer			
Connacher Great Divide Project	500	Lower Grand Rapids Aquifer	500*	Clearwater A Aquifer	Connacher, 2005
Petro-Canada Meadow Creek Project	2,172	Lower Grand Rapids Aquifer	290	Basal McMurray Aquifer	Petro-Canada, 2001
PetroBank Whitesands In-Situ Project	575	Empress Channel Aquifer	147	Clearwater B Aquifer	Orion, 2003
Devon ARL Corporation Jackfish and Jackfish 2 Project	2,400	Lower Grand Rapids Aquifer	2,800	Basal McMurray Aquifer	Devon, 2006
Nexen/OPTI Long Lake Project	9,000	Lower Grand Rapids Aquifer, Quaternary Channel Aquifer and storm water runoff	7,600	Keg River Aquifer	Nexen/OPTI, 2003 and Nexen/OPTI, 2006
Nexen/OPTI Long Lake South Project	17,800	Basal McMurray Aquifer	3,328	Keg River Aquifer	Nexen/OPTI, 2006
ConocoPhillips Surmont Project	9,820[@]	Basal McMurray Aquifer	3,230[@]	Basal McMurray Aquifer	ConocoPhillips, 2006
	6,616	Lower Grand Rapids Aquifer			Gulf, 2001
Japan Canada Oil Sands Ltd. (JACOS) Hangingstone Project	1,127	Quaternary/Tertiary Aquifer	1,127 *	Basal McMurray Aquifer	JACOS, 1997

Notes:
*Injection rate assumed to be equal to withdrawal rate.
TBD - to be determined
[@]ConocoPhillips proposes that injection will take place until 2017 and then the injection wells will be transformed into source wells

5.6 Impact Assessment

The nature of the disturbance and the potential impact as a result of each operational aspect of the Project is described in the following subsections. Project operations included in the assessment are: surface facilities, potable water withdrawal, make-up water withdrawal, wastewater injection and production and steaming. The potential impacts are evaluated with respect to the potential changes expected for Surface Waterbodies, Overburden Aquifers, Empress Terrace Aquifer, Empress Channel Aquifer, Lower Grand Rapids Aquifer, Clearwater A Aquifer, Clearwater B Aquifer and the Basal McMurray Aquifer with respect to water levels and water quality.

5.6.1 Surface Facilities

Surface facilities for the Project include several Central Processing Facilities (CPFs) and well pads. Measurable impacts to water levels as a result of the operation of these surface facilities are not expected and are considered neutral, with a prediction confidence of high and a final impact rating of no impact (Table 5.6-1).

Table 5.6-1 Impact Due to Surface Facilities

Key Indicator Resource	Attribute	Direction	Extent	Magnitude	Duration	Frequency	Permanence	Prediction Confidence	Final Impact Rating
Surface Waterbodies	water levels	neutral	n/a	n/a	n/a	n/a	n/a	high	no impact
	water quality	negative	local	high	long term	isolated	reversible in the short to long term	high	low impact
Overburden Aquifers	water levels	neutral	n/a	n/a	n/a	n/a	n/a	high	no impact
	water quality	negative	local	high	long term	isolated	reversible in the short to long term	high	low impact
Empress Terrace Aquifer	water levels	neutral	n/a	n/a	n/a	n/a	n/a	high	no impact
	water quality	neutral	n/a	n/a	n/a	n/a	n/a	high	no impact
Empress Channel Aquifer	water levels	neutral	n/a	n/a	n/a	n/a	n/a	high	no impact
	water quality	neutral	n/a	n/a	n/a	n/a	n/a	high	no impact
Lower Grand Rapids Aquifer	water levels	neutral	n/a	n/a	n/a	n/a	n/a	high	no impact
	water quality	neutral	n/a	n/a	n/a	n/a	n/a	high	no impact
Clearwater A Aquifer	water levels	neutral	n/a	n/a	n/a	n/a	n/a	high	no impact
	water quality	neutral	n/a	n/a	n/a	n/a	n/a	high	no impact
Clearwater B Aquifer	water levels	neutral	n/a	n/a	n/a	n/a	n/a	high	no impact
	water quality	neutral	n/a	n/a	n/a	n/a	n/a	high	no impact
Basal McMurray Aquifer	water levels	neutral	n/a	n/a	n/a	n/a	n/a	high	no impact
	water quality	neutral	n/a	n/a	n/a	n/a	n/a	high	no impact

Accidental releases from surface facilities such as, pipelines, tanks, buildings and well casings all have the potential to negatively impact groundwater quality. The potential risk to receptors will be dependent upon the location of the release, the volume of release, the duration of the release, the nature of materials released and the subsurface hydraulic conditions (e.g., depth to groundwater, groundwater flow velocity and adsorption capacity of the soil).

Much of the LSA is covered by a veneer of organic soils underlain by the clay till Grand Centre Formation (North American 2006). The Grand Centre Formation has a low hydraulic conductivity (approximately 4×10^{-7} m/s, Table 5.5-1). Accidental releases have the potential to adversely impact shallow groundwater and surface water quality. Thus, North American will implement the following mitigative strategies at the project:

- Where possible, flowlines and tanks will be located above ground to facilitate leak detection;
- Storage tanks will be protected against leaks using environmental controls such as internal coatings, cathodic protection and secondary containment (EUB Directive 55). Leak detection equipment will be installed where appropriate;
- North American will develop contingency plans that will serve as a guide for spill response;
- North American will establish formal asset integrity programs to ensure that equipment quality is managed and maintained;
- North American will require all persons whose work may create an impact on the environment receive appropriate training; and

- Groundwater monitoring will be conducted at all CPFs and select well pads (Section 5.8) to monitor the effectiveness of the implemented mitigative measures.

Because of their depth below ground surface, accidental releases from ground surface pose little threat to the Empress Terrace, Empress Channel, Lower Grand Rapids, Clearwater A, Clearwater B and Basal McMurray aquifers. The direction of impact is considered neutral, with a high prediction confidence and a final impact rating of no impact.

Accidental releases from surface facilities could result in a deterioration of the water quality in the Surface Waterbodies and Overburden Aquifers and is considered a negative impact, the extent is local, the magnitude is potentially high, the duration is long term, the frequency is isolated and the permanence is reversible in the short to long term depending on the size and nature of the release. The prediction confidence in this assessment is high. The final impact rating of surface facilities on Surface Waterbodies and Overburden aquifers is low impact.

The mitigative measures and groundwater monitoring in the vicinity of surface facilities will ensure that any releases will be identified and response measures implemented to minimize impacts. Although potential changes in water quality due to surface facility releases are possible (and potentially high magnitude), the final impact rating is considered low impact because effective industry standard mitigation and monitoring efforts will be implemented at the Project surface facilities.

5.6.2 Potable Water Withdrawal

The Project will require a water source to meet potable water demands for domestic use and utility use. Potable water will be required for each CPF and for construction, drilling and operations camps. Some of this water may come from make-up water supply if the water quality is deemed acceptable.

The potable water supply is dependent on the expected site occupancy and is estimated to be 70 litres per day per person to 90 litres per day per person. Camps will be sized for 450 occupants therefore the expected water demand would be approximately 40,500 L/d or 40.5 m^3/d. For more details on water supply for camps and CPFs see Sections 5.2.11.1 and 5.2.12.

The following sections describe the selection process for choosing a potable water source and the predicted impacts as a result of the potable water withdrawal.

5.6.2.1 Candidate Aquifer Selection

Table 5.6-2 summarizes the advantages and disadvantages of the physical characteristics of the use of each of the aquifers beneath the LSA.

Table 5.6-2 Advantages and Disadvantages of Physical Characteristics of the Aquifers Beneath the LSA

Aquifer	Depth	Thickness	Sediment Type	Continuity	Aquifer Properties	Water Chemistry	Primary Pore Contents
Overburden Aquifers	Shallow	Limited Thickness	Sand	Limited areal extent	Untested in LSA. Exploration results in RSA suggest discontinuous productive aquifers likely exist	Potable	Water

Aquifer	Depth	Thickness	Sediment Type	Continuity	Aquifer Properties	Water Chemistry	Primary Pore Contents
Empress Terrace Aquifer	Shallow	Limited thickness	Sand	Limited areal extent	Good aquifer properties (K and S)	Potable	Water
Empress Channel Aquifer	Shallow	Limited thickness to thick	Sand	Limited areal extent	Good aquifer properties (K and S)	Potable	Water
Viking Aquifer	Shallow	Limited thickness	Mainly sandstone	Laterally discontinuous and limited thickness. Erosion in Leismer and Christina channels may present possible hydraulic communication with Empress Formation	Untested in LSA	Potable	Gas and Water
Upper Grand Rapids Aquifer	Deep	Limited thickness	Interbedded shale and sandstone	Laterally continuous	Good aquifer properties (K and S)	Non-saline (unsuitable for potable water supply)	Water
Lower Grand Rapids Aquifer	Deep	Thick	Sandstone	Laterally continuous	Good aquifer properties (K, T and S)	Non-saline (unsuitable for potable water supply)	Water
Clearwater A Aquifer	Deep	Thick	Sandstone	Laterally continuous	Good aquifer properties (K, T and S)	Non-saline (unsuitable for potable water supply)	Gas and Water
Clearwater B Aquifer	Deep	Thick	Sandstone	Laterally Continuous	Good aquifer properties (K, T and S)	Saline (unsuitable for potable water supply)	Gas and Water
Wabiskaw Aquifer	Deep	Limited thickness below Project Area	Glauconitic sandstone	Laterally continuous	Undetermined	Saline (unsuitable for potable water supply)	Water, bitumen and gas saturated
Basal McMurray Aquifer	Deep	Limited thickness to thick	Sand	Limited lateral extent of water saturated interval in LSA	Good aquifer properties (K, T and S)	Saline (unsuitable for potable water supply)	Water

In areas of the LSA where the Empress Terrace and Empress Channel aquifers are present (Figures 5.5-22 and 5.5-23) they are the most feasible aquifers capable of providing potable water to the Project on a long term, sustainable basis. In areas where the Empress Terrace and Empress Channel aquifers are not present, North American will explore for an overburden aquifer of sufficient productivity capable of providing potable water to select camps or CPFs.

Currently, North American has license to divert 102 m^3/d of water for camp supply from a well located in 11-14-78-9 W4M and screened within the Empress Terrace Aquifer (License No. 00238979; Table 5.5-9).

5.6.2.2 Impacts Due to Potable Water Withdrawal

Because overburden aquifers have not been explored within the LSA, this assessment assumed that all potable water would be sourced from either of the Empress Terrace or Channel aquifers. Previous testing in the RSA has demonstrated that these aquifers typically have hydraulic conductivities on the order of 1×10^{-4} m/s and long term safe yield greater than 500 m^3/d per well. Thus, the estimated pumping rate per well (40.5 m^3/d) is much less that the estimated long term safe yield.

The potential impact of potable water withdrawal from one of the Empress Aquifers is a decrease in water levels within adjacent aquifers. Potential impacts to water quality are not expected and, therefore the direction of that impact is considered neutral and the final impact rating is no impact (Table 5.6-3).

Surface Waterbodies

A decrease in head in the Empress Formation aquifers could potentially decrease water levels in surface waterbodies. However, the Empress Formation is separated from surface by 80 m to 230 m of mainly fine-grained deposits. It is anticipated that impacts to surface waterbodies due to pumping the Empress Formation aquifers at 40.5 m^3/d would not be measurable or detectable given seasonal fluctuations in surface water levels.

The direction of impact is negative, the magnitude is negligible, and the prediction confidence is high. The final impact rating of potable water withdrawal on surface waterbodies is no impact.

Overburden Aquifers

A decrease in head in the Empress Formation aquifers could potentially decrease water levels in overburden aquifers. However, the Empress Formation is separated from overburden aquifers by mainly fine-grained deposits of unsubstantiated thickness and there is a very low density of local water users in the Project area.

The direction of impact is negative and the magnitude is negligible. The prediction confidence in this assessment is medium. The final impact rating of potable water withdrawal on overburden aquifers is no impact.

Empress Terrace Aquifer and Empress Channel Aquifer

As a result of using Empress Formation aquifers as a potable water source there will be a negative impact to groundwater quantity in the Empress Formation. As the project is constructed, North American will prepare an application for groundwater diversion under the water act. Each of these applications will include an assessment of aquifer productivity and potential impacts for other groundwater users based on well specific testing results. Under the conditions of North American’s current groundwater license (License No. 00238979; Table 5.5-9), North American will monitor the ability of an Empress Formation aquifer to provide up to 102 m^3/d.

Based on operating experience from other oil sands projects in the region, the predicted demand is much less than the estimated aquifer productivity and the magnitude is negligible and limited to a local scale, the duration is long term, the frequency is continually and the permanence is reversible in the long term. The prediction confidence in this assessment is high. The final impact rating of potable water withdrawal on the Empress Formation is low impact.

Lower Grand Rapids, Clearwater B and Basal McMurray Aquifers

A decrease in head in the Empress Formation aquifers could potentially decrease water levels in deeper aquifers. However, the Empress Formation is separated from deeper aquifers by at least 20 m of Colorado Group aquitard almost everywhere in the LSA except for in the Christina Channel. Even in the Christina Channel the Empress Formation is separated from the Lower Grand Rapids Aquifer by about 40 m of Upper Grand Rapids sands and shales. It is anticipated that impacts to deeper bedrock aquifers due to pumping the Empress Formation aquifers at 40.5 m^3/d would not be measurable or detectable.

The direction of impact is considered neutral and the prediction confidence in this assessment is high. The final impact rating of potable water withdrawal on deeper bedrock aquifers is no impact.

Table 5.6-3 Impact Due to Potable Water Withdrawal

Key Indicator Resource	Attribute	Direction	Extent	Magnitude	Duration	Frequency	Permanence	Prediction Confidence	Final Impact Rating
Surface Waterbodies	Water Levels	negative	n/a	negligible	n/a	n/a	n/a	high	no impact
	Water Quality	neutral	n/a	n/a	n/a	n/a	n/a	high	no impact
Overburden Aquifers	Water Levels	negative	n/a	negligible	n/a	n/a	n/a	medium	no impact
	Water Quality	neutral	n/a	n/a	n/a	n/a	n/a	high	no impact
Empress Terrace Aquifer	Water Levels	negative	local	low	long term	continually	reversible in the long term	high	low impact
	Water Quality	neutral	n/a	n/a	n/a	n/a	n/a	high	no impact
Empress Channel Aquifer	Water Levels	negative	local	low	long term	continually	reversible in the long term	high	low impact
	Water Quality	neutral	n/a	n/a	n/a	n/a	n/a	high	no impact
Lower Grand Rapids Aquifer	Water Levels	neutral	n/a	n/a	n/a	n/a	n/a	high	no impact
	Water Quality	neutral	n/a	n/a	n/a	n/a	n/a	high	no impact
Clearwater A Aquifer	Water Levels	neutral	n/a	n/a	n/a	n/a	n/a	high	no impact
	Water Quality	neutral	n/a	n/a	n/a	n/a	n/a	high	no impact
Clearwater B Aquifer	Water Levels	Neutral	n/a	n/a	n/a	n/a	n/a	high	no impact
	Water Quality	Neutral	n/a	n/a	n/a	n/a	n/a	high	no impact
Basal McMurray Aquifer	Water Levels	Neutral	n/a	n/a	n/a	n/a	n/a	high	no impact
	Water Quality	Neutral	n/a	n/a	n/a	n/a	n/a	high	no impact

5.6.3 Make-up Water Withdrawal and Wastewater Injection

The Project will require make-up water for the purpose of steam generation and will generate wastewater requiring injection. The make-up water withdrawal the wastewater injection rates will change as the Project progresses through development phases. The water demands of the Project and the water supply and disposal strategy of the Project are described in detail in Volume 1, Section 4.4.

5.6.3.1 Candidate Aquifer Selection and Water Use Requirements

The Basal McMurray Aquifer was chosen as the primary groundwater source for make-up water because the Basal McMurray Aquifer was interpreted to have the lowest potential for adverse environmental effects of the candidate aquifers due to the depth and saline nature of the aquifer (Table 5.6-2). Groundwater from the Basal McMurray Aquifer in the LSA is quite saline (>10,000 mg/L TDS) and is unsuitable for potable water supply. The main disadvantage of the Basal McMurray Aquifer as a groundwater source is that it has variable thickness and is not laterally extensive in the LSA. North American proposes a balanced push-pull approach where groundwater withdrawal equals wastewater disposal in the Basal McMurray Aquifer in order to minimize pressure change in the aquifer. The target groundwater withdrawal rates for the McMurray Aquifer for each of the development areas ranges from 950 m^3/d at the Hangingstone and Thornbury development areas to 2,850 m^3/d at the Leismer development areas (Table 5.6-4).

North American also proposes that make-up water be sourced from the Clearwater A and B Aquifers. As discussed in Section 5.5, the salinity of the Clearwater A and B Aquifers is variable throughout the LSA and contains both saline and non-saline groundwater and contains local accumulations of natural gas. The Clearwater A and B Aquifers are also not present throughout the entire LSA. North American proposes to source groundwater from the Clearwater A and B Aquifers where they are present and the target groundwater withdrawal rates for the Clearwater Aquifers for each development area are listed in Table 5.6-4.

North American also proposes that make-up water be sourced from the Lower Grand Rapids Aquifer to supplement water demand. Groundwater from the Lower Grand Rapids Aquifer is non-saline but unsuitable for potable water supply because of moderate TDS concentrations.

The regional nature of the aquifer makes it the only aquifer that is present beneath the entire Project and therefore the only sustainable candidate aquifer for some areas. The target groundwater withdrawal rates for the Lower Grand Rapids Aquifer for each development area are listed in Table 5.6-4.

North American proposes that all wastewater be disposed/injected into the Basal McMurray Aquifer. The Basal McMurray Aquifer was chosen based on depth and groundwater chemistry (>10,000 mg/L TDS). In addition, wastewater injection into the Basal McMurray Aquifer is balanced with the Basal McMurray Aquifer target pumping rates for each development area and will offset pressure reductions due to make-up water withdrawal (Table 5.6-4).

The projected total make-up water demand and wastewater injection rates for the life of the Project are summarized on Figure 5.6-1. The Project make-up water demand increases steadily from 2010 to the end of 2017 as each of the development areas commence operations. The total water demand is fairly constant from 2018 to the end of 2037 and decreases steadily after 2037 as operation at each of the development areas cease. Maximum make-up water withdrawal from the Basal McMurray Aquifer occurs from the end of 2018 to the end of 2029 with make-up water demand decreasing rapidly after the end of 2037. The wastewater disposal requirements for the Basal McMurray Aquifer are equal to that of the make-up water demand. Maximum Clearwater aquifer make-up water demand occurs from 2030 to the end of 2039 with demands decreasing rapidly thereafter. Maximum Lower Grand Rapids Aquifer make-up water demand occurs from 2017 to the end of 2029 with demand decreasing rapidly at the end of 2037.

Table 5.6-4 Kai Kos Dehseh Project Water Demand

			WLS + WAC Process				
Based on 10% RR and 3.0 SOR			**Source**			**Disposal**	
	Size Kbpd	**Start**	**Grand R m^3/d**	**Clearwater m^3/d**	**McMurray m^3/d**	**McMurray m^3/d**	**End**
Leismer Commercial	20	2010	980		950	950	2029
Leismer Expansion	20	2011	980		950	950	2029
Corner	40	2012	1960		1900	1900	2037
Thornbury	40	2013	1960		1900	1900	2038
Corner Expansion	40	2014		1960	1900	1900	2039
Hangingstone	20	2016		980	950	950	2041
Thornbury Expansion	20	2017	980		950	950	2042
Northwest Leismer	20	2018		980	950	950	2043
South Leismer	20	2029		980	950	950	2054
Totals	240		6860	4900	11400	11400	

5.6.3.2 Assessed Make-up Water Withdrawal and Wastewater Injection Schedule

The potential impact to indicator resources as a result of make-up water withdrawal from the Basal McMurray, Clearwater A, Clearwater B and Lower Grand Rapids aquifers is a decrease in water levels. By contrast, wastewater injection into the Basal McMurray Aquifer will increase water levels. In order to facilitate an impact discussion regarding the Project three simulations were run with the numerical groundwater model; a baseline case simulation, an Application Case simulation and a cumulative effects case simulation.

Baseline Case

There are several existing and approved in-situ oil sands projects in the RSA that require a make-up water aquifer(s) and a wastewater disposal aquifer(s). As such, these projects were included in the baseline case simulation. Projects included in the baseline case include:

- Nexen/OPTI Long Lake
- Petro-Canada Meadow Creek
- ConocoPhillips Surmont
- JACOS Hangingstone
- MEG Energy Christina Lake
- PetroBank Whitesands
- Devon Jackfish
- EnCana Christina Lake
- Connacher Great Divide
- Canadian Natural Resources Kirby Pilot

The baseline case does not include the Project and illustrates predicted baseline groundwater levels that incorporate both the current water levels in the various hydrostratigraphic units as well as the effects of future cumulative groundwater pumping and wastewater injection at the projects listed above. The baseline case simulated pumping rates for each of these projects is listed on Table 5.5-10. The simulated baseline case well locations are illustrated in Figures 5.6-5 to 5.6-8. The baseline case simulation commenced in 2010 and finished at the end of 2099. The baseline case simulation conservatively assumed that the pumping rates listed in Table 5.5-10 commenced in 2010 and finished at the end of 2054 (the proposed timeline of the Project). Therefore, the simulation included 45 years of pumping followed by 45 years of simulated water level recovery.

Application Case

An application case was also simulated to predict the incremental change in groundwater levels due to proposed groundwater withdrawal and wastewater injection at the Project compared to the baseline case. The Application Case included the pumping and injections rates simulated in the baseline case plus the proposed groundwater withdrawal and wastewater injection at the Project. The proposed Project well pad locations are listed in Table 5.6-5 and the locations of these well pads are illustrated in Figures 5.6-2 to 5.6-4. Table 5.6-5 also lists the screened interval(s) at each of the proposed well pads and cross references the well pad locations to the simulated pumping schedule summarized in Table 5.6-6. The proposed pumping schedule is consistent with the proposed make-up water supply and wastewater injection schedule described in Section 5.6.3.1 and summarized in Table 5.6-4.

The Application Case simulation commenced in 2010 and finished at the end of 2099 (45 years after the proposed completion of the Project).

Table 5.6-5 Proposed Groundwater Well Location, Completion Aquifer and Pumping Schedule

	Well Pad LSD	Completion Aquifer			
		Lower Grand Rapids	Clearwater A	Clearwater B	Basal McMurray
1	4-1-83-10	---	D	---	---
2	16-6-83-9	---	D	---	---
3	16-5-83-9	---	D	---	---
4	11-17-82-8	---	D	---	K
5	7-9-82-8	---	---	---	J
6	11-31-81-7	---	---	---	K
7	6-30-81-7	---	---	---	J
8	10-29-81-9	B	---	---	---
9	3-28-81-9	B	---	---	---
10	4-27-81-9	B	---	---	---
11	10-16-81-9	B	---	---	---
12	3-4-81-9	B	---	---	---
13	4-3-81-9	B	---	---	---
14	10-7-81-8	B	---	---	---
15	11-9-81-8	B	---	---	---
16	10-6-81-8	B	---	---	---
17	10-5-81-8	B	---	---	---
18	11-4-81-8	B	---	---	---
19	12-33-80-8	B	---	---	---
20	8-17-79-10	---	---	---	G
21	1-8-79-10	A	---	---	F
22	3-6-79-10	A	---	---	---
23	3-5-79-10	---	---	---	G
24	3-4-79-10	---	---	---	F
25	3-3-79-10	---	---	---	G
26	6-2-79-10	A	---	---	---
27	13-33-78-10	A	---	---	F
28	14-20-78-10	A	---	---	F
29	5-23-78-10	A	---	---	G
30	3-16-78-10	A	---	---	G
31	1-14-78-10	A	---	---	F
32	8-4-80-11	C	---	---	N
33	9-5-80-11	C	---	---	O
34	9-6-80-11	C	---	---	N
35	3-12-80-12	C	---	---	---
36	13-11-80-12	C	---	---	M
37	16-9-80-12	C	---	---	L
38	15-16-80-12	---	---	---	L
39	2-8-80-12	C	---	---	L
40	3-18-80-12	C	---	---	M
41	13-23-79-13	C	---	---	M
42	16-19-79-12	C	---	---	L
43	3-26-77-12	---	---	---	P
44	7-28-77-12	---	---	---	Q
45	2-29-77-11	---	---	E	---
46	2-28-77-11	---	---	E	---
47	2-27-77-11	---	---	E	---
48	16-20-77-10	---	---	E	---
49	15-19-77-10	---	---	---	I
50	5-18-77-10	---	---	---	H
51	5-7-77-10	---	---	---	I
52	14-32-76-10	---	---	E	I
53	16-30-76-10	---	---	---	H
54	15-19-76-10	---	---	---	H
55	10-15-76-11	---	---	---	I
56	10-10-76-11	---	---	---	H
57	10-3-76-11	---	---	E	I

Table 5.6-6 Proposed Pumping Schedule

Start Date	Pumping Interval (days)		Pumping Schedule																
			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
			Source	Source	Source	Source	Source	Source	Disposal	Source	Disposal	Source	Disposal	Source	Disposal	Source	Disposal	Source	Disposal
	Start	Stop	(m^3/d)	(m^3/d)	(m^3/d)	(m^3/d)	(m^3/d)	(m^3/d)	(m^3/d)	(m^3/d)	(m^3/d)	(m^3/d)	(m^3/d)	(m^3/d)	(m^3/d)	(m^3/d)	(m^3/d)	(m^3/d)	(m^3/d)
2010	0.0	365.0	122.5	0.0	0.0	0.0	0.0	190.0	-190.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2011	365.0	730.0	245.0	0.0	0.0	0.0	0.0	380.0	-380.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2012	730.0	1096.0	245.0	163.3	0.0	0.0	0.0	422.2	-380.0	422.2	-380.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2013	1096.0	1461.0	245.0	163.3	196.0	0.0	0.0	333.3	-300.0	333.3	-300.0	0.0	0.0	500.0	-666.7	350.0	-700.0	0.0	0.0
2014	1461.0	2191.0	245.0	163.3	196.0	0.0	326.7	477.8	-430.0	477.8	-430.0	300.0	-300.0	500.0	-666.7	350.0	-700.0	0.0	0.0
2016	2191.0	2557.0	245.0	163.3	196.0	245.0	326.7	483.3	-435.0	483.3	-435.0	500.0	-500.0	600.0	-800.0	400.0	-800.0	0.0	0.0
2017	2557.0	2922.0	245.0	163.3	294.0	245.0	326.7	538.9	-485.0	538.9	-485.0	500.0	-500.0	600.0	-800.0	400.0	-800.0	450.0	-450.0
2018	2922.0	7304.0	245.0	163.3	294.0	245.0	490.0	622.2	-560.0	622.2	-560.0	500.0	-500.0	600.0	-800.0	500.0	-1000.0	450.0	-450.0
2029	7304.0	10226.0	0.0	163.3	294.0	245.0	653.3	583.3	-525.0	583.3	-525.0	400.0	-400.0	500.0	-666.7	400.0	-800.0	650.0	-650.0
2037	10226.0	10591.0	0.0	163.3	294.0	245.0	653.3	438.9	-395.0	438.9	-395.0	300.0	-300.0	450.0	-600.0	300.0	-600.0	650.0	-650.0
2038	10591.0	10956.0	0.0	163.3	98.0	245.0	653.3	100.0	-100.0	400.0	-320.0	300.0	-300.0	437.5	-583.3	300.0	-600.0	650.0	-650.0
2039	10956.0	11687.0	0.0	0.0	98.0	245.0	326.7	0.0	0.0	375.0	-300.0	300.0	-300.0	262.5	-350.0	0.0	0.0	650.0	-650.0
2041	11687.0	12052.0	0.0	0.0	98.0	0.0	326.7	0.0	0.0	362.5	-290.0	0.0	0.0	237.5	-316.7	0.0	0.0	450.0	-450.0
2042	12052.0	12417.0	0.0	0.0	0.0	0.0	326.7	0.0	0.0	362.5	-290.0	0.0	0.0	0.0	0.0	0.0	0.0	450.0	-450.0
2043	12417.0	16435.0	0.0	0.0	0.0	0.0	163.3	0.0	0.0	187.5	-150.0	0.0	0.0	0.0	0.0	0.0	0.0	200.0	-200.0
2054	Project End	NA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Cumulative Effects Case

A cumulative effects case simulation was conducted to assess the potential impacts of proposed groundwater withdrawal and wastewater disposal at all existing, approved and proposed in-situ oil sands projects within the RSA. The cumulative effects case included the pumping and injections rates simulated in the application case, plus the proposed groundwater withdrawal and wastewater injection at the following projects:

- Devon Jackfish II
- Nexen/OPTI Long Lake South

Similar to the baseline case and the application case, this simulation commenced in 2010 and finished at the end of 2099. The cumulative effects case simulated pumping rates for each of the above projects is listed on Table 5.5-10. The simulated cumulative effects case well locations are illustrated in Figures 5.7-1 to 5.7-4.

5.6.3.3 Predicted Impacts Due to Make-Up Water Withdrawal and Wastewater Injection With Respect to Water Levels

The following section describes the predicted impact to groundwater levels and groundwater recharge as a result of both baseline case groundwater withdrawals and wastewater injection and Application Case groundwater withdrawals and wastewater injection. The predicted impacts to groundwater levels and groundwater recharge for the cumulative effects case are described in Section 5.7.

To facilitate the discussion of the predicted water levels changes, a series of hypothetical observation wells were included in the simulations. The predicted water level changes at these locations within the Basal McMurray Aquifer, Clearwater Aquifers, and Lower Grand Rapids Aquifer are illustrated in the following sections to describe the predicted timing of water level changes at representative locations within the RSA. The observation wells were located in four of the main development areas of the Project (Leismer, South Leismer, Thornbury and Corner). Since the Clearwater A and B aquifers are spatially restricted, a Clearwater A observation well was placed at the Hangingstone development area and a Clearwater B observation well was placed at the South Leismer development area. Observation wells for the Basal McMurray, Clearwater and Lower Grand Rapids aquifers were also placed at the ConocoPhillips Surmont and EnCana Christina Lake projects.

The simulation results are also represented using a series of maps of simulated drawdown within Basal McMurray Aquifer, Clearwater Aquifers, Lower Grand Rapids Aquifer and Overburden Aquifers. The maps typically illustrate the predicted drawdown at the end of 2037 immediately before the total water demand and wastewater injection requirements of the Project begin to decrease rapidly over time (Table 5.6-4 and Figure 5.6-1). As such, the maximum incremental drawdown in the application Case compared to the baseline case is expected to occur at the end of 2037.

Basal McMurray Aquifer

Baseline Case

Groundwater pumping from the Basal McMurray Aquifer at the ConocoPhillips Surmont Project, is predicted to result in a decrease in water levels within the Basal McMurray Aquifer with a maximum simulated drawdown of approximately 18 m at the ConocoPhillips Surmont observation well in 2058 (approximately four years following the end of the simulated Surmont Project operations in 2054). In contrast, the EnCana Christina Lake, MEG Christina Lake and Devon Jackfish projects, as well as the JACOS Hangingstone and Petro-Canada Meadow Creek projects will inject wastewater into the Basal McMurray Aquifer. As a result of these injection activities, the water levels in the McMurray Aquifer in the vicinity of these projects are expected to rise and the simulated water level increase at the EnCana Observation point is approximately 7 m at the end of simulated project operations (Figure 5.6-9).

Due to operations at the surrounding projects, drawdown is predicted to occur at all four Project observation wells. The simulated drawdown (approximately 10 m) is predicted to occur at the Corner observation well in approximately 2070. The simulated drawdown at Corner is greater than the simulated drawdown at Leismer, South Leismer and Thornbury (less than 4 m) because these observation wells are located a greater distance from the Basal McMurray Aquifer pumping wells at the Surmont Project.

The maximum predicted drawdown at the Project observation wells are predicted to occur in 2070 or later with a greater lag time between the end of pumping and the start of water level recovery for those observation wells located a greater distance from the ConocoPhillips Surmont Project (i.e., simulated water level recovery occurs in approximately 2070 at the Corner observation well and occurs in approximately 2078 at the Leismer observation well). Extrapolating the water level recovery trends observed at the observation wells beyond the simulation period suggests that water levels will continue to recover for several decades beyond 2100.

Maximum drawdown in 2037 is predicted to occur at the ConocoPhillips Surmont Project Basal McMurray Aquifer water supply wells and be on the order of 70 m. Drawdown greater than 40 m is predicted to cover an area of approximately 150 km^2 surrounding the ConocoPhillips Surmont Project Basal McMurray Aquifer water supply wells (Figure 5.6-10). The simulated drawdown in the vicinity of the Surmont Project is offset by the simulated rise in water levels surrounding the injection wells at the EnCana Christina Lake, MEG Christina Lake and Devon Jackfish projects, as well as the JACOS Hangingstone and Petro-Canada Meadow Creek projects. The maximum simulated increase in water levels in 2037 is on the order of 50 m near the Devon Jackfish and EnCana Christina Lake projects (Figure 5.6-10). An increase in hydraulic head greater than 20 m is predicted to cover an area of approximately 100 km^2 surrounding the Devon Jackfish and EnCana Christina Lake projects wastewater injection wells. The simulated water level increases at the JACOS Hangingstone and Petro-Canada Meadow Creek injection wells are significantly greater and on the order of 150 m. At these injection locations, the Basal McMurray Aquifer is interpreted to be either not present or thin and discontinuous. The large simulated increase in water levels at these injection wells is due to the absence of the Basal McMurray Aquifer in the numerical groundwater model in these areas (Figure 5.6-5).

Application Case

The addition of the Project pumping schedule, which includes Basal McMurray Aquifer balanced push-pull to the baseline case, is predicted to result in an incremental decrease in water levels at all of the observation wells (Figure 5.6-9). Within each of the Project development areas, hydraulic head at each of the injection wells is predicted to increase and hydraulic head at each of the pumping wells is predicted to decrease.

Similar to the baseline case, maximum simulated drawdown in the ConocoPhillips Surmont observation occurs in 2058 with water level recovery occurring following 2058 (Figure 5.6-9). The maximum simulated drawdown is approximately 20 m and is 2 m greater than the simulated baseline drawdown (Figure 5.6-9). In other words, operations at the Project result in an increase in drawdown of approximately 10% within the Basal McMurray Aquifer at the ConocoPhillips observation well. The EnCana Christina Lake observation well has a maximum simulated water level increase of approximately 8 m compared to the simulated baseline water level increase of

9.5 m. Hence, the Project is predicted to mitigate the pressure increases in the EnCana Christina Lake, MEG Christina Lake, Devon Jackfish, JACOS Hangingstone and Petro-Canada Meadow Creek project areas.

All four Kai Kos Dehseh observation wells are predicted to have greater simulated drawdown compared to the Baseline case with water level recovery occurring following the cessation of operations at each of the development areas (for example, the simulated water level at the Leismer observation well begin recovery following cessation of operations at the Leismer development area in 2037).

The greatest incremental change from baseline is predicted to be at the Leismer observation well at the end of 2037. At this time, the simulated application drawdown at the Leismer observation well is expected to be approximately 19 m as opposed to 1 m of baseline drawdown.

A spatial representation of application drawdown at the end of 2037 is illustrated on Figure 5.6-11 (RSA scale) and Figure 5.6-12 (LSA scale). At the RSA scale, maximum drawdown at the ConocoPhillips Surmont Project in 2037 is essentially unchanged compared to the baseline case and is approximately 70 m in the vicinity of the ConocoPhillips Surmont Project Basal McMurray water supply wells. As in the Baseline case, the area with more than 40 m of simulated drawdown is still approximately 150 km^2. Likewise near the Devon Jackfish and EnCana Christina Lake projects, at the RSA scale, the maximum simulated increase in head is nearly unchanged compared to the baseline case (Figure 5.6-11).

Within the Project LSA, there are isolated areas of pressure change with localized maximum water level increases at the injection wells and localized maximum drawdown at the pumping wells. The pressure changes are kept isolated because of the North American strategy of Basal McMurray Aquifer balanced push-pull where the injection rate is equal to the pumping rate with individual Basal McMurray Aquifer deposits. The maximum simulated application drawdown at the Project is 40 m to 50 m covering an area of about a quarter of a section (~0.6 km^2) in the Leismer development area. The maximum simulated application negative drawdown at the Project is -40 m to -50 m. The maximum spatial extent of the -20 m head contour is located in the Thornbury development area and is approximately 5 km^2 in size. All four Project observation wells happen to be located in areas of net decrease in hydraulic head (Figure 5.6-12).

Application Impact Assessment

Make-up water withdrawal from the Basal McMurray Aquifer is considered to have a negative effect, subregional in extent, long term in duration, continual in frequency, and reversible in the long term (Table 5.6-6). The magnitude of impact with respect to make-up water withdrawal is low in the vicinity of the Project, but medium to high in the vicinity of the ConocoPhillips Surmont Project because the change in aquifer productivity is greater than 15% and exceeds 30% in some areas (Figure 5.6-13). The medium to high impact exists in the baseline case and the point of control and mitigation is not the Project.

Wastewater injection into the Basal McMurray is considered to have a positive effect, subregional in extent, long term in duration, continual in frequency, reversible in the long term and a prediction confidence of high. The magnitude of wastewater disposal is low impact in the vicinity of the Project, but medium to high impact in the vicinity of the JACOS Hangingstone and Petro-Canada Meadow Creek projects. The medium to high impact exists in the baseline case and the point of control and mitigation is not the Project.

The final impact rating with regard to changes in water levels (increase and decrease) is considered low impact for the following reasons:

- Water Quality of the Basal McMurray Aquifer is not suitable for human or livestock consumption.
- North American's push-pull strategy mitigates pressure change in the aquifer.
- A decrease in aquifer productivity of 15% to 30% is not a concern for SAGD water supply because there would be still be at least 70% of available drawdown remaining in the Basal McMurray Aquifer in the vicinity of the supply wells.

The confidence in the impact rating is medium because of the limited exploration and testing completed to date on the Basal McMurray Aquifer at the Project.

Table 5.6-7 Impact due to Make-Up Water Withdrawal and Wastewater Injection

Key Indicator Resource	Attribute	Direction	Extent	Magnitude	Duration	Frequency	Permanence	Confidence	Final Impact Rating
Surface Waterbodies	Water Quality	neutral	n/a	n/a	n/a	n/a	n/a	high	no impact
Overburden Aquifers	Water Levels	negative	subregional	low	long term	continually	reversible in the long term	high	low impact
	Water Quality	neutral	n/a	n/a	n/a	n/a	n/a	high	no impact
Empress Terrace Aquifer	Water Levels	negative	subregional	low	long term	continually	reversible in the long term	high	low impact
	Water Quality	neutral	n/a	n/a	n/a	n/a	n/a	high	no impact
Empress Channel Aquifer	Water Levels	negative	subregional	low	long term	continually	reversible in the long term	high	low impact
	Water Quality	neutral	n/a	n/a	n/a	n/a	n/a	high	no impact
Lower Grand Rapids Aquifer	Water Levels	negative	subregional	high	long term	continually	reversible in the long term	medium	medium impact
	Water Quality	neutral	n/a	n/a	n/a	n/a	n/a	high	no impact
Clearwater A Aquifer	Water Levels	negative	subregional	high	long term	continually	reversible in the long term	medium	medium impact
	Water Quality	neutral	n/a	n/a	n/a	n/a	n/a	high	no impact
Clearwater B Aquifer	Water Levels	negative	subregional	medium	long term	continually	reversible in the long term	medium	low impact
	Water Quality	neutral	n/a	n/a	n/a	n/a	n/a	high	n/a
Basal McMurray Aquifer	Water Levels	negative/ positive	subregional	low	long term	continually	reversible in the long term	medium	low impact
	Water Quality	negative	subregional	medium	long term	continually	reversible in the long term	high	low impact

Clearwater A and B Aquifers

Figure 5.6-14 illustrates the simulated drawdown (baseline and application) at four hypothetical observation wells in the Clearwater Formation. The maximum Project make-up water demand from the Clearwater A and B aquifers occurs from 2030 to the end of 2039 and decreases substantially thereafter. As such, the maximum incremental drawdown (application minus baseline) is expected to occur at the end of 2039 (Figure 5.6-14). Spatial representations of simulated baseline and application drawdown at the end of 2039 are illustrated on Figures 5.6-15 and 5.6-16, respectively.

Baseline Case

Groundwater pumping from the Clearwater A and B aquifers at MEG Christina Lake and EnCana Christina Lake projects, respectively, is predicted to result in a decrease in water levels in the Clearwater Formation. The EnCana Christina Lake observation well has a maximum simulated baseline drawdown of 72 m following the end of the simulated EnCana and MEG Christina Lake operations in 2054 (Figure 5.6-14). As well, the ConocoPhillips Surmont observation well also predicts a decrease in water levels of about 25 m in 2054. In contrast, the Connacher Great Divide and PetroBank Whitesands projects will inject wastewater into the Clearwater A and B aquifers, respectively. As a result of wastewater injection, the water levels in the Clearwater A and B aquifers in the vicinity of these projects are expected to rise and the simulated water level increase is expected to be on the order of 10 m at the Connacher Great Divide Project (Figure 5.6-15).

Due to operations at the surrounding projects, drawdown is predicted for both Kai Kos Dehseh observation wells. The maximum simulated drawdown (approximately 13 m) is predicted to occur at the Hangingstone observation well at the end of 2054 (Figure 5.6-14). The simulated drawdown at Hangingstone is greater than the simulated drawdown at South Leismer (approximately 7 m) because Hangingstone is in close proximity to several projects withdrawing make-up water from adjacent aquifers. Water levels in all observation wells are predicted to essentially recover by the end of 2100 (Figure 5.6-14).

Maximum simulated baseline drawdown for the Clearwater A Aquifer (at the end of 2039) is predicted to occur at the ConocoPhillips Surmont Project and be on the order of 30 m (Figure 5.6-15). Drawdown greater than 30 m is predicted to cover an area of approximately 25 km^2 near the ConocoPhillips Surmont Project. Maximum simulated baseline drawdown for the Clearwater B Aquifer (at the end of 2039) is predicted occur at the EnCana Christina Lake Project and be on the order of 70 m. Drawdown greater than 50 m is predicted to cover an area of approximately 100 km^2 at the EnCana Christina Lake Project.

Maximum negative drawdown (i.e., groundwater mounding due to wastewater injection) is simulated for the projects that are disposing of wastewater in the Clearwater Formation. The maximum increase in head is predicted to be on the order of 10 m at the Connacher Great Divide Project and cover an area of approximately 25 km^2.

Application Case

The addition of the Project pumping schedule to the baseline case is predicted to result in an incremental decrease in water levels at all of the observation wells (Figure 5.6-14).

Similar to the baseline case, maximum simulated application drawdown in the EnCana Christina Lake observation well occurs at the end of 2054 with water levels recovering quickly thereafter (Figure 5.6-14). The maximum simulated drawdown is approximately 76 m which is 4 m greater than the simulated baseline drawdown. In other words, about 5% of the drawdown at the EnCana Christina Lake observation well is due to the Project. The ConocoPhillips Surmont observation well has a simulated drawdown of approximately 29 m compared to the simulated baseline drawdown of 26 m. In other words, about 10% of the drawdown at the ConocoPhillips Surmont observation well is due to the Project.

Both Kai Kos Dehseh observation wells are predicted to have greater simulated application drawdown compared to the baseline case with water level recovery occurring following the cessation of operations at each development area. The greatest incremental change from baseline is predicted to be at the South Leismer observation well at the end of 2039. At this time, the simulated application drawdown at the South Leismer observation well is expected to be approximately 28 m as opposed to the 5 m baseline drawdown for the same time. In other words, 82% of the drawdown at the South Leismer observation well is from the Project. For comparison purposes, the simulated application drawdown for the Hangingstone observation well is expected to be 26 m and the simulated baseline drawdown for the same time is expected to be 10 m. Approximately 62% of the simulated drawdown at the Hangingstone observation well is attributed to the Project.

A spatial representation of application drawdown at the end of 2039 is illustrated on Figure 5.6-16. The maximum simulated application drawdown at EnCana Christina Lake Project is essentially unchanged compared to the baseline case and is on the order of 70 m in the vicinity of EnCana Christina Lake supply wells. However, the 50 m drawdown contour is approximately 125 km^2 which is about a 25% increase in size from the baseline to application case. Likewise, the maximum drawdown at ConocoPhillips Surmont is essentially unchanged compared to the baseline case and is on the order of 30 m.

At the Connacher Great Divide Project the baseline simulation predicted an increase in water levels on the order of 10 m whereas, the maximum simulated application increase was predicted to be on the order of 5 m. Hence, the Project acts to mitigate pressure increases at the Connacher Great Divide Project.

Within the LSA, the greatest application drawdown is predicted for the South Leismer development area where drawdown in the Clearwater B Aquifer is predicted to be on the order of 40 m. The spatial extent of the 40 m drawdown contour is approximately 25 km^2. Simulated application drawdown in the Clearwater A Aquifer is approximately 20 m in the Hangingstone development area.

Application Impact Assessment

Make-up water withdrawal from the Clearwater A and B aquifers is considered to have a negative effect, subregional in extent, long term in duration, continual in frequency, and reversible in the long term (Table 5.6-6). The magnitude of make-up water withdrawal is medium to high impact in the vicinity of the Project because the change in aquifer productivity is greater than 15% and exceeds 30% in some areas. Medium to high impacts are predicted in the Clearwater A Aquifer in the vicinity of the Hangingstone area (Figure 5.6-17). Medium impacts are predicted for the Clearwater B Aquifer in the vicinity of the South Leismer area (Figure 5.6-18). The medium to high impact exist in both the Clearwater A and B aquifers in the vicinity of ConocoPhillips Surmont and EnCana Christina Lake projects, respectively. The predicted high magnitude impacts at the ConocoPhillips Surmont and EnCana Christina Lake projects exist in the baseline case and therefore the point of control and mitigation is not the Project.

Although other projects in the area are injecting wastewater in the Clearwater Formation, North American is not proposing this option. Therefore, wastewater injection was not assessed.

The final impact rating with regard to a decrease in water is considered medium impact for the Clearwater A Aquifer and low impact for the Clearwater B Aquifer for the following reasons:

- Water Quality of the Clearwater A and B aquifers is not potable.
- Within the project LSA, the areal extent of predicted change in aquifer productivity greater than 30% is limited to the vicinity of the development areas and is reversible.
- A decrease in aquifer productivity of 15% to 30% is not a concern for SAGD water supply because there would be still be at least 70% of available drawdown remaining in the Clearwater A or B aquifers in the vicinity of the supply wells.

The confidence in the impact rating is medium because of the limited exploration and testing completed to date on the Clearwater Aquifers at the Project.

Lower Grand Rapids Aquifer

Figure 5.6-19 illustrates the simulated drawdown (baseline and application) at six hypothetical observation wells in the Lower Grand Rapids Aquifer. The maximum Project make-up water demand from the Lower Grand Rapids Aquifer occurs from 2017 to the end of 2029 but decreases substantially after the end of 2037. As such, the maximum incremental drawdown (application minus baseline) is expected to occur at the end of 2037 (Figure 5.6-19). Spatial representations of simulated baseline and application drawdown at the end of 2037 are illustrated on Figures 5.6-20 and 5.6-21, respectively.

Baseline Case

Groundwater pumping from the Lower Grand Rapids Aquifer at the Connacher Great Divide, Devon Jackfish, Nexen/OPTI Long Lake, ConocoPhillips Surmont and Petro-Canada Meadow Creek projects is predicted to result in a decrease in water levels within the Lower Grand Rapids Aquifer. The ConocoPhillips Surmont observation well has a maximum simulated baseline drawdown of 58 m following the end of the simulated pumping in 2054 (Figure 5.6-19). The EnCana Christina Lake observation well is predicted to have a decrease in water levels of about 24 m in 2054.

Due to operations at surrounding projects, drawdown is predicted to occur at all four Project observation wells. The simulated baseline drawdown (approximately 25 m) is predicted to occur at the Corner observation well at the end of 2054. The simulated baseline drawdown at Corner is greater than the simulated drawdown at Leismer, South Leismer and Thornbury (between 5 m and 10 m) because the Corner observation well is closest to the ConocoPhillips Surmont and Nexen/OPTI Long Lake pumping wells. Water levels at all observation wells are predicted to essentially recover by the end of 2100 (Figure 5.6-19).

The maximum simulated baseline drawdown for the Lower Grand Rapids Aquifer (at the end of 2037) is predicted to occur at the ConocoPhillips Surmont Project and be on the order of 60 m (Figure 5.6-20). Drawdown greater than 50 m is predicted to cover an area of approximately 400 km^2 in the vicinity of Nexen/OPTI Long Lake and ConocoPhillips Surmont projects. The maximum simulated baseline drawdown near the Devon Jackfish Project is predicted to be on the order of 30 m. Drawdown greater than 20 m is predicted to cover an area of approximately 13 km^2.

Application Case

The addition of the Project pumping schedule to the baseline case is predicted to result in an incremental decrease in water levels at all of the observation wells (Figure 5.6-19).

Similar to the baseline case, maximum simulated application drawdown in the ConocoPhillips observation well occurs at the end of 2054 with water levels recovering quickly thereafter (Figure5.6-19). The maximum simulated drawdown is approximately 62 m which is 4 m greater than the simulated baseline drawdown. About 6% of the drawdown at the ConocoPhillips Surmont observation well is attributed to the Project. The EnCana Christina Lake observation well has a simulated drawdown of approximately 17 m compared to the simulated baseline drawdown of 15 m. Thus, about 12% of the drawdown at the EnCana Christina Lake observation well is due to the Project.

All four Kai Kos Dehseh observation wells are predicted to have greater simulated application drawdown compared to the baseline case with water level recovery occurring following the cessation of operations at each development area. The greatest incremental change from baseline is predicted to be at the Thornbury observation well at the end of 2038. At this time, the simulated application drawdown at the Thornbury observation well is expected to be approximately 34 m as opposed to the 6 m baseline drawdown for the same time. For comparison purposes, the simulated application drawdown for the Corner observation well is expected to be 44 m and the simulated baseline drawdown for the same time is expected to be 21 m. In other words, 52% of the drawdown at the Corner observation well is due to the Project.

A spatial representation of application drawdown at the end of 2039 is illustrated on Figure 5.6-21. The maximum simulated application drawdown at the ConocoPhillips Surmont Project is essentially unchanged compared to the baseline case and is on the order of 60 m in the vicinity of ConocoPhillips Surmont supply wells. However, the 50 m drawdown contour is approximately 600 km^2 which is about a 50% increase in size from the baseline to application case. Likewise, the maximum drawdown at the Devon Jackfish Project is essentially unchanged compared to the baseline case and is on the order of 30 m.

Within the LSA, the greatest drawdown is in the Corner development area where drawdown in the Lower Grand Rapids Aquifer is predicted to be on the order of 40 m.

Application Impact Assessment

Make-up water withdrawal from the Lower Grand Rapids Aquifer is considered to have a negative effect, regional in extent, long term in duration, continual in frequency, reversible in the long term and a prediction confidence of high (Table 5.6-6). The magnitude of make-up water withdrawal is medium to high impact in the vicinity of the Project because the change in aquifer productivity is greater than 15% and exceeds 30% in areas (Figure 5.6-22). High impacts exist in the baseline case with greater than 70% change in aquifer productivity in the vicinity of the ConocoPhillips Surmont and Nexen/OPTI Long Lake projects and greater than 30% change in aquifer productivity in the northeast quarter of the LSA. The point of control and mitigation for the predicted high magnitude impacts at the ConocoPhillips Surmont and Nexen/OPTI Long Lake projects and in the northeast quarter of the LSA is not the Project.

The final impact rating with regard to a decrease in water is considered medium impact for the following reasons:

- Water Quality of the Lower Grand Rapids Aquifer is not potable.
- The areal extent of the predicted change in aquifer productivity greater than 30% attributable to the Project is limited to the LSA and is reversible.
- A decrease in aquifer productivity of 30% to 70% is of moderate concern for SAGD water supply because there would be still be at least 30% of available drawdown remaining in the Lower Grand Rapids Aquifer in the vicinity of the supply wells.

Empress Terrace, Empress Channel and Overburden Aquifers

Figure 5.6-23 illustrates the simulated drawdown (baseline and application) at four hypothetical observation wells. One observation well is located in the Empress Terrace Aquifer, one observation well is located in the Empress Channel Aquifer and two observation wells are located at the base of the Undifferentiated Overburden Aquifer/Aquitard. Of the two wells at the base of the Undifferentiated Overburden Aquifer/Aquitard, one was located in the Corner area because of the relatively high simulated drawdown predictions and one was located at the Hamlet of Conklin because of the relatively high number of domestic water wells completed in the Undifferentiated Overburden Aquifer/Aquitard.

Baseline Case

All four observation wells experience some drawdown in the baseline case simulation. However, the greatest simulated baseline drawdown is at the Empress Channel Aquifer observation well. The simulated baseline drawdown in the Empress Channel Aquifer Corner is less than 2 m.

As seen on Figure 5.6-23 the largest drawdown (baseline or otherwise) during the lifespan of the Project occurs at the end of 2054. A spatial representation of baseline drawdown at the end of 2054 is illustrated on Figure 5.6-24.

Maximum simulated baseline drawdown is approximately 10 m at the JACOS Hangingstone Project. Simulated baseline drawdown in the vicinity of the Project is less than 1 m.

Application Case

All four observation wells experience greater simulated drawdown with the inclusion of the Project. The incremental change from baseline at each well is approximately the same value and is predicted to be approximately 0.1 m at the end of 2054. At this time, the simulated application drawdown at the Empress Channel Aquifer observation well is expected to be approximately 2 m as opposed to the 1.9 m baseline drawdown for the same time. In other words, only 5% of the drawdown at the Empress Channel Aquifer observation well is from the Project.

A spatial representation of application drawdown at the end of 2037 is illustrated on Figure 5.6-25. The maximum drawdown is still approximately 10 m at the JACOS Hangingstone Project and the drawdown contours appear to be essentially unchanged. For the Project the greatest drawdown is in the Corner/Hangingstone and South Leismer areas where drawdown is predicted to be approximately 1 m.

Application Impact Assessment

Make-up water withdrawal impact on the Empress Terrace, Empress Channel and Overburden aquifers is considered to have a negative effect, subregional in extent, long term in duration, continual in frequency, reversible in the long term and a prediction confidence of high (Table 5.6-6). The magnitude of make-up water withdrawal is low impact in the vicinity of the Project and for the RSA because the change in aquifer productivity is predicted to be less than 15%.

The final impact rating with regard to a decrease in water is considered low impact because of the relatively small predicted drawdown values.

Surface Waterbodies

The potential impacts to surface waterbodies with respect to water levels were assessed by calculating the change in groundwater flux normal to ground surface and comparing it to the simulated steady state flux. An increase in flux normal to ground surface could potentially decrease water levels in surface waterbodies.

Baseline Case

Figure 5.6-26 illustrates the change in flux normal to ground surface when comparing the baseline case simulation (end 2054) to the simulated steady state flux. The largest change in flux is expected to be approximately 8 mm/y in the vicinity of the Nexen/OPTI Long Lake Project.

Application Case

Figure 5.6-27 illustrates the change in flux normal to ground surface when comparing the application Case simulation (end 2054) to the simulated steady state flux. The largest change in flux is also expected to be approximately 8 mm/y in the vicinity of the Nexen/OPTI Long Lake Project.

The incremental change in flux as a result of the Project is predicted to be approximately 0.5 mm/y, which is believed to be negligible and not measurable (comparing Figures 5.6-26 and 5.6-27).

An assessment of the predicted change to surface waterbodies is included in Volume 3, Section 6.

5.6.3.4 Impacts Due to Wastewater Injection With Respect to Water Quality

The potential impacts related to vertical migration of wastewater injected into the Basal McMurray Aquifer will be mitigated by the presence of naturally occurring aquitards. Wastewater injected into the Basal McMurray Aquifer is predicted not to migrate vertically to the overlying aquifers. Therefore, the direction of impact for Surface Waterbodies, Overburden Aquifers, the Empress Terrace Aquifer, the Empress Channel Aquifer, the Lower Grand Rapids Aquifer, the Clearwater A Aquifer and the Clearwater B Aquifer is considered neutral (Table 5.6-6).

However, changes to the Basal McMurray Aquifer water quality are expected as a result of wastewater injection and subsequent migration. As seen on Figure 5.5-29, Basal McMurray groundwater flow for most of the Project is to the west-southwest. It is anticipated that most injected wastewater will travel to the southwest and drain down into the Grosmont Aquifer. Groundwater flow in the Grosmont Aquifer is to the north towards the formation outcrop along the Peace River. The travel distance from the Project to the Peace River is over 300 km. In the northern portion of the Project there is potential for Basal McMurray Aquifer groundwater flow to be directed to the northeast. In which case, the closest surface waterbody receptor is the Clearwater River. The Clearwater River is located more than 70 km north of the closest proposed Kai Kos Dehseh injection wells.

The wastewater travel time between the proposed northern Kai Kos Dehseh injection wells and the Clearwater River was estimated to range from 3,100 years to 16,000 years. At the predicted discharge point, the maximum simulated concentration of the wastewater plume was between 0.6% and 3.4% of the initial concentration. Considering the relatively large flow rate of the Clearwater River, it is interpreted that this discharge would result in a non-detectable change in surface water quality.

Within the LSA, the McMurray Formation contains water with TDS concentrations of approximately 10,000 mg/L. Due to the TDS concentrations, the water within the Basal McMurray Aquifer is not suitable for domestic use, livestock watering, irrigation or most industrial demands. The final impact rating is considered low impact because the baseline Basal McMurray Aquifer quality can be considered poor and there are no non-industrial users of the Basal McMurray Aquifer. The level of confidence of this assessment is considered high.

5.6.4 Production and Steaming

The SAGD process involves injecting steam into the bitumen reservoir to improve the mobility of the bitumen. The steam is produced at surface and injected into the bitumen reservoir through steel well casings drilled to depth and extended horizontally from the surface location. The mobilized bitumen is extracted through a second horizontal well placed below the steam injection well and connected to surface through a second steel production casing.

Processes using extreme pressures and repeated stages of on and off pressures may cause well and production casings to fatigue and fail. These conditions do not occur as part of the SAGD process used by North American. Therefore, there is decreased risk of casing failure between the ground surface and the bitumen reservoir. The water quality of potable water aquifers is therefore at minimal risk due to casing failure.

Increased pressures in the reservoir due to steam injection are offset by decreased pressures that result from bitumen production. As a result, there is very little net change in hydraulic head within the reservoir. As a consequence, with the exception of the immediate area of the horizontal well pairs, it is predicted that there will be no measurable change in water levels and the direction of impact is considered neutral (Table 5.6-7).

Table 5.6-8 Impact Due to Production and Steaming

Key Indicator Resource	Attribute	Direction	Extent	Magnitude	Duration	Frequency	Permanence	Prediction Confidence	Final Impact Rating
Surface Waterbodies	Water Levels	neutral	n/a	n/a	n/a	n/a	n/a	high	no impact
	Water Quality	neutral	n/a	n/a	n/a	n/a	n/a	high	no impact
Overburden Aquifers	Water Levels	neutral	n/a	n/a	n/a	n/a	n/a	high	no impact
	Water Quality	negative	subregional	low	long term	continually	reversible in the medium term	moderate	low impact
Empress Terrace Aquifer	Water Levels	neutral	n/a	n/a	n/a	n/a	n/a	high	no impact
	Water Quality	negative	subregional	low	long term	continually	reversible in the medium term	moderate	low impact
Empress Channel Aquifer	Water Levels	neutral	n/a	n/a	n/a	n/a	n/a	high	no impact
	Water Quality	negative	subregional	low	long term	continually	reversible in the medium term	moderate	low impact
Lower Grand Rapids Aquifer	Water Levels	neutral	n/a	n/a	n/a	n/a	n/a	high	no impact
	Water Quality	neutral	n/a	n/a	n/a	n/a	n/a	high	no impact
Clearwater A Aquifer	Water Levels	neutral	n/a	n/a	n/a	n/a	n/a	high	no impact
	Water Quality	neutral	n/a	n/a	n/a	n/a	n/a	high	no impact
Clearwater B Aquifer	Water Levels	neutral	n/a	n/a	n/a	n/a	n/a	high	no impact
	Water Quality	neutral	n/a	n/a	n/a	n/a	n/a	high	no impact
Basal McMurray Aquifer	Water Levels	neutral	n/a	n/a	n/a	n/a	n/a	high	no impact
	Water Quality	neutral	n/a	n/a	n/a	n/a	n/a	high	no impact

Project operations may affect the thermal regime of groundwater aquifers because the steam will be injected at temperatures far greater than those in the ambient groundwater. High temperature steam in the well bore may result in the development of a heat plume in the vicinity of the SAGD well bores. Under baseline conditions minerals in the groundwater and minerals in the sediments are considered to be in thermodynamic equilibrium. As temperature in the subsurface increases, mineral solubilities may change and a new thermodynamic equilibrium will be achieved. For some minerals, the solubility will increase resulting in increased concentrations in the pore water of the aquifers and aquitards. Once temperature conditions return to baseline conditions, the baseline thermodynamic equilibrium should re-establish.

Arsenic occurs naturally in Alberta soils, bedrock and groundwater (Muloin and Dudas, 2005) and is an example of a mineral whose solubility increases with increased temperature. The following impact assessment assesses the extent and potential magnitude of temperature change in the vicinity of the well bore to infer the potential change in pore water concentration of minerals such as arsenic.

5.6.4.1 Impacts Due to Production and Steaming

Potential impacts exist primarily to those aquifers that are considered potable. In potable aquifers, relatively small ion concentration changes have the potential to affect domestic and non-industrial water users as compared to industrial users. Within the LSA, potential and existing non-industrial and domestic wells are completed in Overburden Aquifers, the Empress Terrace Aquifer and the Empress Channel Aquifer. For that reason, the potential impacts to Overburden Aquifers, the Empress Terrace Aquifer and the Empress Channel Aquifer are only considered. The direction of impact for the Lower Grand Rapids, Clearwater A, Clearwater B and the Basal McMurray aquifers is considered neutral, with a high prediction confidence and a final impact rating of no impact because the groundwater within these formations are considered to be non-potable.

As presented in Figure 5.6-28, the thermal plume is predicted to extend 25 m from the well bore in the Undifferentiated Overburden Aquifer/Aquitard, 125 m in the Empress Terrace Aquifer and 175 m in the Empress Channel Aquifer as a result of eight years of steam injection. The variation in extent of the thermal plume between the different formations is largely the result of contrasting rates of forced convection which is a function of the groundwater flow velocity for that specific formation.

Thermal plume impacts on Overburden, Empress Terrace and Channel aquifers are considered negative in direction, subregional in extent, high in magnitude (>10% change in temperature) within a very localized area and low in magnitude beyond the immediate vicinity of the well pads, long term in duration, continual in frequency, reversible in the short term and the prediction confidence is medium.

The final impact rating is considered low impact because there are only three wells (all completed in the Undifferentiated Overburden Aquifer/Aquitard) located near Project well pads. The closest water well to a SAGD well pad is much greater than 25 m away. In addition, once steaming ceases, the temperature and mineral concentrations are predicted to return to near baseline conditions.

5.7 Cumulative Effects

5.7.1 Basal McMurray Aquifer

The simulated cumulative drawdown for the Basal McMurray Aquifer at the end of 2037 is presented on Figure 5.7-5. The simulated distribution of drawdown is similar to the application case with the primary difference being additional drawdown in the vicinity of the Nexen/OPTI Long Lake Project. As in the application case, the maximum drawdown is predicted for the

ConocoPhillips Surmont Project area where greater than 90 m of drawdown is simulated. It is interpreted that simulated drawdown in the Surmont area is primarily the result of proposed operations at the ConocoPhillips Surmont and Nexen/OPTI Long Lake projects and the point of control and mitigation for the predicted drawdown is not the Project.

5.7.2 Clearwater A and B Aquifers

The simulated cumulative drawdown for the Clearwater A and B aquifers at the end 2039 is similar to the Application case as there is no change in incremental groundwater pumping from the Clearwater Formation between the two cases (Figure 5.7-6). The maximum drawdown is predicted in the vicinity of the EnCana Christina Lake Project area where greater than 80 m of drawdown is simulated. The point of control and mitigation for the predicted drawdown in the vicinity of the EnCana Christina Lake Project is not the Project.

5.7.3 Lower Grand Rapids Aquifer

Compared to the application case the cumulative effects case included additional groundwater withdrawal from the Lower Grand Rapids aquifer at the Devon Jackfish II Project. As expected, the predicted drawdown for the cumulative effects case is similar to the application case with slightly larger drawdown in the vicinity of the Devon Jackfish II Project area in 2037 (Figure 5.7-7). The maximum drawdown is predicted to occur within the ConocoPhillips Surmont Project area where greater than 70 m of drawdown is simulated. As in the application case, the point of control and mitigation is not the Project.

5.7.4 Empress Terrace, Empress Channel and Overburden Aquifers

As in the application case, cumulative drawdown for the Empress Terrace, Empress Channel and Overburden Aquifers at the end 2054 is predicted to be greater than 1 m in the vicinity of the JACOS Hangingstone, ConocoPhillips Surmont and Nexen/OPTI Long Lake project areas (Figure 5.7-8). The maximum predicted drawdown is on the order of 10 m. As in the application case, the point of control and mitigation is not the Project.

5.7.5 Surface Waterbodies

The simulated change in flux normal to the ground surface at the end 2054 is presented on Figure 5.7-9. The maximum change in flux is predicted for the Nexen/OPTI Long Lake Project area where 9 mm/y of induced flux is simulated. The hydrology cumulative effects are described in Volume 3, Section 6.

5.8 Follow-up and Monitoring

In Section 5.6, the potential hydrogeologic impacts were described with respect to the following project operations:

- Surface facilities;
- Groundwater withdrawal, including potable and make-up water;
- Wastewater injection; and
- Production and steaming.

Section 5.8 describes existing and proposed groundwater monitoring plans for each of the operation components.

5.8.1 Surface Facilities

A network of groundwater monitoring wells will be installed at each Project CPF unit and select well pads to establish baseline data for groundwater levels, flow conditions and groundwater quality. Data from the groundwater monitoring program will provide information on:

- Geologic and hydrogeologic properties of the shallow Quaternary sediments;
- Pre-development groundwater levels and groundwater chemistry; and
- Potential changes to groundwater quality related to the Project.

Groundwater monitoring well networks, for each individual CPF and select well pads, will focus on the shallowest groundwater-bearing zone and therefore target the most vulnerable hydrostratigraphic unit with respect to potential impacts associated with CPF operations. Monitoring wells will be installed on-site and adjacent to areas exposed to potential sources of accidental releases. At least one on-site monitoring well location will consist of a nested pair with one well completed at the water table and a second monitoring well completed at a depth of approximately 10 m below ground surface. The deeper well of the nest will provide a measure of the direction and magnitude of the vertical hydraulic gradient and monitor groundwater quality below the water table aquifer. At least one monitoring well will be located hydraulically upgradient of the site to serve as a background (control) well.

Groundwater samples will be collected from each monitoring well on a regular basis and analyzed for field parameters, including temperature, pH, electrical conductivity (EC), dissolved oxygen (DO) and oxidation-reduction potential (ORP). Laboratory analyses may include the indicator parameters, which are based on potential impact to groundwater quality associated with heavy oil facilities listed on Table 5.8-1.

Table 5.8-1 Analytical Parameters That May be Used in the Groundwater Monitoring Program

Source of Impact	Routine[1]	Dissolved Metals[2]	DOC	BTEX, F1 and F2[3]	NO_2-NO_3 and NH_4	Phenols
Bitumen			X	X		X
Diluent			X	X		
Produced Water	X	X	X	X		
Sewage Lagoons					X	
Process Chemicals	X		X			

1 Routine water includes EC, pH, total dissolved solids, sodium, potassium, calcium, magnesium, manganese, iron, hydroxide, chloride, carbonate, bicarbonate, sulphate, hardness and alkalinity.

2 Metals includes aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, iron, lead, lithium, manganese, molybdenum, nickel, phosphorus, selenium, silicon, strontium, sulphur, thallium, tin, titanium, uranium, vanadium, zinc and zirconium.

3 BTEX includes benzene, toluene, ethylbenzene and xylenes, F1 includes hydrocarbon fractions C_5-C_{10} and F2 includes hydrocarbon fractions C_{10}-C_{16}.

In the event that significant changes in groundwater quality are detected, an incident-specific groundwater response plan will be developed and implemented (Section 5.8.6).

5.8.2 Potable Water Withdrawal

North American will responsibly manage Project potable water usage by operating all potable wells as per the conditions of the groundwater diversion license (*Water Act*). This includes monitoring actual water usage from the candidate aquifer.

5.8.3 Make-Up Water Withdrawal

North American will participate in the Southern Athabasca Oil Sands Group groundwater modelling initiative. In addition, North American will responsibly manage the Project makeup water usage by:

- Monitoring actual water usage from the Basal McMurray, Lower Grand Rapids, Clearwater A and Clearwater B aquifers;
- Monitoring select aquifers in the vicinity of select groundwater source wells; and
- Conducting annual reviews and interpretations of water level and water usage data including a comparison of actual changes in water level compared to the predictions. If necessary, the annual review will include recommendations to further mitigate impacts and/or improve monitoring.

5.8.4 Wastewater Injection

Disposal wells will be drilled, completed and tested following all requirements outlined in EUB Directive 51: Injection and Disposal Wells. Each disposal well will be equipped with a surface-installed turbine meter, flow choke and a pressure recorder. The wellhead injection pressure and injection rate for each well will be monitored on a daily basis.

5.8.5 Production and Steaming

A groundwater monitoring program will be initiated at a representative Project well pad in order to monitor possible impacts to groundwater quality as a result of thermal plumes. The monitoring program will document pre-development conditions and monitor changes in temperature with distance.

The monitoring program will include water levels, temperature, and analysis of major ions and dissolved metals, including arsenic. In the event that significant changes in groundwater quality are detected, a groundwater response plan will be implemented (Section 5.8.6).

5.8.6 Groundwater Response Plan

In the event that major changes in groundwater quality are detected as a result of Project operations, an incident-specific response plan will be developed and implemented. Aspects of the plan include:

- Conducting confirmatory sampling;
- Notifying AENV on confirmation of impact; and

- Identifying the source(s) of impact.

Once the source(s) of impact have been identified, a remediation plan and a site specific risk management strategy based on the nature and concentration of contaminants and potential receptors in the area will be developed. The remediation plan and/or risk management strategy will be submitted to AENV for approval and the remediation plan and risk management strategy will be implemented.

5.9 Summary

The potential impacts of the Project on groundwater were assessed with respect to water levels and water quality for the following: Surface Waterbodies, Undifferentiated Overburden Aquifer/Aquitard, Empress Terrace Aquifer, Empress Channel Aquifer, Lower Grand Rapids Aquifer, Clearwater A Aquifer, Clearwater B Aquifer and Basal McMurray Aquifer.

Through the lifespan of the Project, components which have the potential to affect indicator resources include:

- Operation of surface facilities;
- Potable water withdrawal;
- Make-up water withdrawal;
- Wastewater injection; and
- Production and steaming.

Of the above components, the operation of surface facilities, potable water withdrawal, wastewater injection and production and steaming were given a final impact rating of no impact or low impact.

In order to assess the impacts of the Project's make-up water demand, three groundwater simulations were completed using the numerical groundwater model. One simulation called the baseline case simulation implemented the pumping schedules from all existing and approved SAGD projects in the region. The second simulation called the application case simulation combined the baseline case simulation with the pumping schedule for the Project. The third simulation, called the cumulative effects case simulation, combined the application case with the planned projects in the RSA.

The baseline case simulation predicted high magnitude impacts to the Basal McMurray, Clearwater A, Clearwater B and Lower Grand Rapids aquifers in localized areas centred at existing and/or approved SAGD projects in the region. Within these localized areas, the predicted change in aquifer productivity is greater than 30% suggesting that competition for groundwater with future groundwater users is possible. Because these impacts are predicted to occur without the Project operations, the point of control and mitigation for these impacts do not lie with the Project.

Project groundwater withdrawal and wastewater injection add incremental changes to aquifer productivity compared to baseline and within the LSA, the magnitude of the change in aquifer productivity is high within the Lower Grand Rapids and Clearwater A aquifers, medium within the Clearwater B aquifer and low within the Basal McMurray Aquifer. Within areas of the LSA, it is predicted that competition for groundwater with future users of the Lower Grand Rapids and Clearwater A aquifers is possible. However, because groundwater in the Lower Grand Rapids and Clearwater A aquifers is not potable, the impacts are reversible and additional groundwater production will be possible from these aquifers for other future users, the final impact rating for change in aquifer productivity for these aquifers is medium. The final impact rating for change in aquifer productivity for the Clearwater B and Basal McMurray aquifers is low. The confidence in the final impact rating for change in aquifer productivity is medium because of the limited hydrogeologic testing of these formations that has occurred at the Project to date.

The baseline case simulation and application case predicted very similar results regarding change in flux at surface suggesting the Project has a relatively small incremental impact on surface waterbodies. Therefore, the point of control and mitigation of this impact does not lie with the Project.

Overburden and bedrock groundwater monitoring will be required during the operation phase of the Project to confirm that changes in hydraulic head, temperature and/or water quality are consistent with results of the impact assessment and evaluate the environmental performance of operations and engineered structures.

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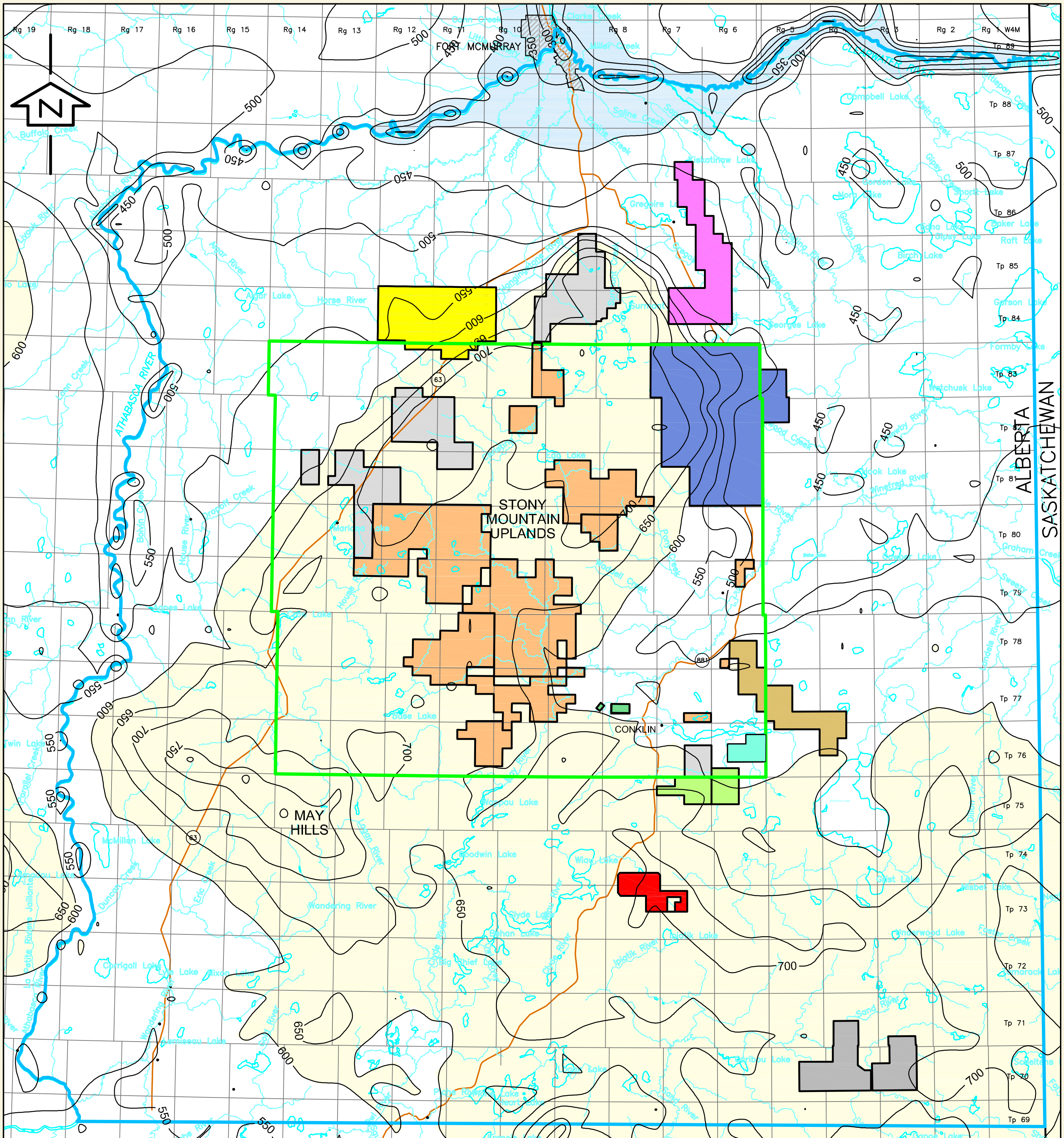

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LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- LOCAL STUDY AREA (LSA)
- REGIONAL STUDY AREA (RSA)
- GROUND ELEVATION CONTOUR (masl)
- ELEVATION <400 (masl)
- ELEVATION >600 (masl)

REFERENCE

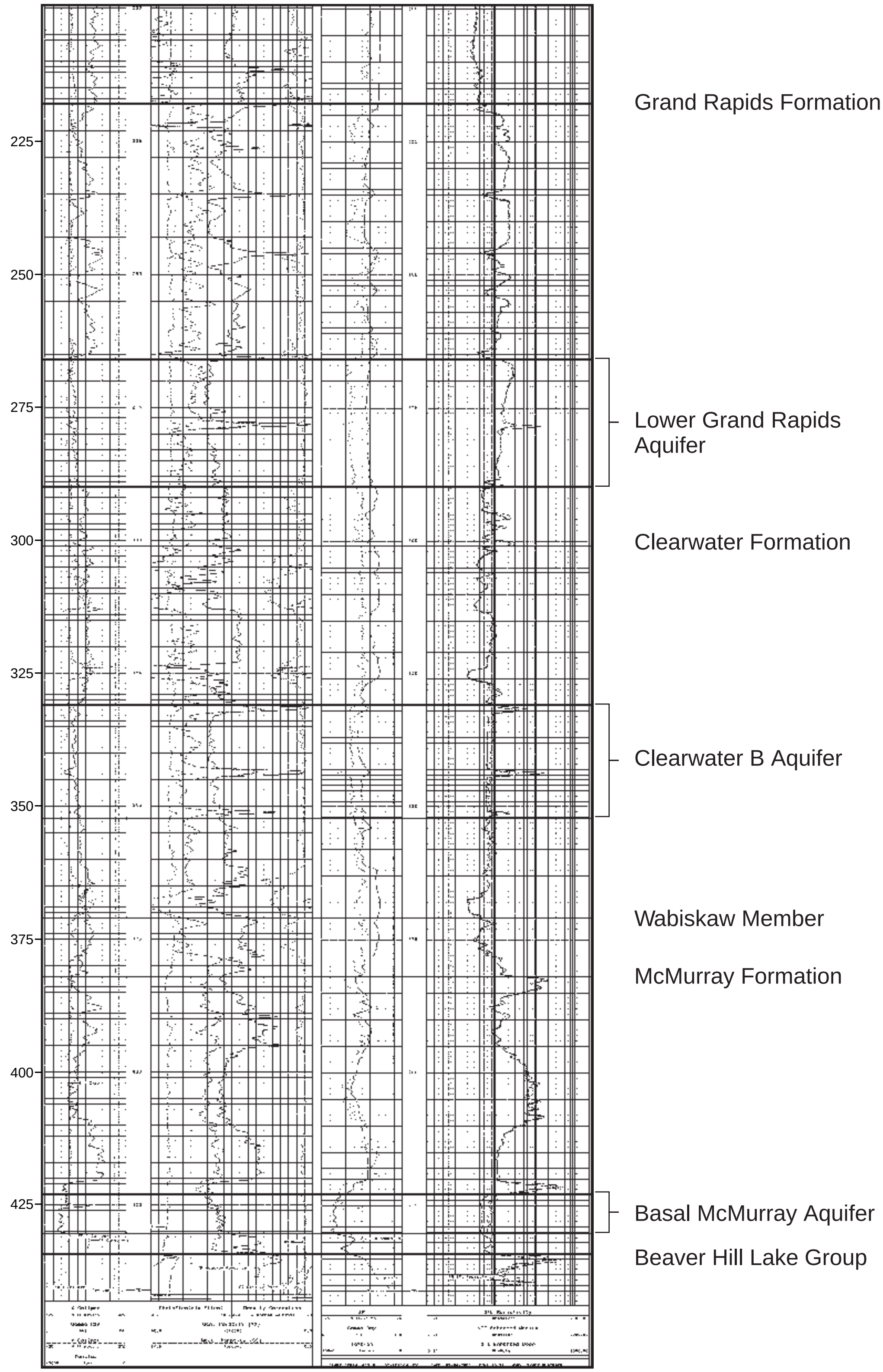
ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

REGIONAL AND LOCAL STUDY AREA LOCATION MAP

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/03/28	
File: 4455-STR-ISO-07.DWG		
Drawn by: GDE	Checked: BW	Fig. No.: **5.2-1**



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TYPE LOG
MANNVILLE GROUP
1AA/03-15-078-10 W4/100

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/05/22
File: 4455-Strat-07.cdr	

Drawn by:	Checked:	Fig. No.:
GDE	BW	**5.4-1**

ERA	PERIOD	EPOCH	GROUP	FORMATION
CENOZOIC	QUATERNARY			GRAND CENTRE
				SAND RIVER
				MARIE CREEK
				ETHEL LAKE
				BONNYVILLE
				MURIEL LAKE
				BRONSON LAKE
				EMPRESS UNIT 3 / TERRACE SAND
				EMPRESS UNIT 2
	TERTIARY			EMPRESS UNIT 1
MESOZOIC	CRETACEOUS	U	BELLY RIVER	WAPITI
			WAPIABI	LEA PARK
			COLORADO	LaBICHE: 1st WHITE SPECKLED SHALE; 2nd WHITE SPECKLED SHALE; BASE OF FISH SCALES
		L		VIKING
				JOLI FOU
			MANNVILLE	GRAND RAPIDS 'A'
				GRAND RAPIDS 'B'
				GRAND RAPIDS 'C'
				CLEARWATER SHALE
				CLEARWATER 'A'
				CLEARWATER 'B'
				CLEARWATER 'C'
				WABISKAW MEMBER
				McMURRAY
PALEOZOIC	DEVONIAN	U	WINTERBURN	
			WOODBEND	GROSMONT
				IRETON / LEDUC
				COOKING LAKE
			BEAVERHILL LAKE	WATER WAYS
				FORT VERMILION
		M	ELK POINT	WATT MOUNTAIN
				MUSKEG
				PRAIRIE EVAPORATE
				KEG RIVER / WINNIPEGOSIS
				CONTACT RAPIDS
		L		COLD LAKE
				ERNESTINA
				LOTSBERG
PRECAMBRIAN				

Title:

STRATIGRAPHIC COLUMN

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP

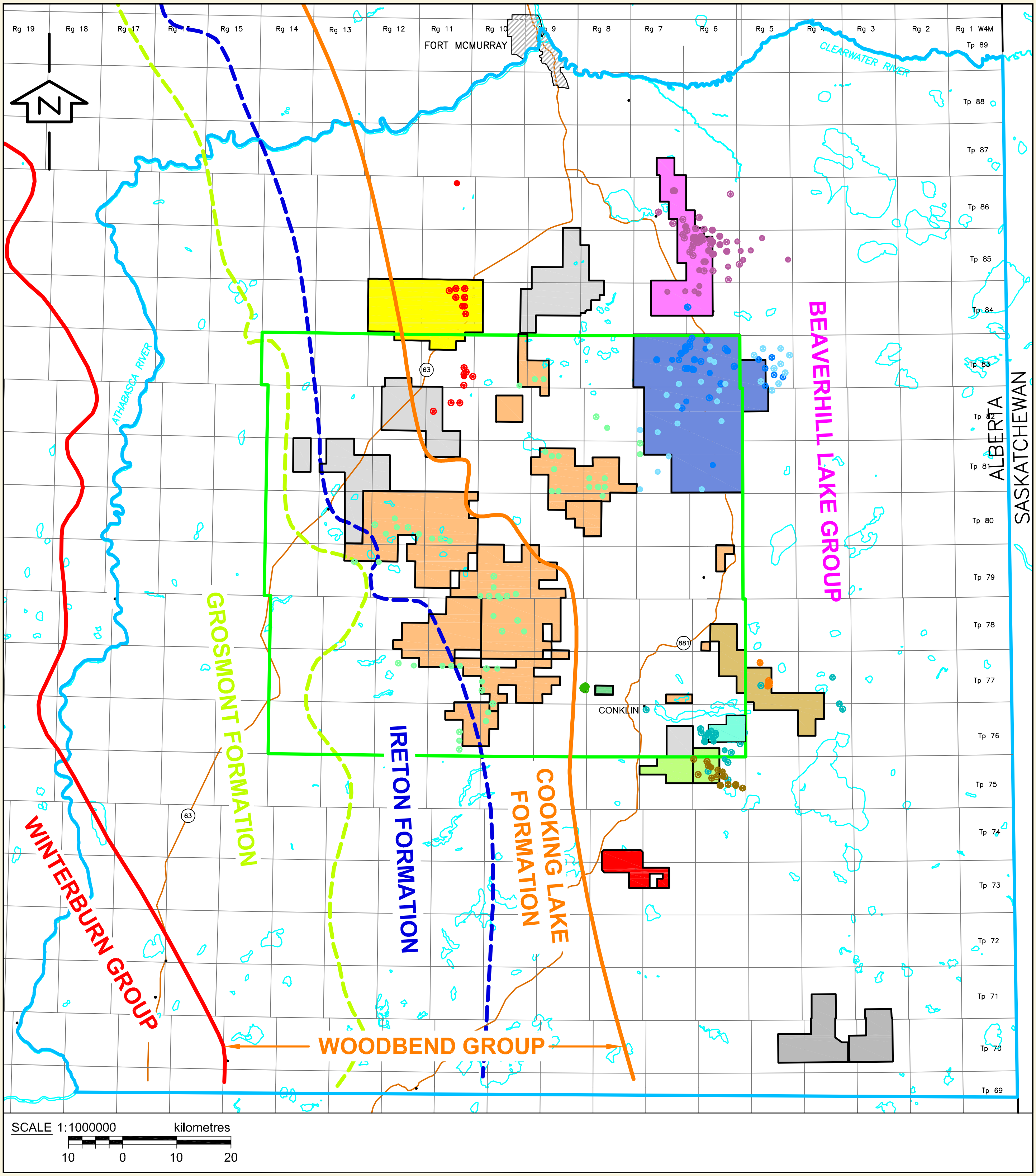
Revision Date: 07/05/22

File: 4455-Strat-07.cdr

Drawn by: GDE

Checked: BW

Fig. No.: **5.5-1**



LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- LOCAL STUDY AREA (LSA)
- REGIONAL STUDY AREA (RSA)
- IRETON FORMATION ZERO EDGE
- GROSMONT FORMATION ZERO EDGE
- WINTERBURN FORMATION ZERO EDGE
- WOODBEND GROUP ZERO EDGE

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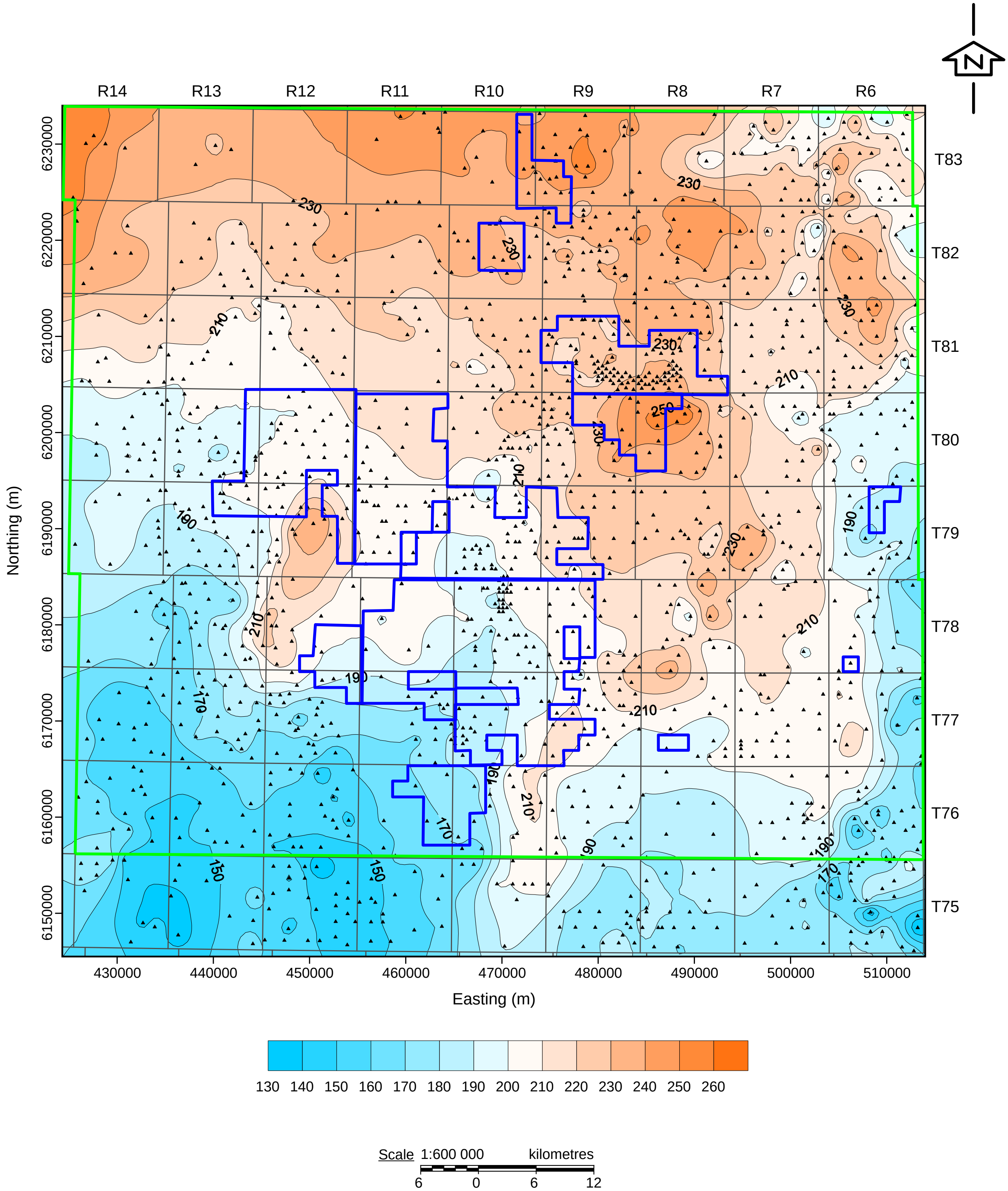
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

DEVONIAN SUBCROP MAP

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/03/28	
File: 4455-STR-ISO-07.DWG		
Drawn by: GDE	Checked: BW	Fig. No.: **5.5-2**



LEGEND
- KAI KOS DEHSEH PROJECT
- LOCAL STUDY AREA (LSA)

REFERENCE: Regional Aquifer and Geology Mapping Study of the Mannville Group, Ranges 6 to 14, Townships 75 to 83, W4. April 2007, prepared by Westwater Environmental Ltd.

Title:

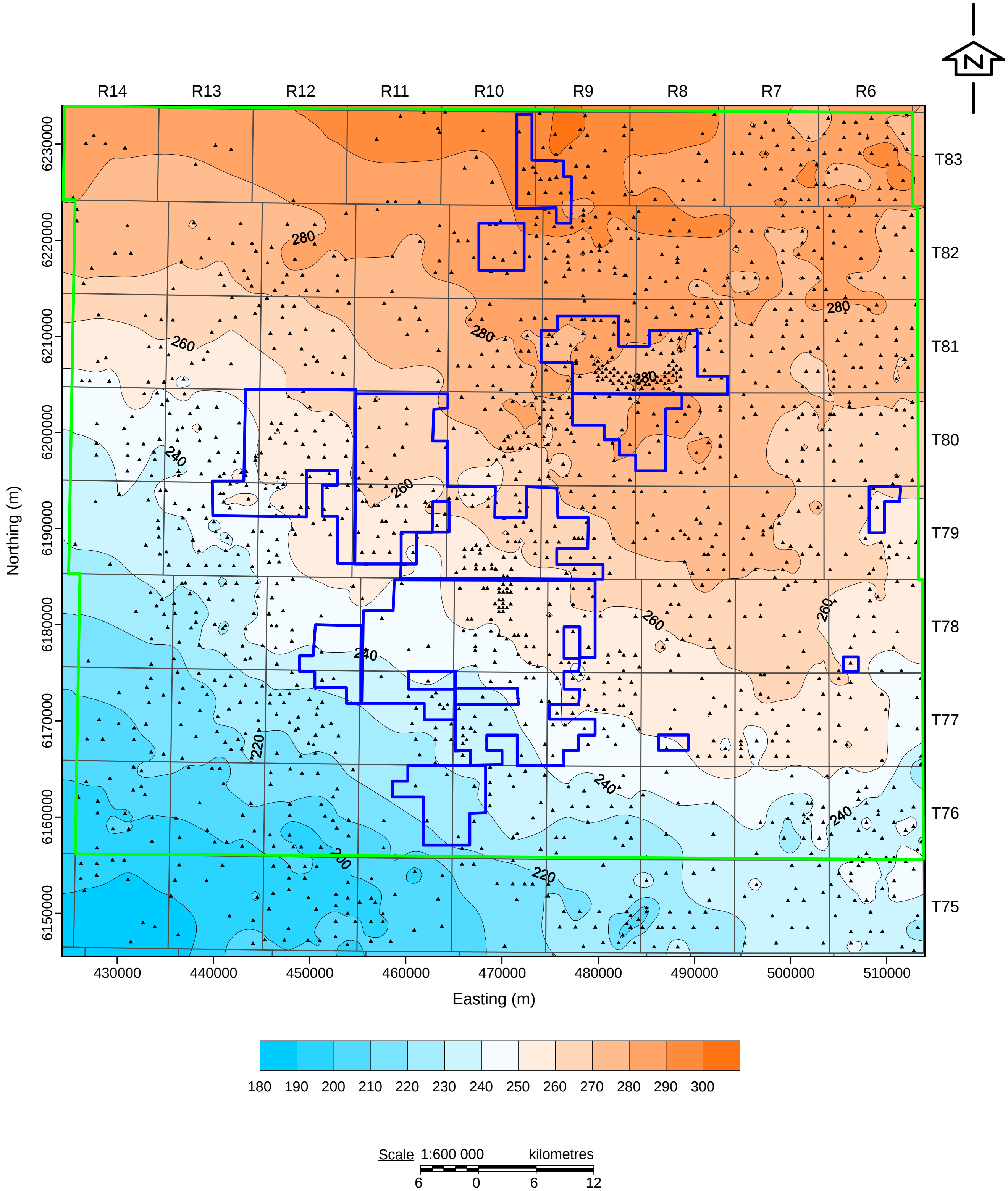
SUB-CRETACEOUS UNCONFORMITY SURFACE

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:
EG	07/05/22

File: 4455-Struct-07.cdr

Drawn by:	Checked:	Fig. No.:
AP	EG	**5.5-3**



LEGEND

- KAI KOS DEHSEH PROJECT
- LOCAL STUDY AREA (LSA)

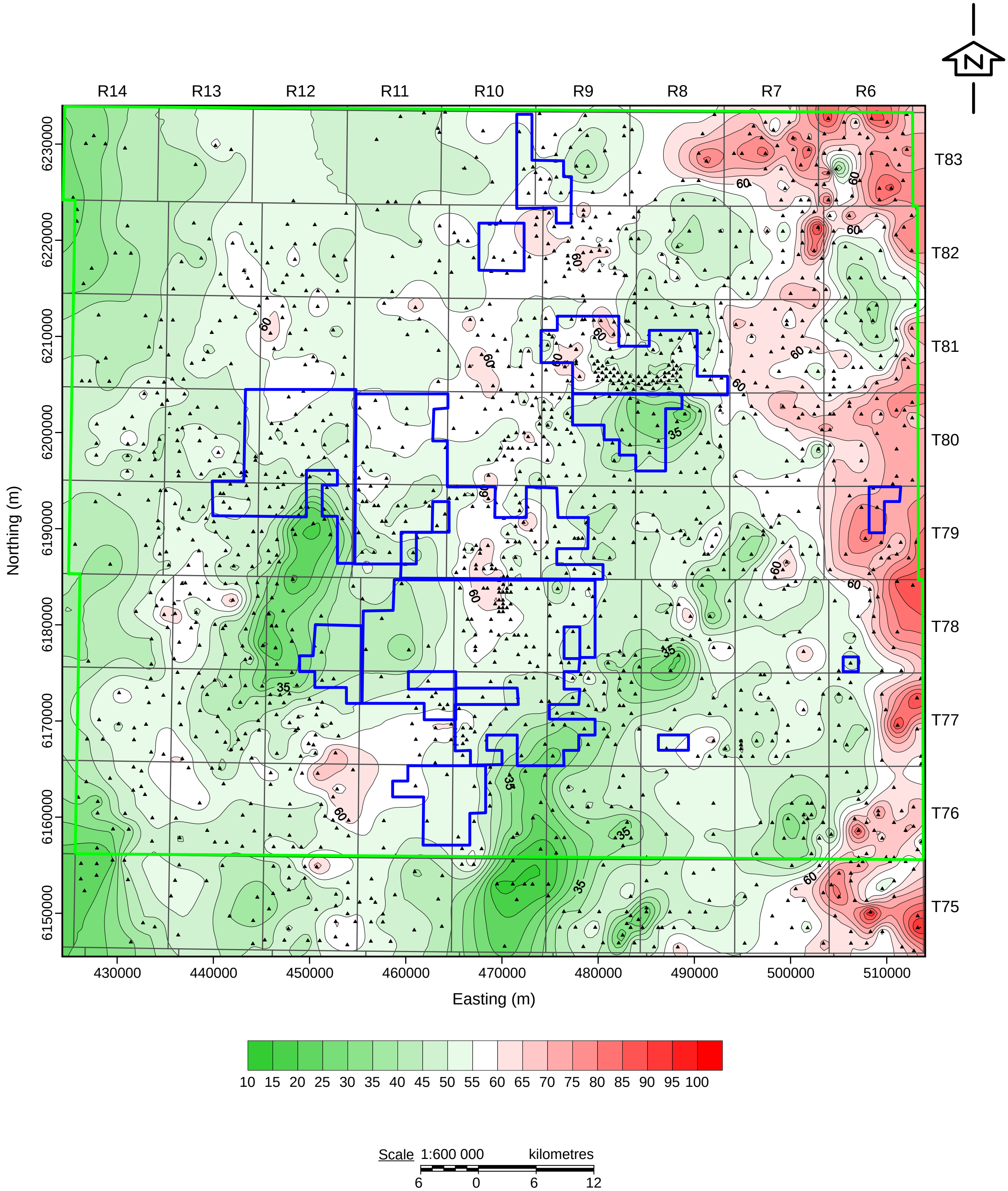
REFERENCE: Regional Aquifer and Geology Mapping Study of the Mannville Group, Ranges 6 to 14, Townships 75 to 83, W4. April 2007, prepared by Westwater Environmental Ltd.

Title:

McMURRAY FORMATION STRUCTURE TOP

NORTH AMERICAN OIL SANDS CORPORATION

Approved: EG	Revision Date: 07/05/22	
File: 4455-Struct-07.cdr		
Drawn by: AP	Checked: EG	Fig. No.: **5.5-4**



LEGEND

KAI KOS DEHSEH PROJECT

LOCAL STUDY AREA (LSA)

REFERENCE: Regional Aquifer and Geology Mapping Study of the Mannville Group, Ranges 6 to 14, Townships 75 to 83, W4. April 2007, prepared by Westwater Environmental Ltd.

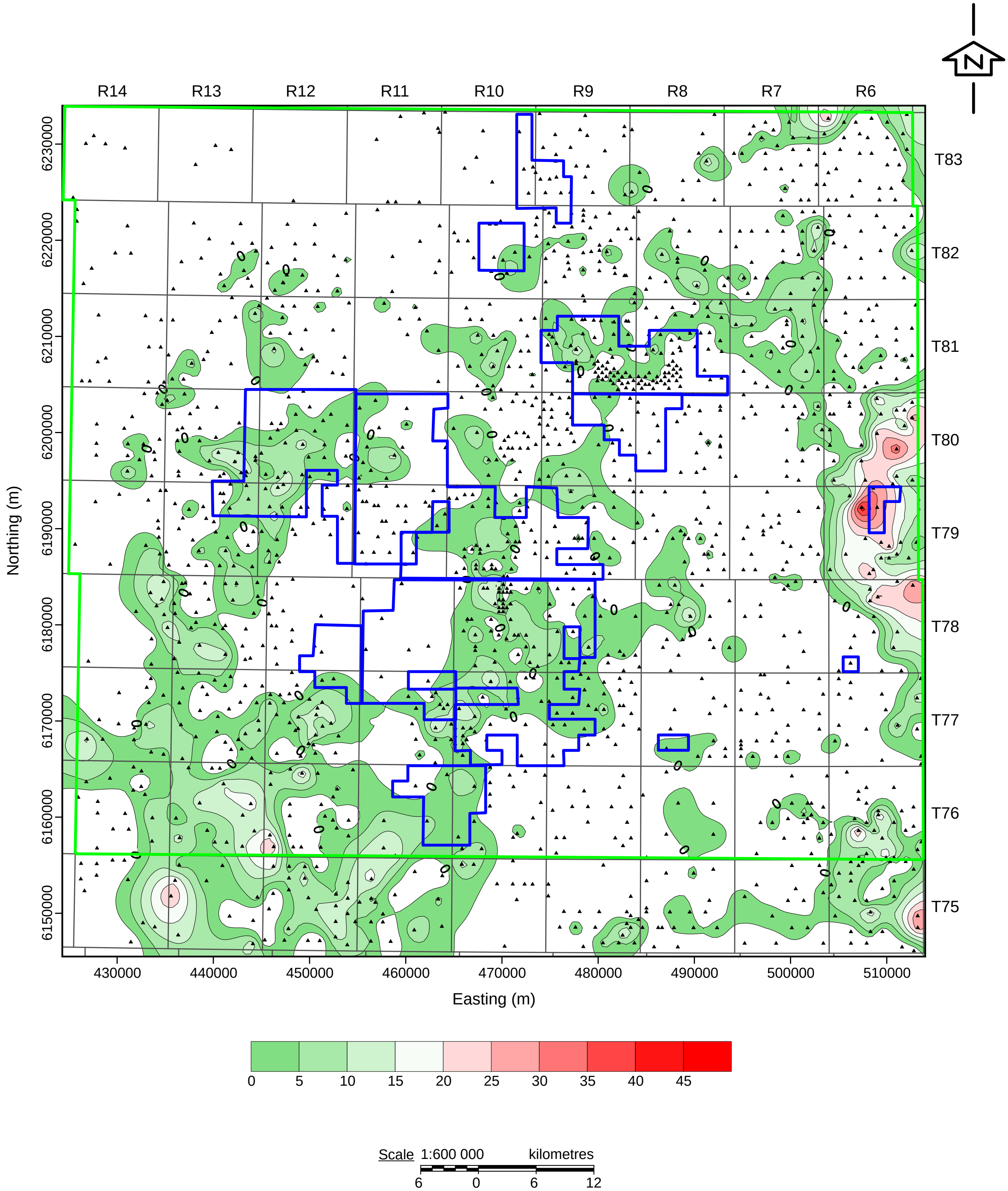
Title:

McMURRAY FORMATION ISOPACH

NORTH AMERICAN OIL SANDS CORPORATION

Approved: EG	Revision Date: 07/05/22
File: 4455-Struct-07.cdr	

Drawn by:	Checked:	Fig. No.:
AP	EG	**5.5-5**



LEGEND

- KAI KOS DEHSEH PROJECT
- LOCAL STUDY AREA (LSA)

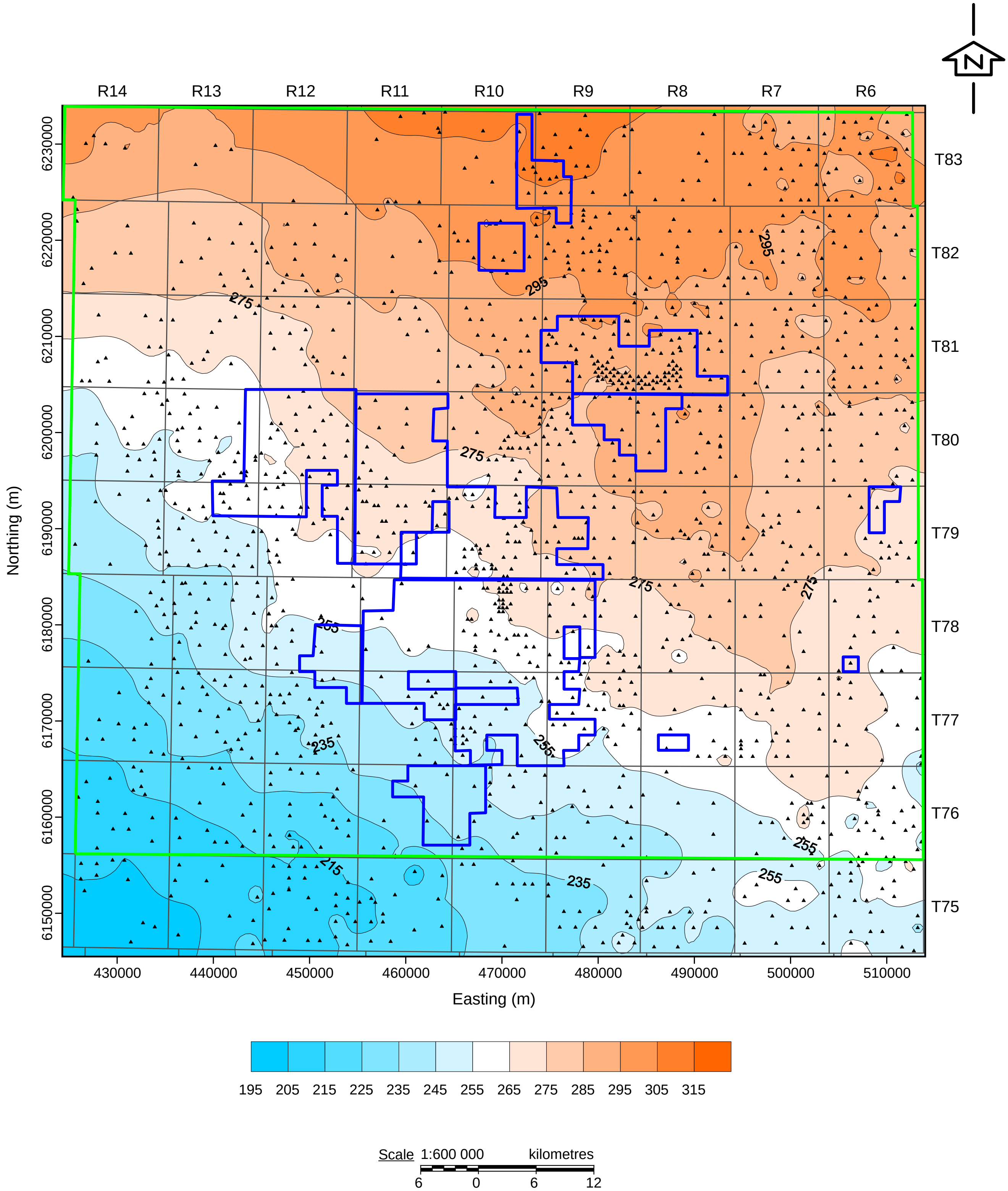
REFERENCE: Regional Aquifer and Geology Mapping Study of the Mannville Group, Ranges 6 to 14, Townships 75 to 83, W4. April 2007, prepared by Westwater Environmental Ltd.

Title:

BASAL McMURRAY AQUIFER ISOPACH

NORTH AMERICAN OIL SANDS CORPORATION

Approved: EG	Revision Date: 07/05/22	
File: 4455-Struct-07.cdr		
Drawn by: AP	Checked: EG	Fig. No.: **5.5-6**



LEGEND

- KAI KOS DEHSEH PROJECT
- LOCAL STUDY AREA (LSA)

REFERENCE: Regional Aquifer and Geology Mapping Study of the Mannville Group, Ranges 6 to 14, Townships 75 to 83, W4. April 2007, prepared by Westwater Environmental Ltd.

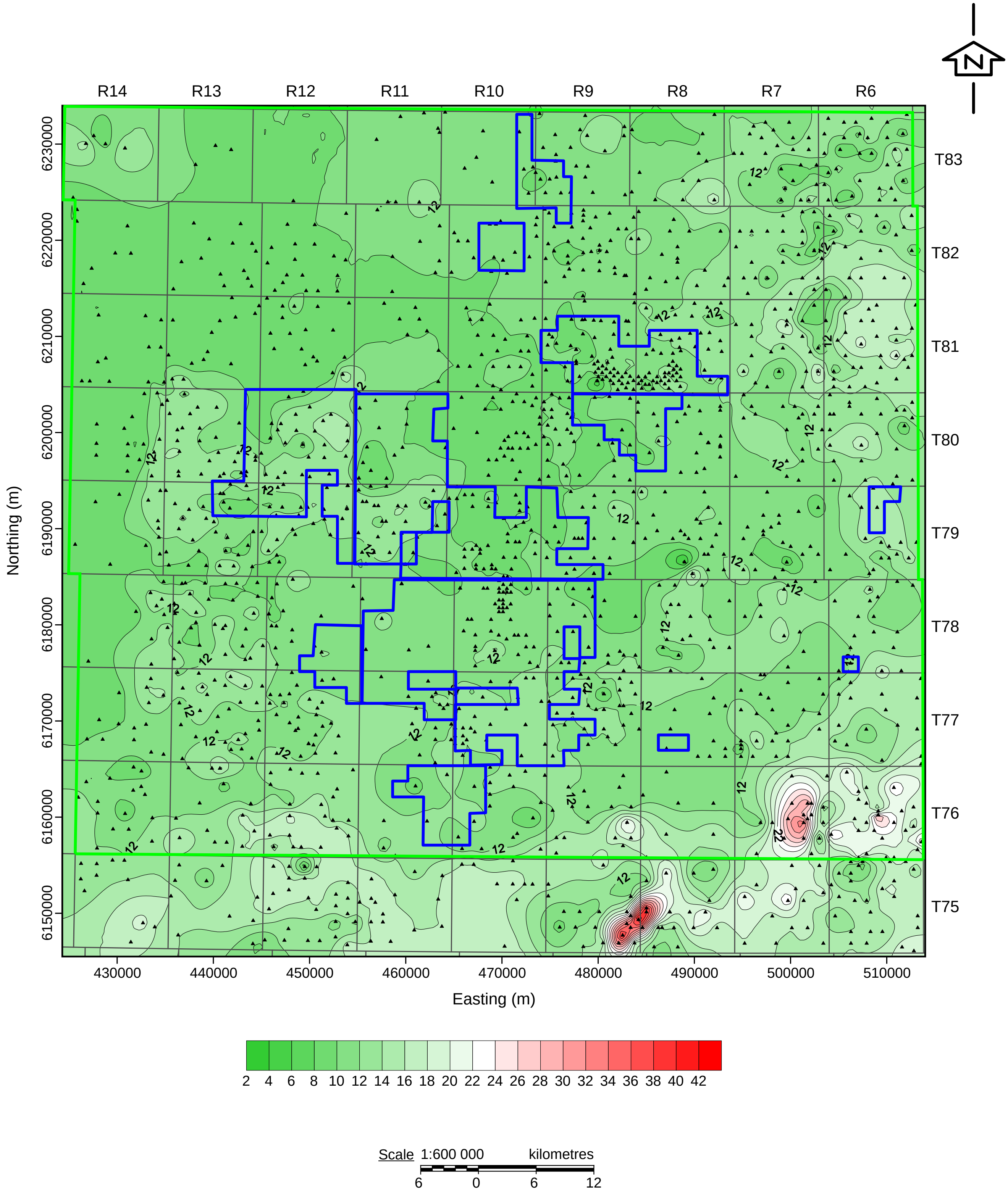
Title:

WABISKAW MEMBER STRUCTURE TOP

NORTH AMERICAN OIL SANDS CORPORATION

Approved: EG	Revision Date: 07/05/22
File: 4455-Struct-07.cdr	

Drawn by:	Checked:	Fig. No.:
AP	EG	**5.5-7**



LEGEND
KAI KOS DEHSEH PROJECT
LOCAL STUDY AREA (LSA)

REFERENCE: Regional Aquifer and Geology Mapping Study of the Mannville Group, Ranges 6 to 14, Townships 75 to 83, W4. April 2007, prepared by Westwater Environmental Ltd.

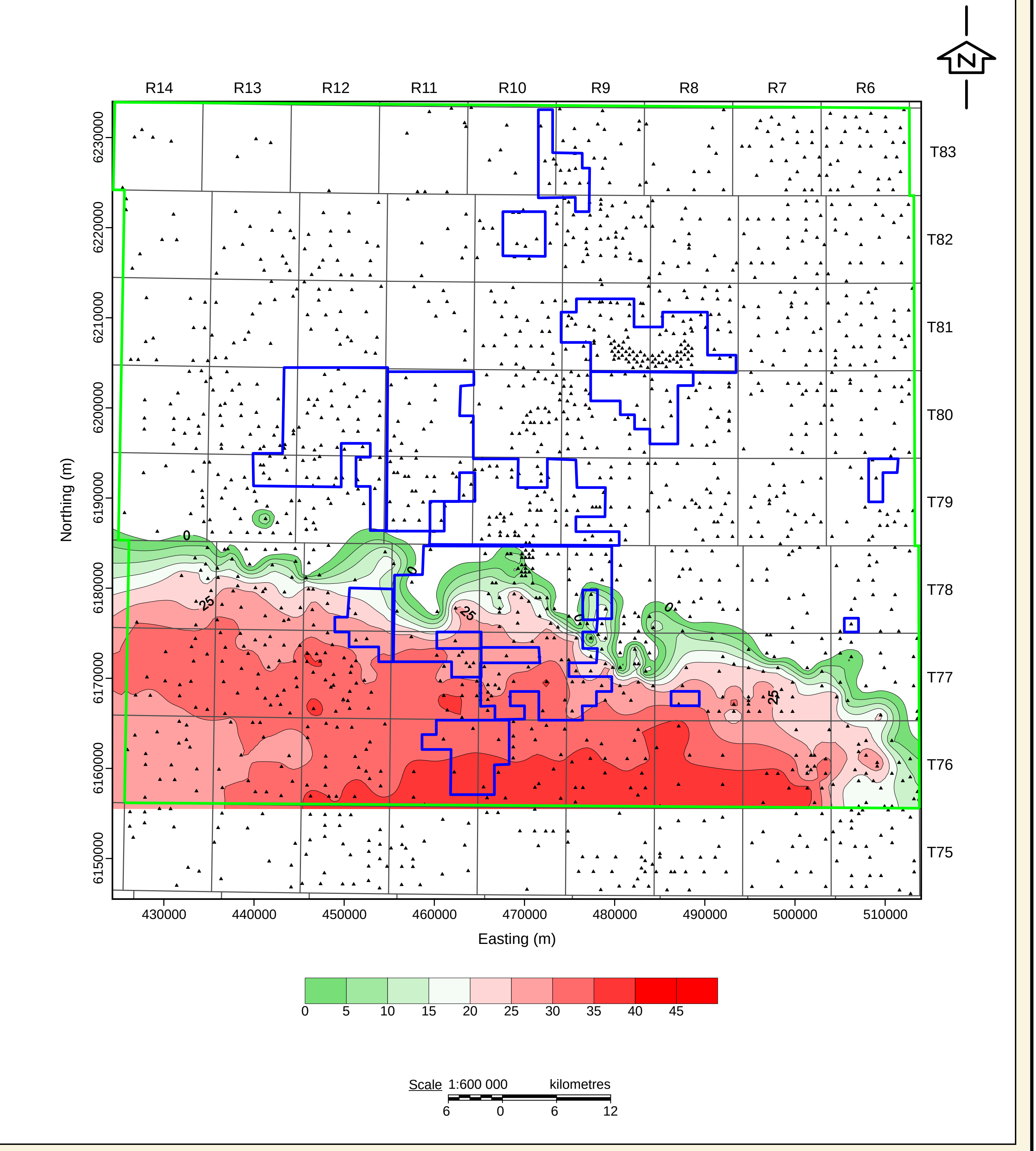
Title:

WABISKAW MEMBER ISOPACH

NORTH AMERICAN OIL SANDS CORPORATION

Approved: EG	Revision Date: 07/05/22
File: 4455-Struct-07.cdr	

Drawn by: AP	Checked: EG	Fig. No.: **5.5-8**



LEGEND
KAI KOS DEHSEH PROJECT
LOCAL STUDY AREA (LSA)

REFERENCE: Regional Aquifer and Geology Mapping Study of the Mannville Group, Ranges 6 to 14, Townships 75 to 83, W4. April 2007, prepared by Westwater Environmental Ltd.

Title:

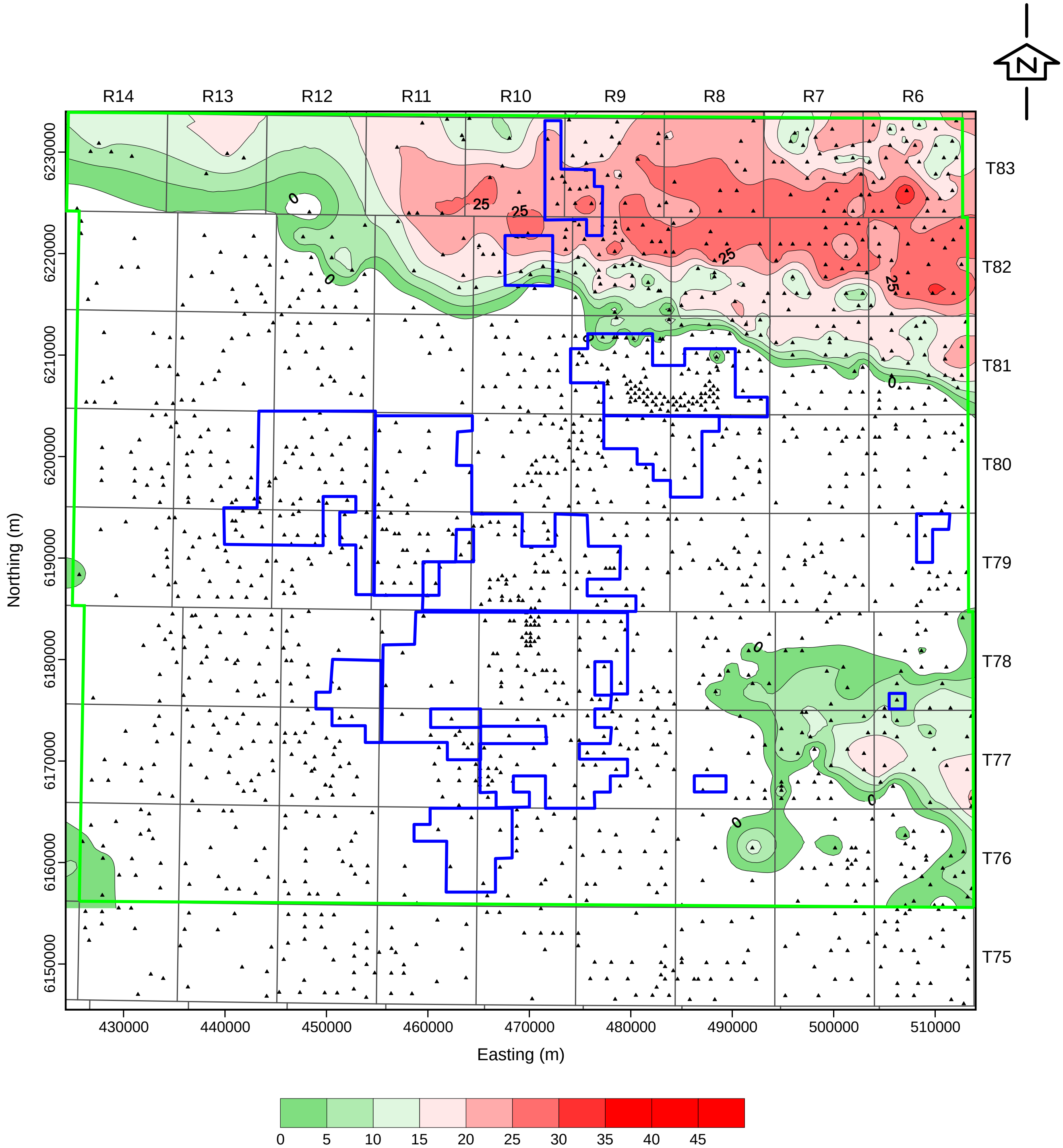
CLEARWATER B POROUS SAND ISOPACH

NORTH AMERICAN OIL SANDS CORPORATION

Approved: EG	Revision Date: 07/05/22

File: 4455-Struct-07.cdr

Drawn by:	Checked:	Fig. No.:
AP	EG	5.5-9



LEGEND
- KAI KOS DEHSEH PROJECT
- LOCAL STUDY AREA (LSA)

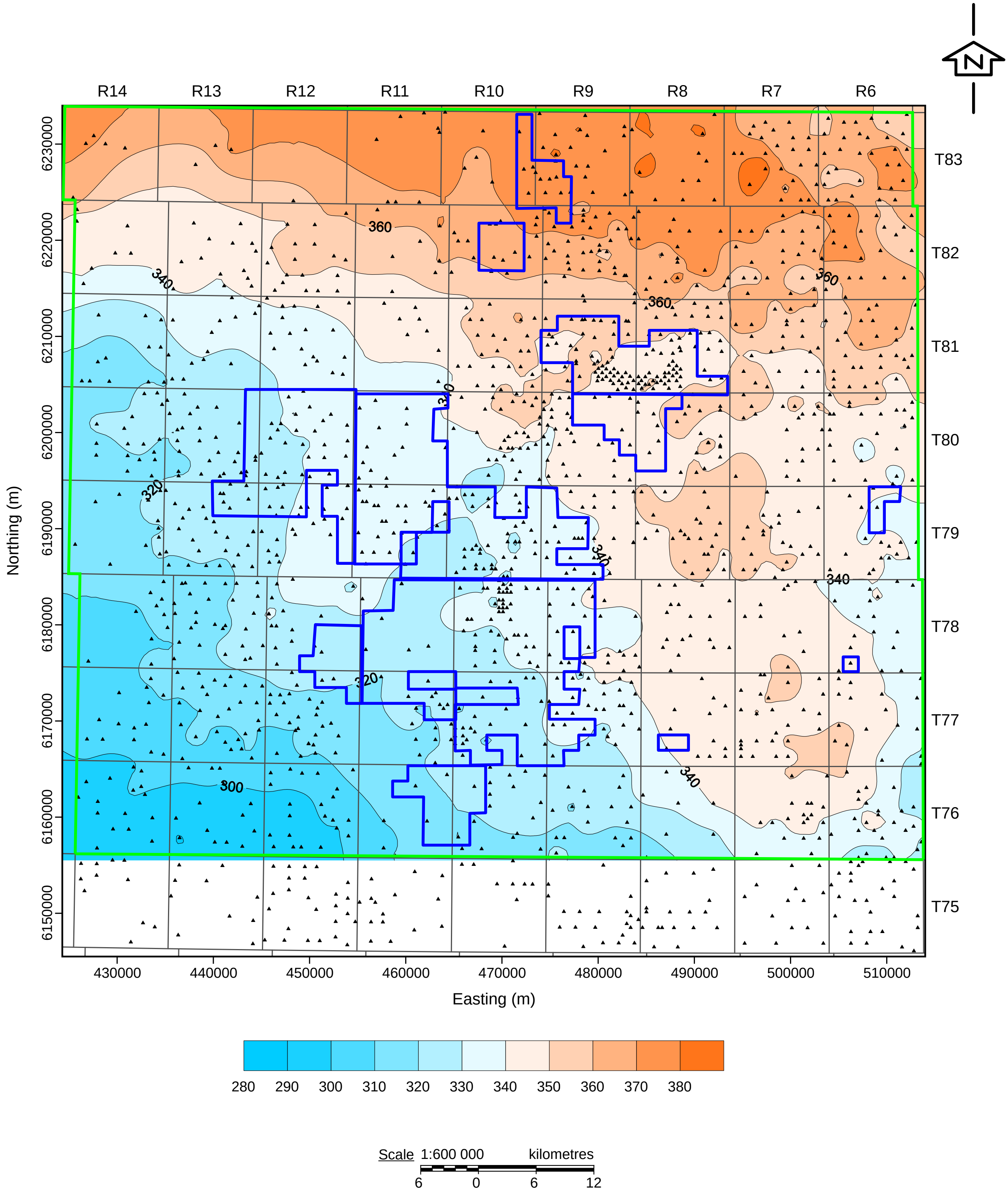
REFERENCE: Regional Aquifer and Geology Mapping Study of the Mannville Group, Ranges 6 to 14, Townships 75 to 83, W4. April 2007, prepared by Westwater Environmental Ltd.

Title:

CLEARWATER A POROUS SAND ISOPACH

NORTH AMERICAN OIL SANDS CORPORATION

Approved: EG	Revision Date: 07/05/22	
File: 4455-Struct-07.cdr		
Drawn by: AP	Checked: EG	Fig. No.: **5.5-10**



LEGEND
KAI KOS DEHSEH PROJECT
LOCAL STUDY AREA (LSA)

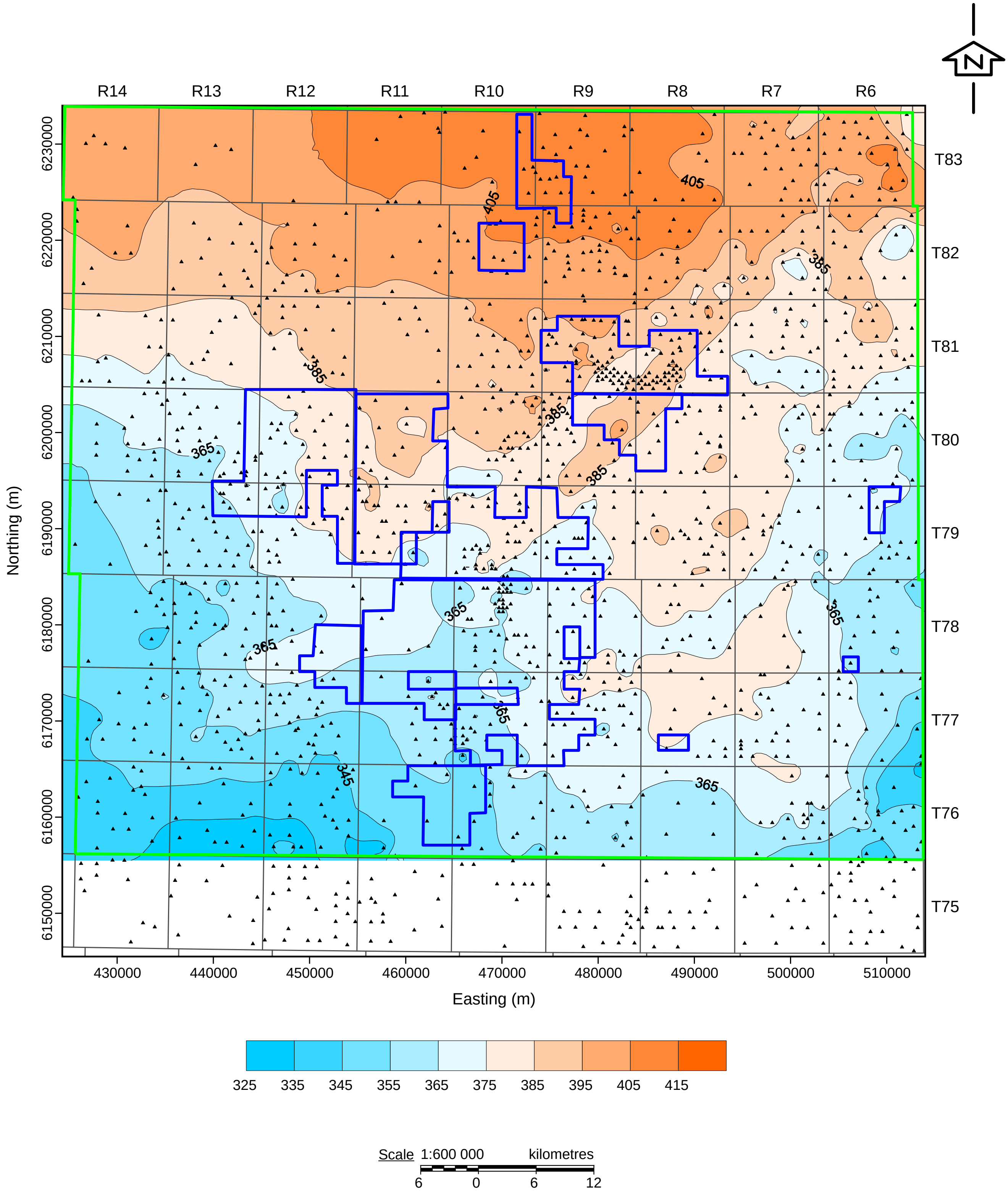
REFERENCE: Regional Aquifer and Geology Mapping Study of the Mannville Group, Ranges 6 to 14, Townships 75 to 83, W4. April 2007, prepared by Westwater Environmental Ltd.

Title:

CLEARWATER FORMATION STRUCTURE TOP

NORTH AMERICAN OIL SANDS CORPORATION

Approved: EG	Revision Date: 07/05/22	
File: 4455-Struct-07.cdr		
Drawn by: AP	Checked: EG	Fig. No.: **5.5-11**



LEGEND
- KAI KOS DEHSEH PROJECT
- LOCAL STUDY AREA (LSA)

REFERENCE: Regional Aquifer and Geology Mapping Study of the Mannville Group, Ranges 6 to 14, Townships 75 to 83, W4. April 2007, prepared by Westwater Environmental Ltd.

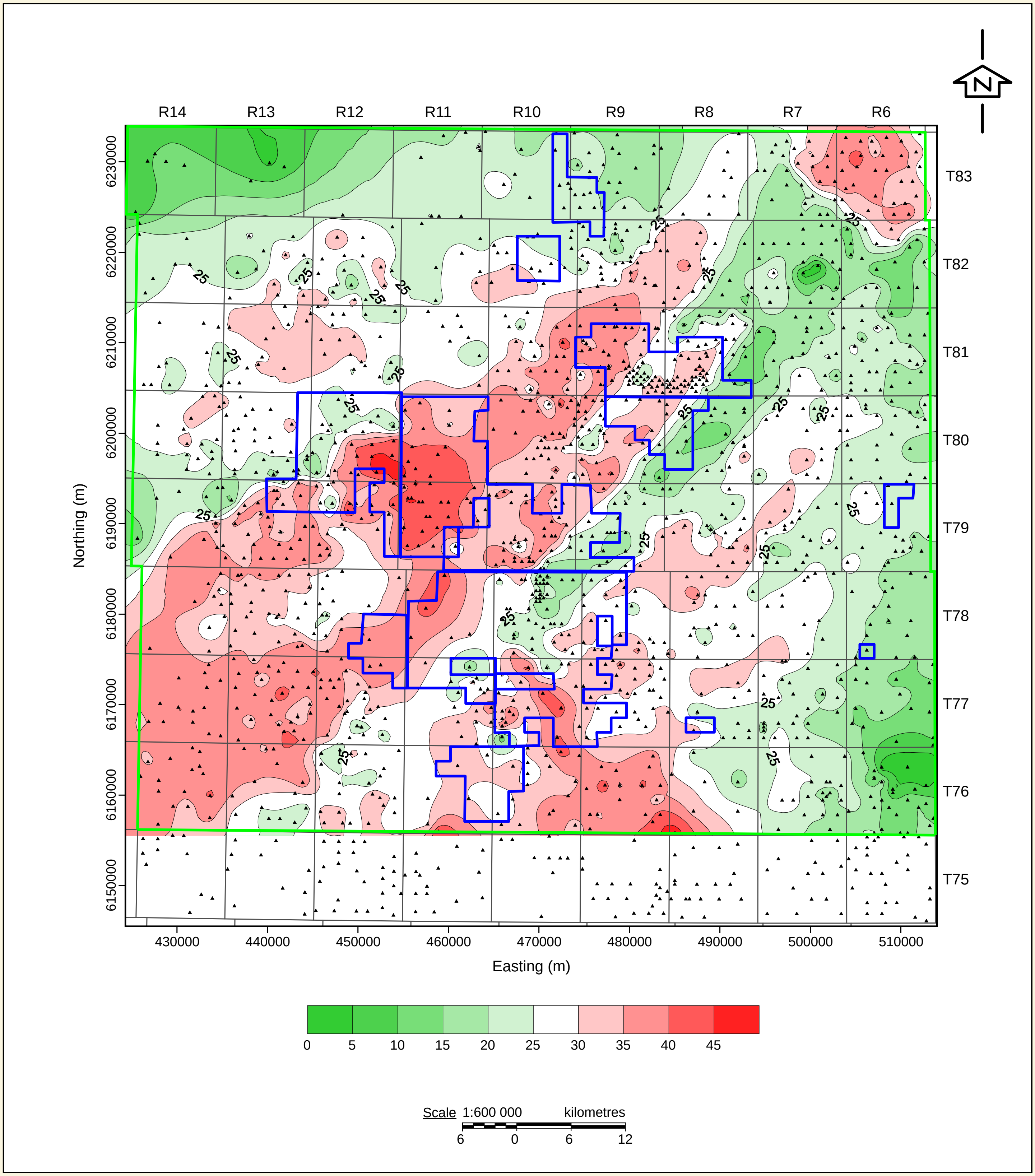
Title:

GRAND RAPIDS C UNIT STRUCTURE TOP

NORTH AMERICAN OIL SANDS CORPORATION

Approved: EG	Revision Date: 07/05/22
File: 4455-Struct-07.cdr	

Drawn by:	Checked:	Fig. No.:
AP	EG	5.5-12



LEGEND
KAI KOS DEHSEH PROJECT
LOCAL STUDY AREA (LSA)

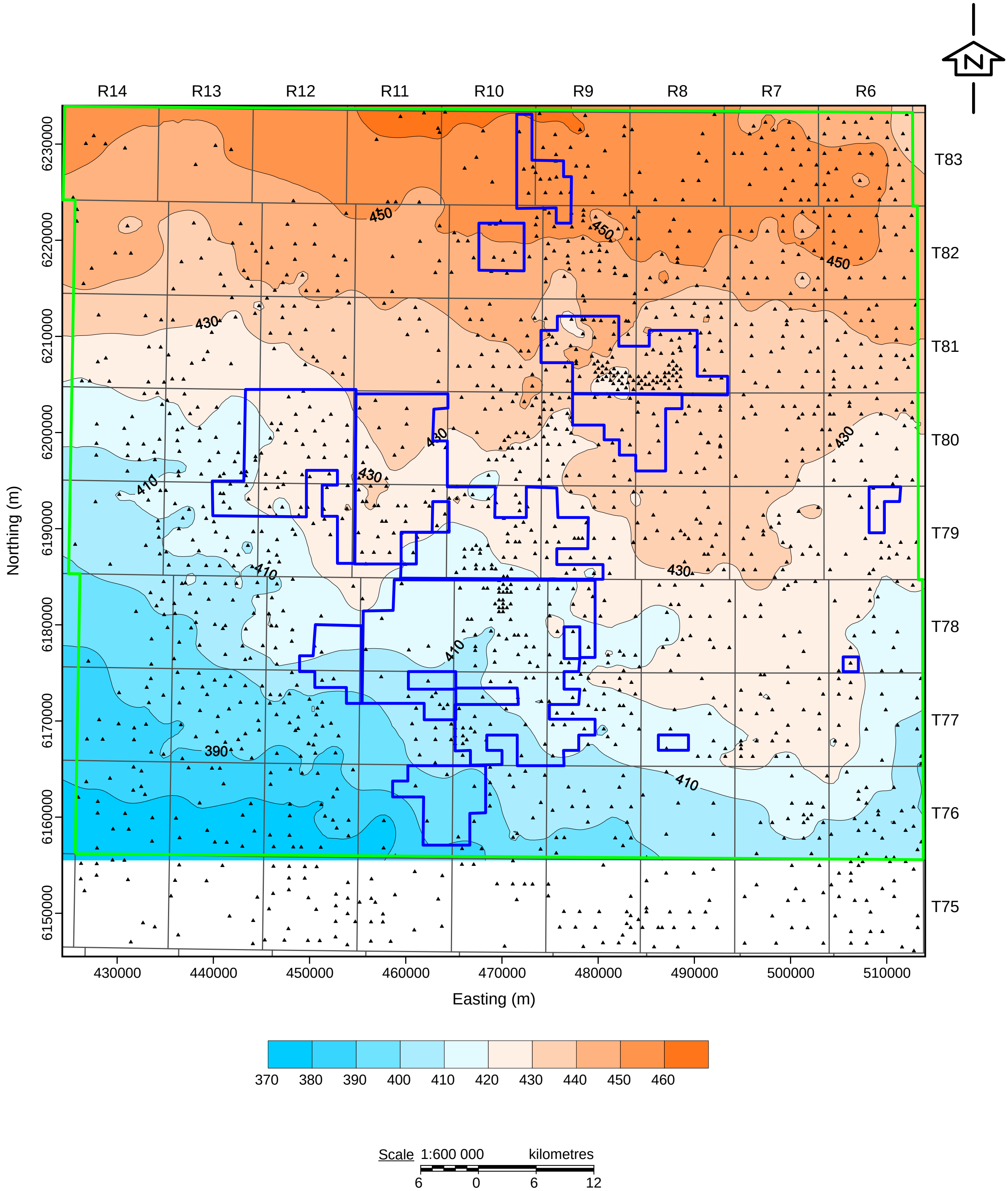
REFERENCE: Regional Aquifer and Geology Mapping Study of the Mannville Group, Ranges 6 to 14, Townships 75 to 83, W4. April 2007, prepared by Westwater Environmental Ltd.

Title:

GRAND RAPIDS C UNIT POROUS SAND ISOPACH

NORTH AMERICAN OIL SANDS CORPORATION

Approved: EG	Revision Date: 07/05/22	
File: 4455-Struct-07.cdr		
Drawn by: AP	Checked: EG	Fig. No.: **5.5-13**



LEGEND
KAI KOS DEHSEH PROJECT
LOCAL STUDY AREA (LSA)

REFERENCE: Regional Aquifer and Geology Mapping Study of the Mannville Group, Ranges 6 to 14, Townships 75 to 83, W4. April 2007, prepared by Westwater Environmental Ltd.

Title:

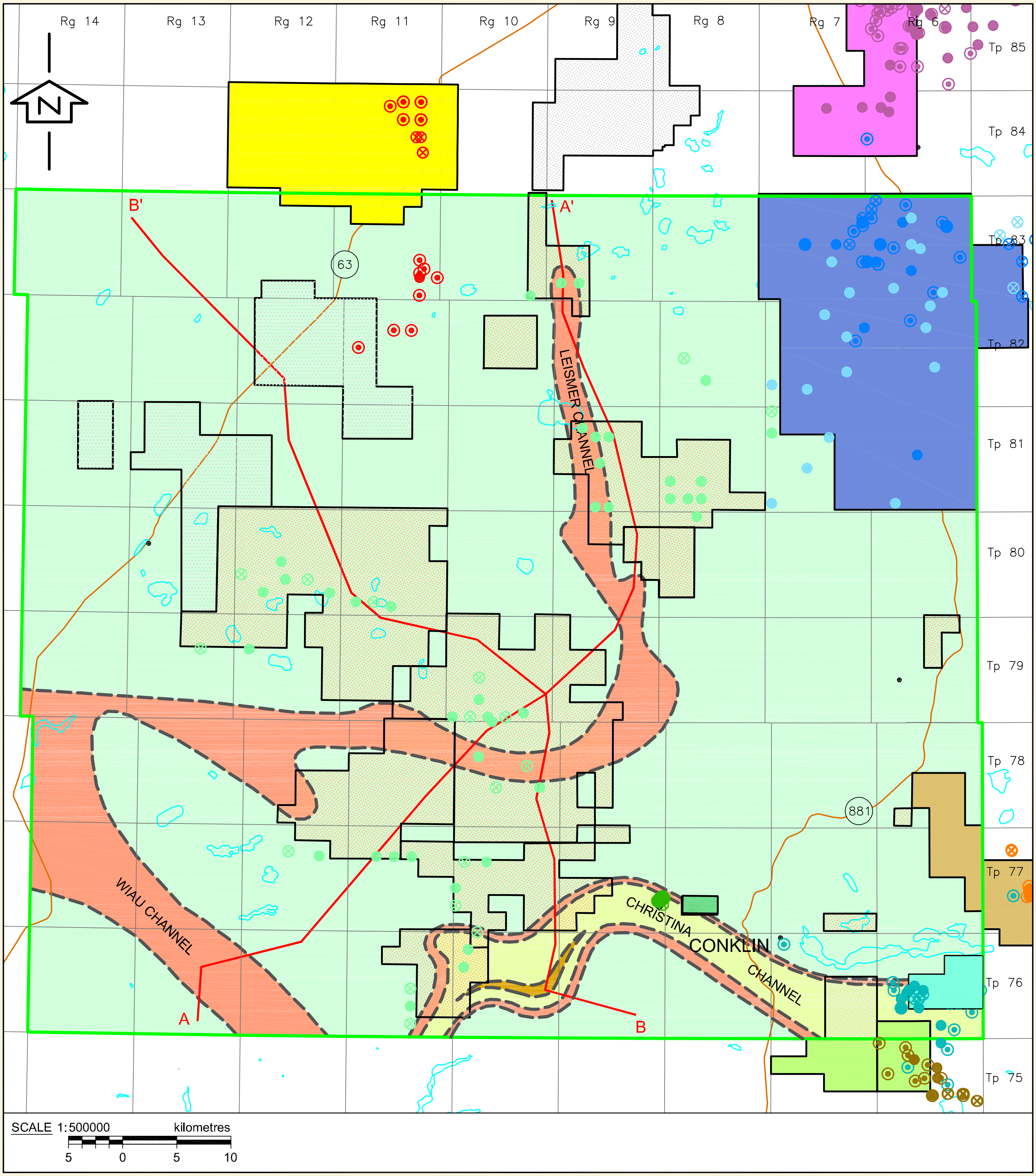
GRAND RAPIDS FORMATION STRUCTURE TOP

NORTH AMERICAN OIL SANDS CORPORATION

Approved: EG	Revision Date: 07/05/22
File: 4455-Struct-07.cdr	

Drawn by:	Checked:	Fig. No.:
AP	EG	5.5-14

*PLOT 1:1 = Letter (P)



LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- LOCAL STUDY AREA (LSA)

- LA BICHE FORMATION
- VIKING FORMATION
- JOLI FOU FORMATION
- GRAND RAPIDS 'A UNIT
- CROSS SECTION LOCATIONS

REFERENCE
ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12
NORTH AMERICAN (2006).

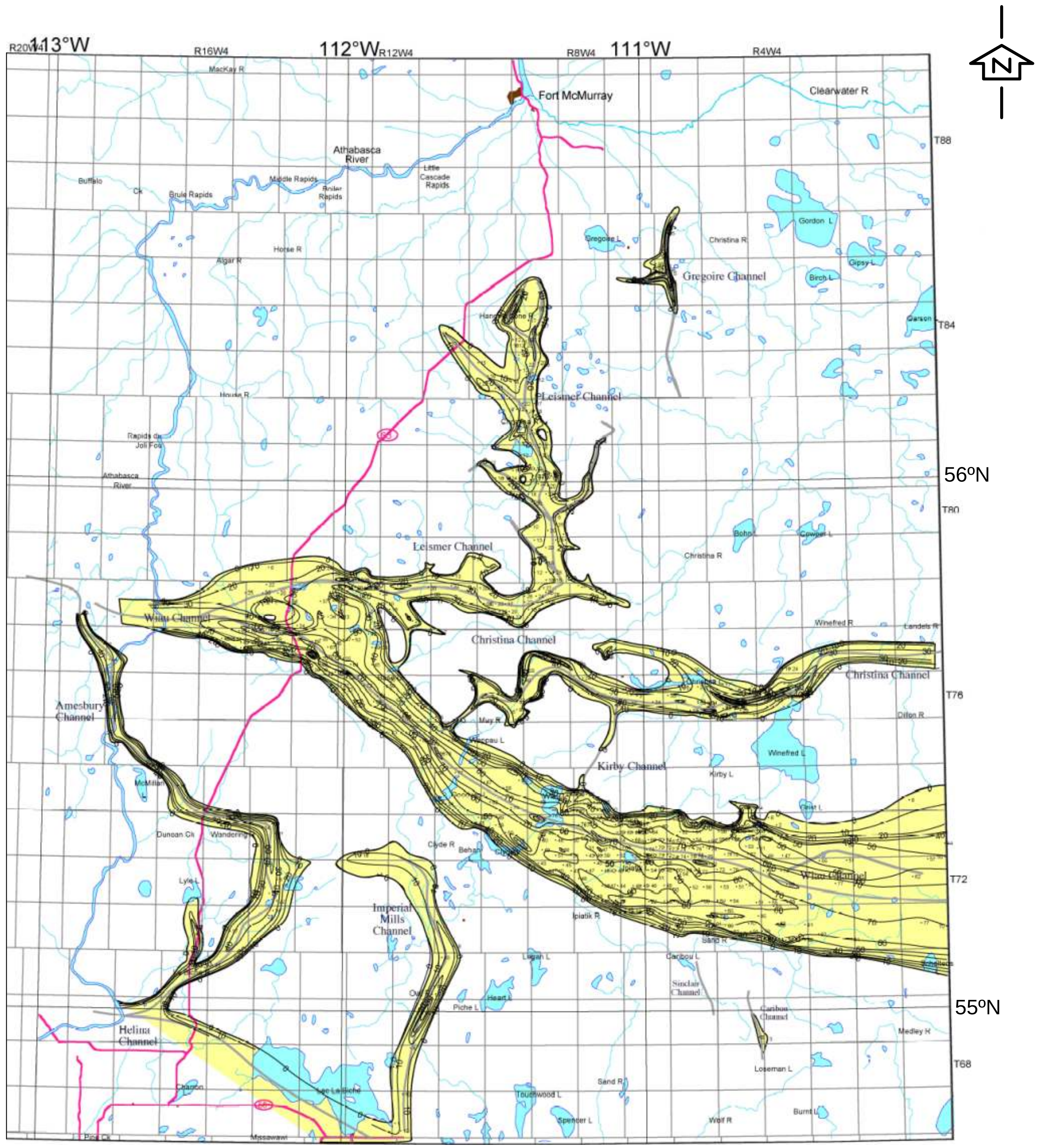
Title:

CRETACEOUS SUBCROP BELOW TERTIARY/QUATERNARY

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/03/28	
File: 4455-STR-ISO-07.DWG		
Drawn by: GDE	Checked: BW	Fig. No.: **5.5-15**

F:\4455 NAOSC\Drafting\2007\4455-STR-ISO-07.dwg - SUBCROP - Friday, April 13, 2007 1:04:00 PM - Gary Evenson



Scale 1:1 250 000 kilometres

12.5 0 12.5 25

Data Legend

- ● 20 - Thickness (in m) equal to value shown
- ○ 20 - Thickness (in m) less than value shown
- □ 20 - Thickness (in m) greater than value shown

Channel talweg

Distribution of Empress Formation channel deposits (undifferentiated and combined Units 1,2 and 3)

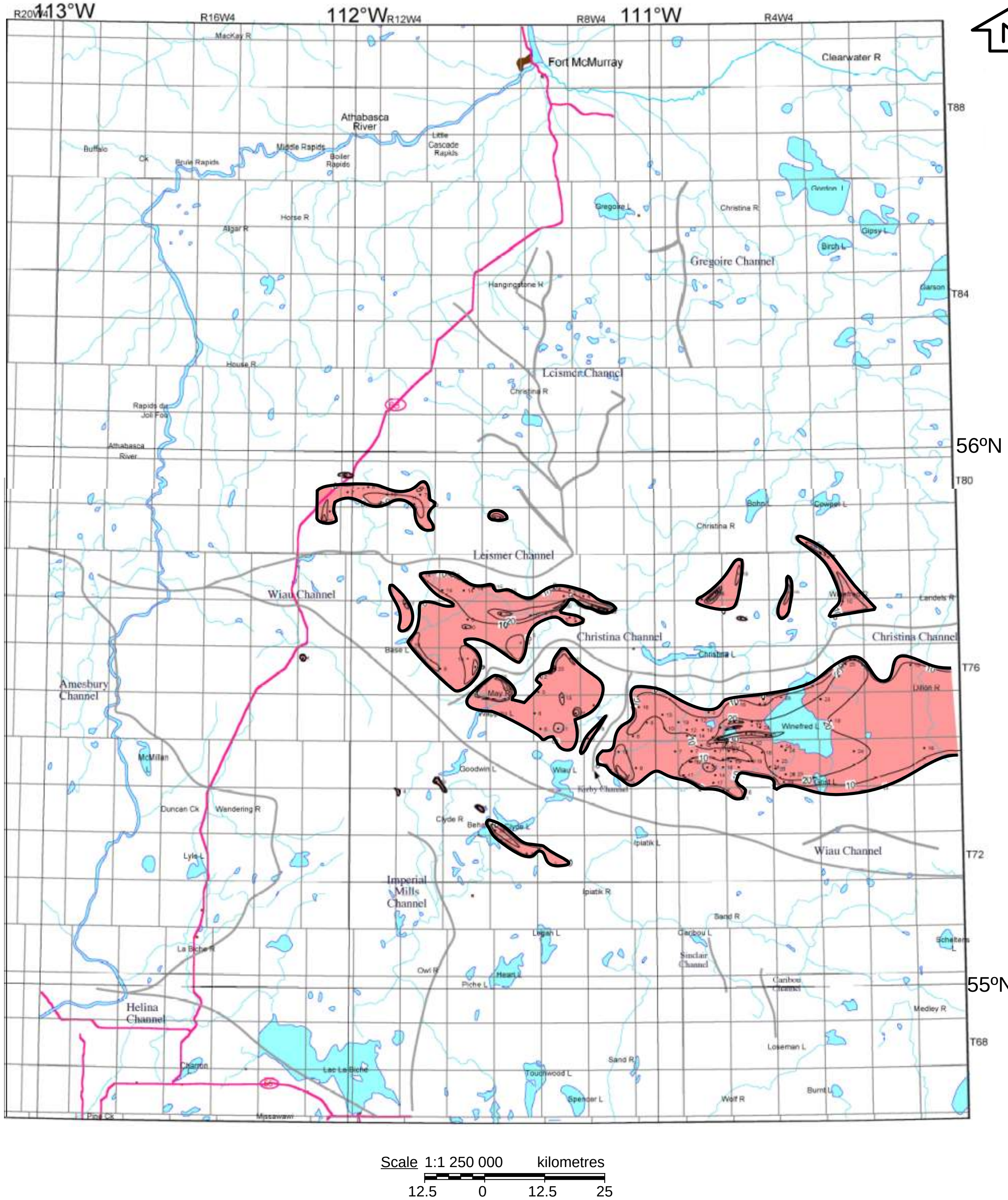
SOURCE: EUB/AGS Earth Sciences Report 2002-03, *"Quaternary Geological Setting of the Athabasca Oil Sands (In Situ) Area, Northeast Alberta"*.

Title:

EMPRESS CHANNEL SAND ISOPACH

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/05/22	
File: 4455-Empress-07.cdr		
Drawn by: GDE	Checked: BW	Fig. No.: **5.5-16**



Data Legend

● 20 - Thickness (in m) equal to value shown
○ 20 - Thickness (in m) less than value shown
□ 20 - Thickness (in m) greater than value shown

Channel talweg

Distribution of Empress Formation interfluve terrace sand and gravel

SOURCE: EUB/AGS Earth Sciences Report 2002-03, *"Quaternary Geological Setting of the Athabasca Oil Sands (In Situ) Area, Northeast Alberta"*.

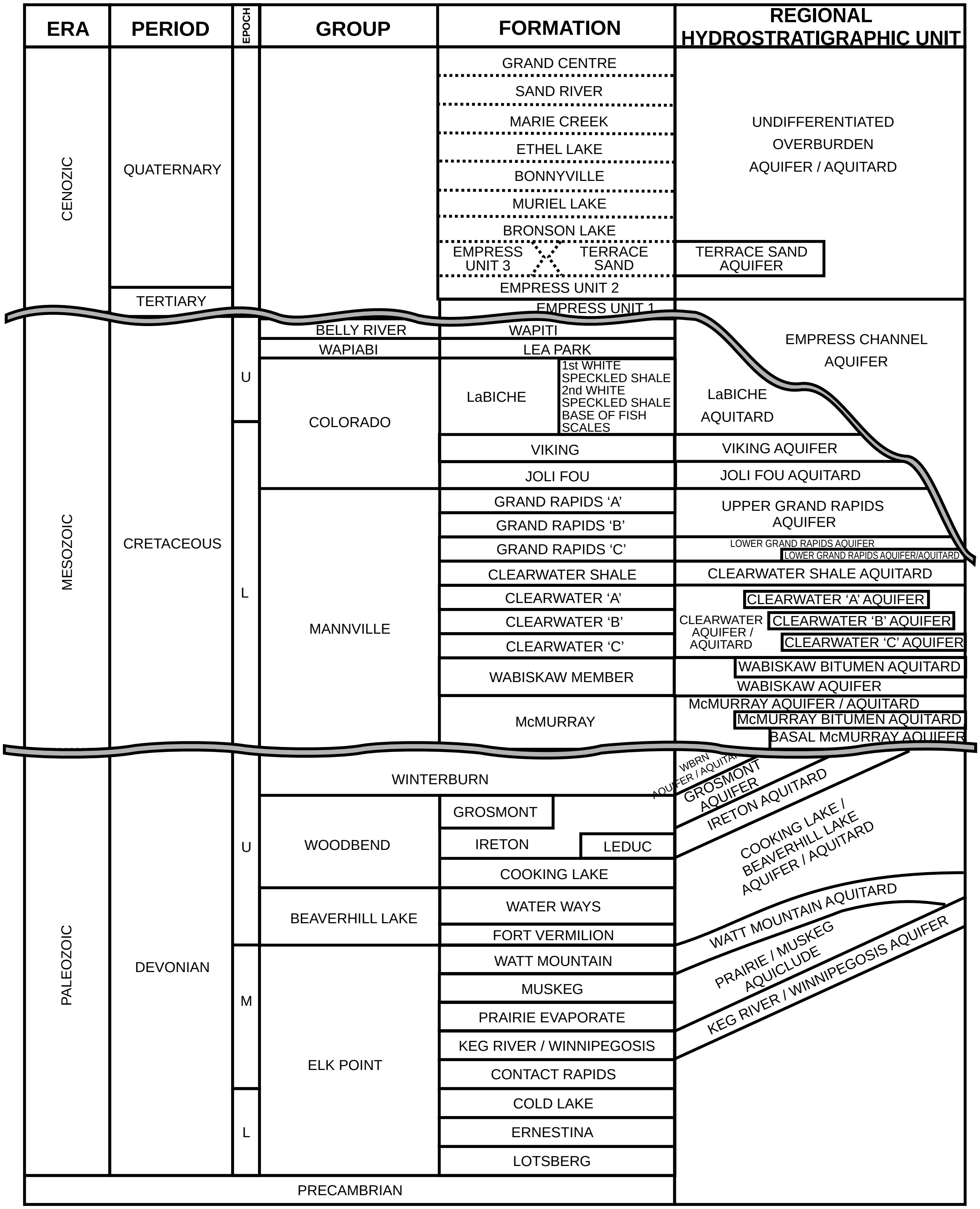
Title:

EMPRESS TERRACE SAND ISOPACH

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/05/22
File: 4455-Empress-07.cdr	

Drawn by:	Checked:	Fig. No.:
GDE	BW	**5.5-17**

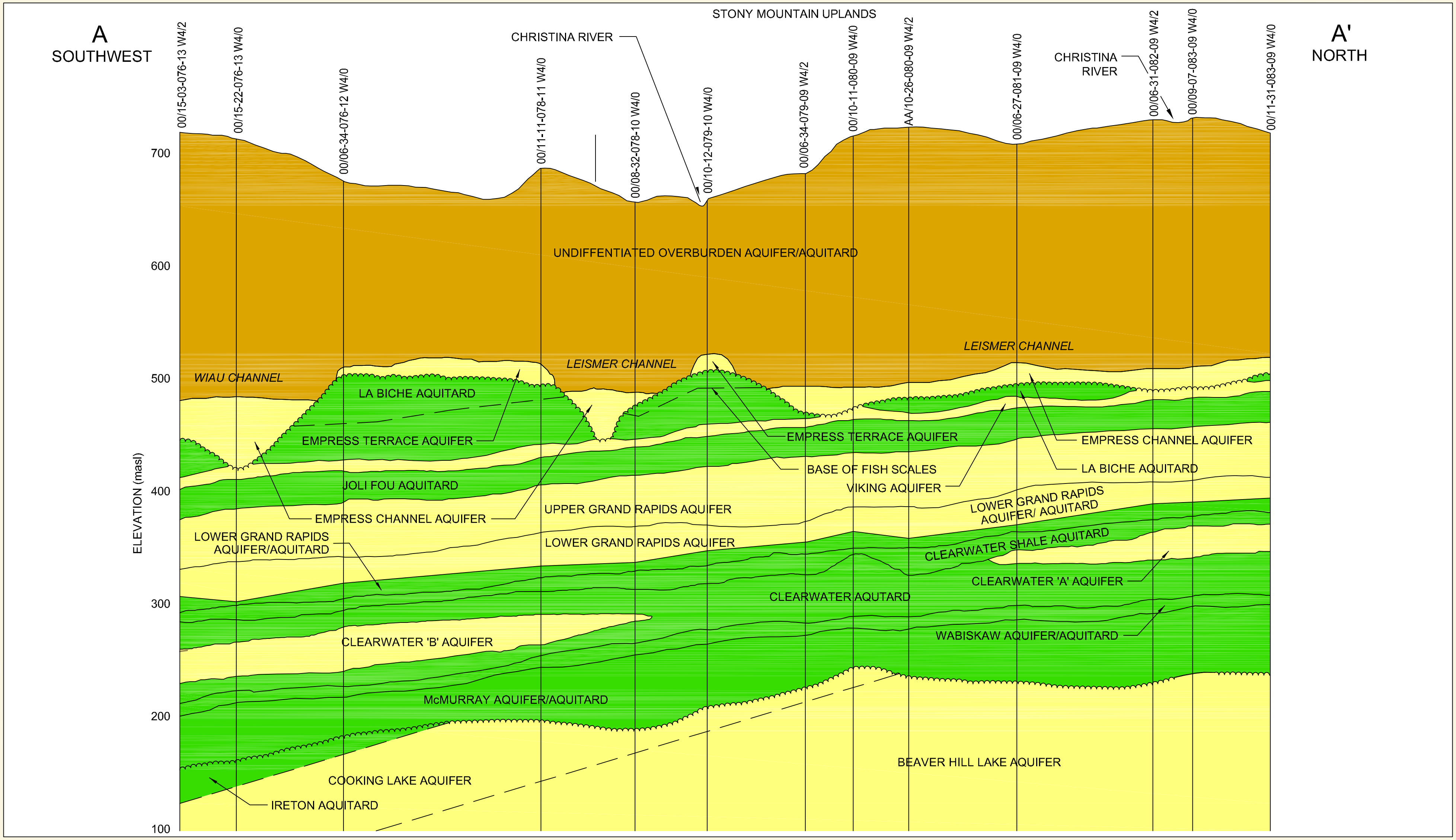


Title:

HYDROSTRATIGRAPHIC COLUMN

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP		Revision Date: 07/05/22
File: 4455-Strat-07.cdr		
Drawn by: GDE	Checked: BW	Fig. No.: **5.5-18**



VERTICAL SCALE 1:5000 metres

50 0 50 100

HORIZONTAL SCALE 1:500000 kilometres

5 0 5 10

REFERENCE: North American, 2006

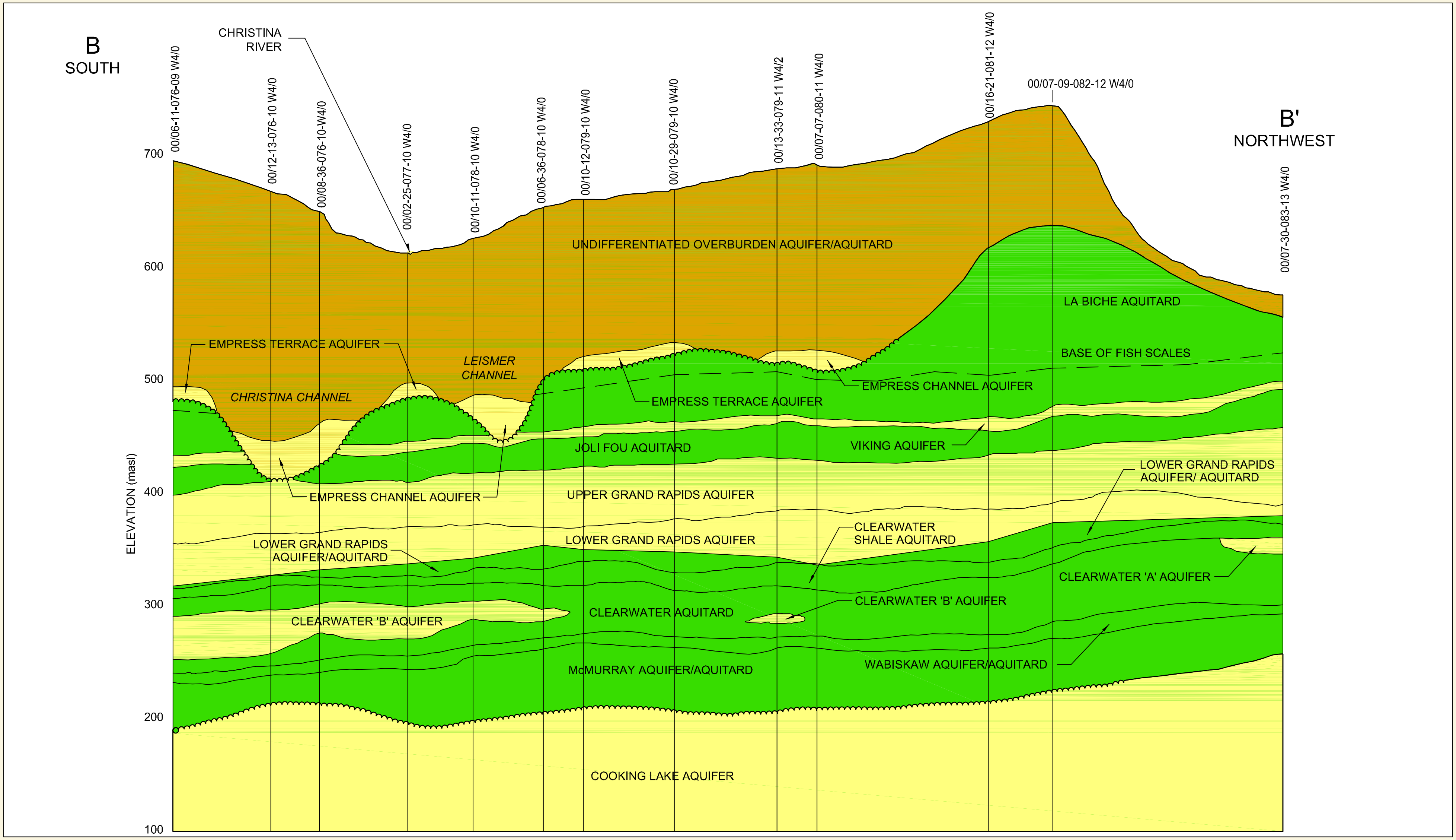
Title:

CROSS SECTION A-A'

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/05/22
File: 4455-XSEC-07.DWG	

Drawn by:	Checked:	Fig. No.:
GDE	BW	**5.5-19**



VERTICAL SCALE 1:5000 metres

50 0 50 100

HORIZONTAL SCALE 1:500000 kilometres

5 0 5 10

REFERENCE: North American, 2006

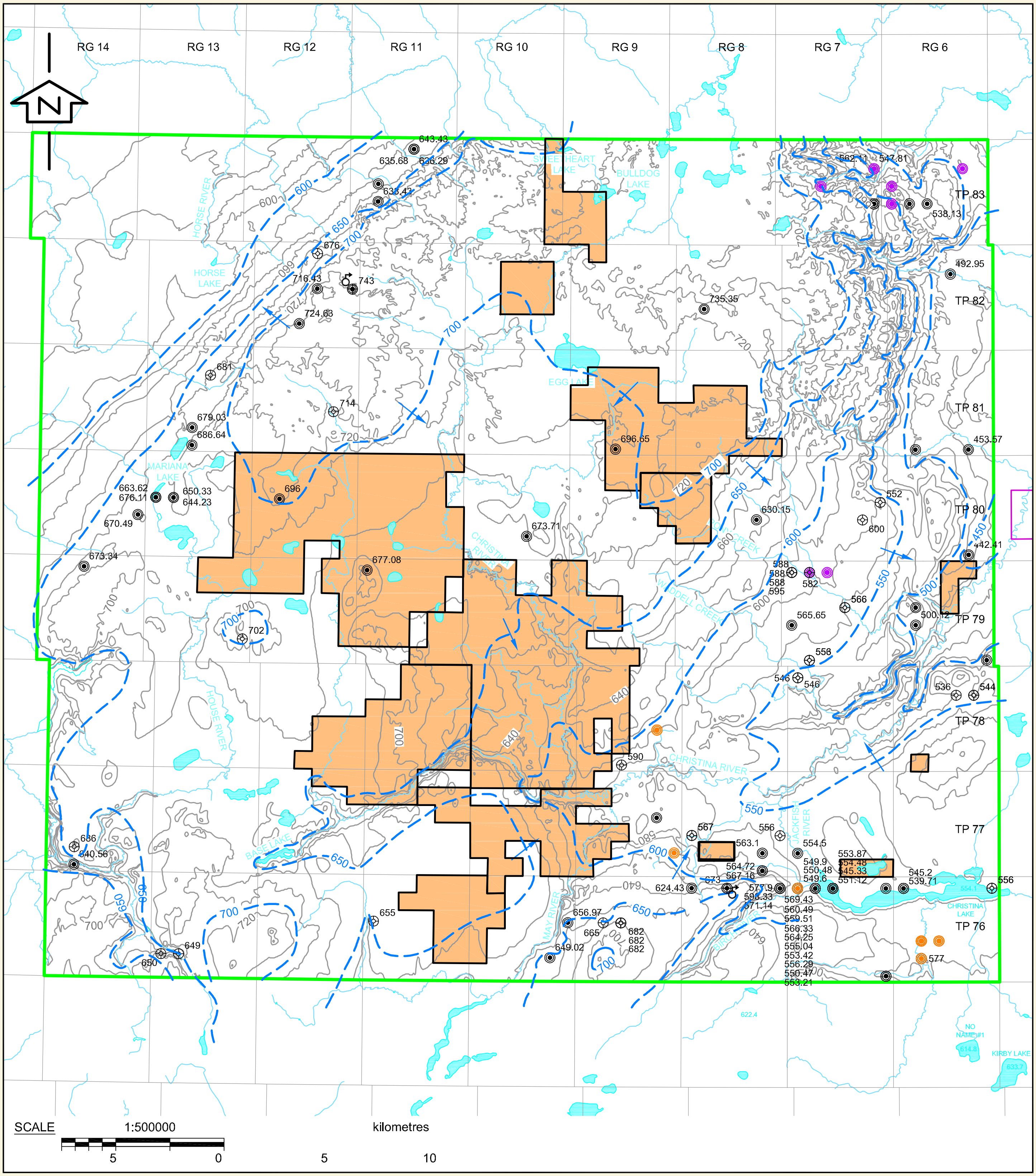
Title:

CROSS SECTION B-B'

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/05/22	
File: 4455-XSEC-07.DWG		
Drawn by: GDE	Checked: BW	Fig. No.: **5.5-20**

*PLOT 1:1 = Letter (P)



LEGEND

- KAI KOS DEHSEH PROJECT
- LOCAL STUDY AREA (LSA)
- SPRING/FLOWING SHOT HOLE
- WATER WELL
- WATER WELL - COMPLETED IN EMPRESS FORMATION
- WATER WELL - COMPLETED IN LOWER GRAND RADIDS AQUIFER
- GROUNDWATER CONTOUR (APPROXIMATE)
- GROUNDWATER FLOW DIRECTION
- 649.00 GROUNDWATER ELEVATION (WHERE REPORTED)

REFERENCE

ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

UNDIFFERENTIATED OVERBURDEN AQUIFER/AQUITARD HYDRAULIC HEADS

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/05/22
File: 4455-HH MAP-07.DWG	

Drawn by:	Checked:	Fig. No.:
GDE	BW	5.5-21

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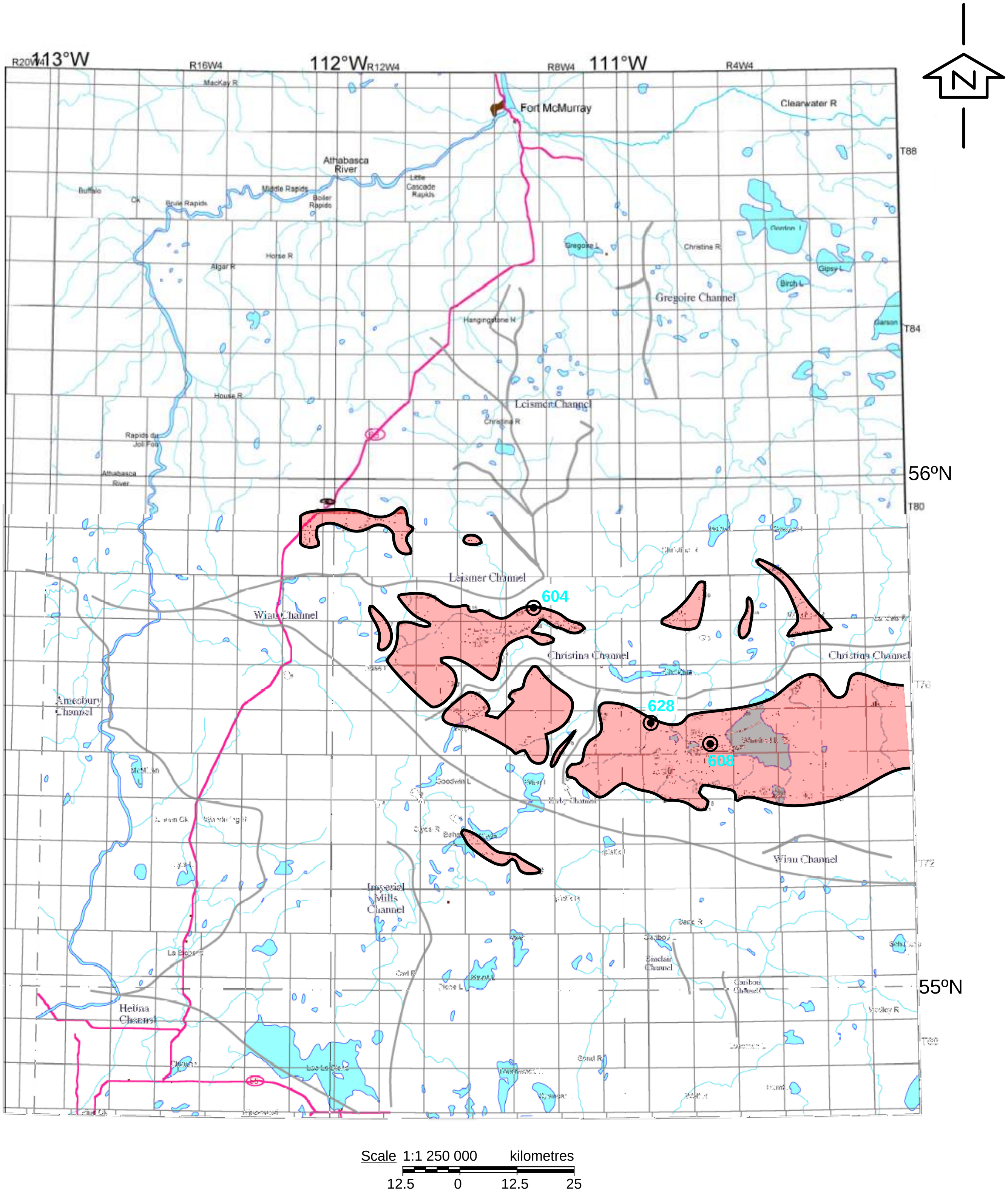


Data Legend

- ● 20 - Thickness (in m) equal to value shown
- ○ 20 - Thickness (in m) less than value shown
- □ 20 - Thickness (in m) greater than value shown
- Channel talweg
- Distribution of Empress Formation interfluve terrace sand and gravel

SOURCE: EUB/AGS Earth Sciences Report 2002-03, *"Quaternary Geological Setting of the Athabasca Oil Sands (In Situ) Area, Northeast Alberta"*.

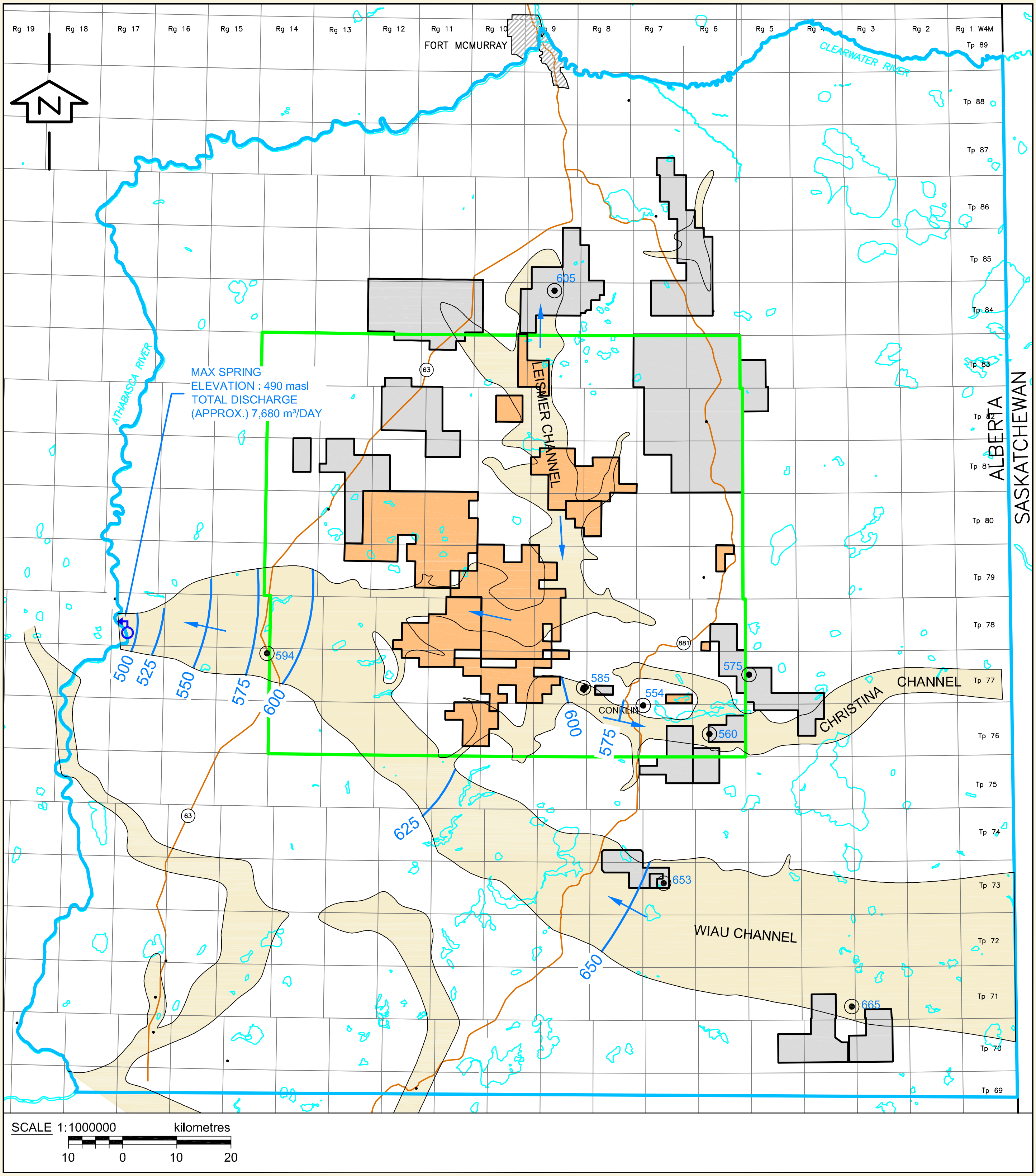
Title:

EMPRESS TERRACE AQUIFER HYDRAULIC HEADS

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/05/22	
File: 4455-Empress-07.cdr		
Drawn by: GDE	Checked: BW	Fig. No.: **5.5-22**

*PLOT 1:1 = Letter (P)



LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- LOCAL STUDY AREA (LSA)
- REGIONAL STUDY AREA (RSA)
- SPRING LOCATION
- WELL LOCATION
- EXTENT OF EMPRESS CHANNEL DEPOSITS (ANDRIASHEK, 2003)
- 500 HYDRAULIC HEAD CONTOUR (masl)
- INTERPRETED DIRECTION OF GROUNDWATER FLOW

REFERENCE
ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

EMPRESS CHANNEL AQUIFER HYDRAULIC HEAD MAP

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/05/22
File: 4455-STR-ISO-07.DWG	
Drawn by: GDE	Checked: BW
Fig. No.: 5.5-23	

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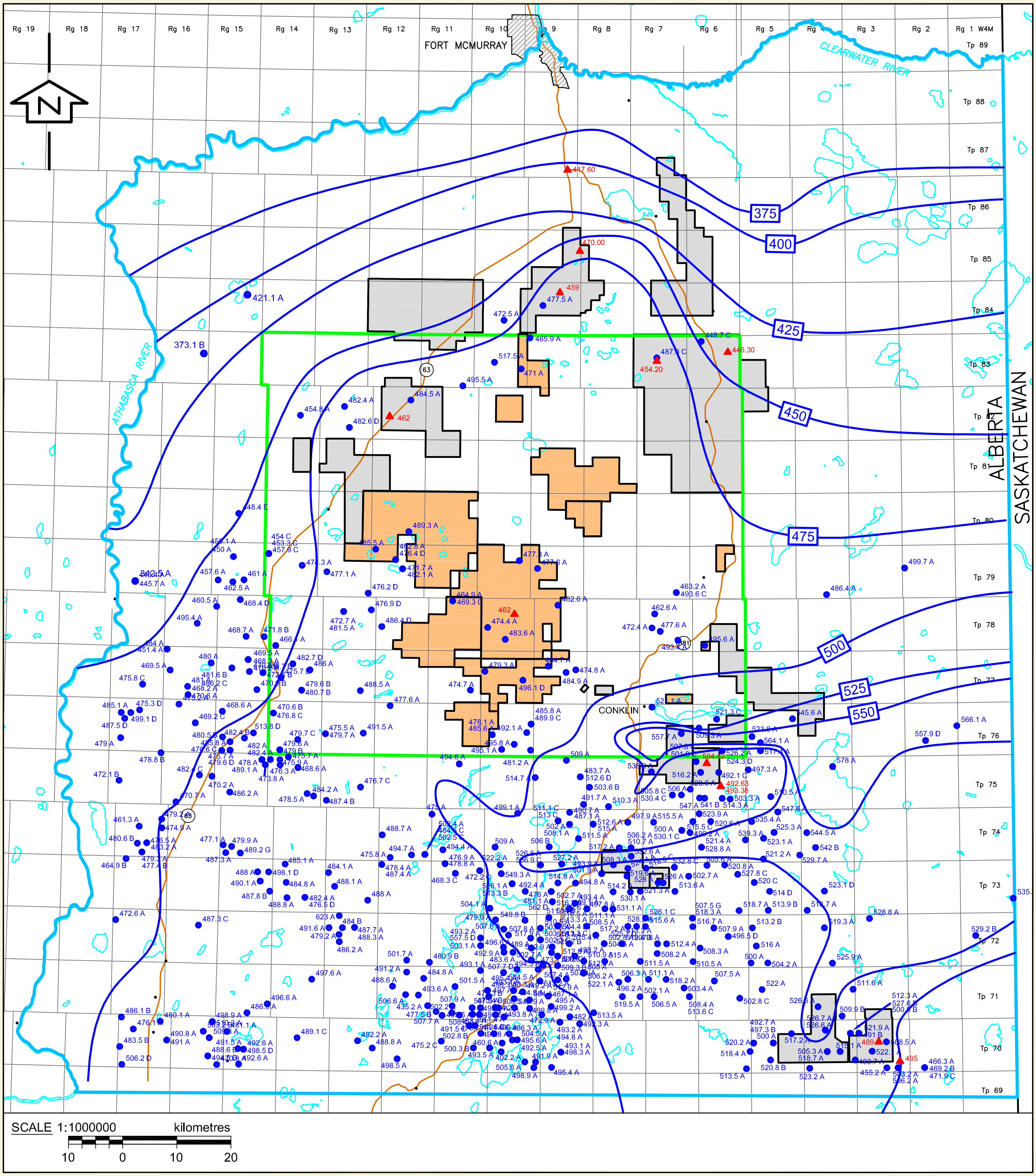


LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- LOCAL STUDY AREA (LSA)
- REGIONAL STUDY AREA (RSA)
- -450- INTERPRETED HYDRAULIC HEAD CONTOUR (masl)
- 444.5 C ● EQUIVALENT HYDRAULIC HEAD (masl), QUALITY CONTROL CODE
- 449.09 ▲ REPORTED HYDRAULIC HEAD VALUES (masl)

REFERENCE

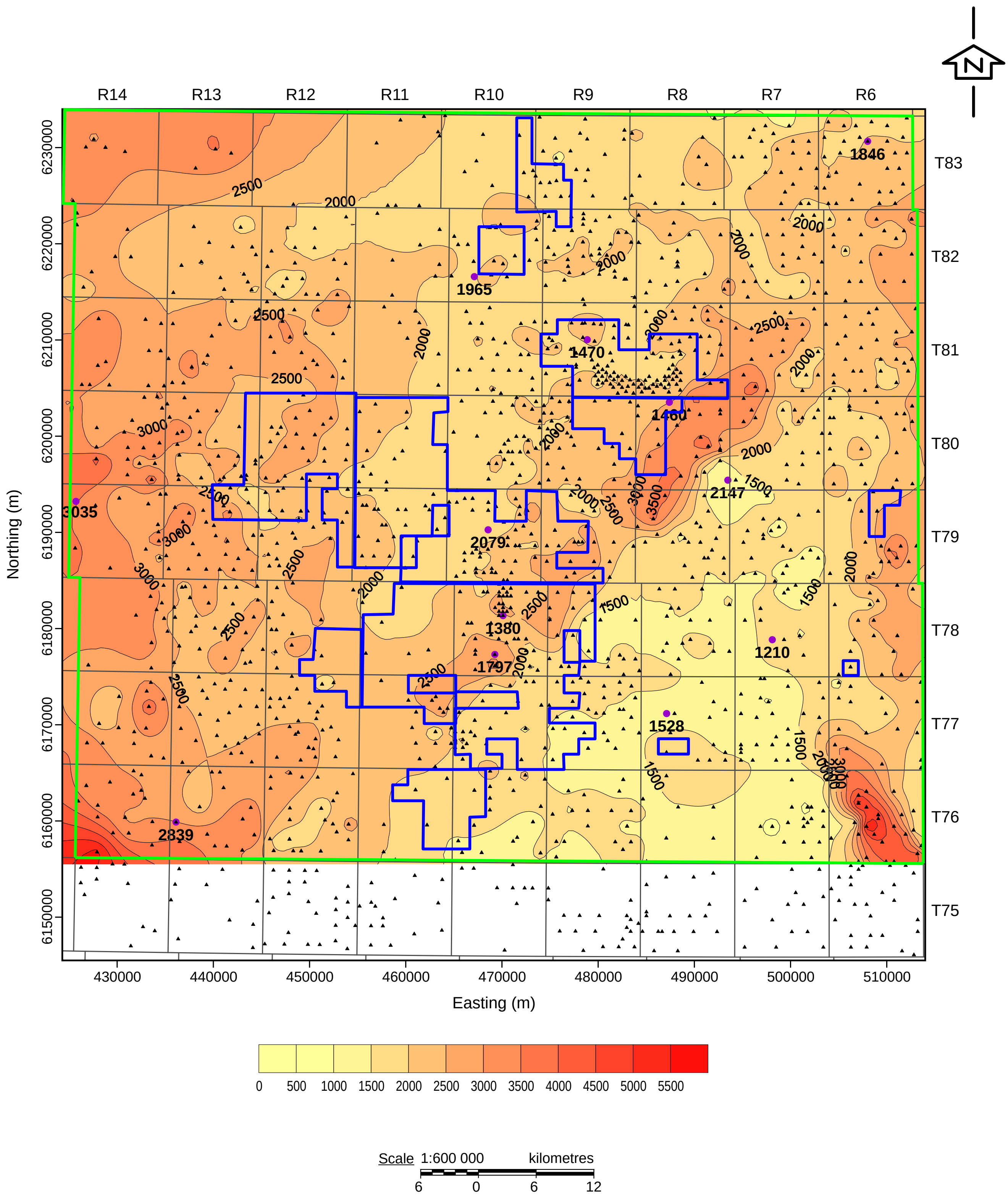
ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

UNDIFFERENTIATED GRAND RAPIDS FORMATION HYDRAULIC HEAD MAP

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/03/28	
File: 4455-STR-ISO-07.DWG		
Drawn by: GDE	Checked: BW	Fig. No.: **5.5-24**



LEGEND
- KAI KOS DEHSEH PROJECT
- GROUNDWATER SAMPLE
- LOCAL STUDY AREA (LSA)

NOTE:
Groundwater sample points were not honoured in contouring. Value shown for general correlation purposes.

REFERENCE: Regional Aquifer and Geology Mapping Study of the Mannville Group, Ranges 6 to 14, Townships 75 to 83, W4. April 2007, prepared by Westwater Environmental Ltd.

Title:

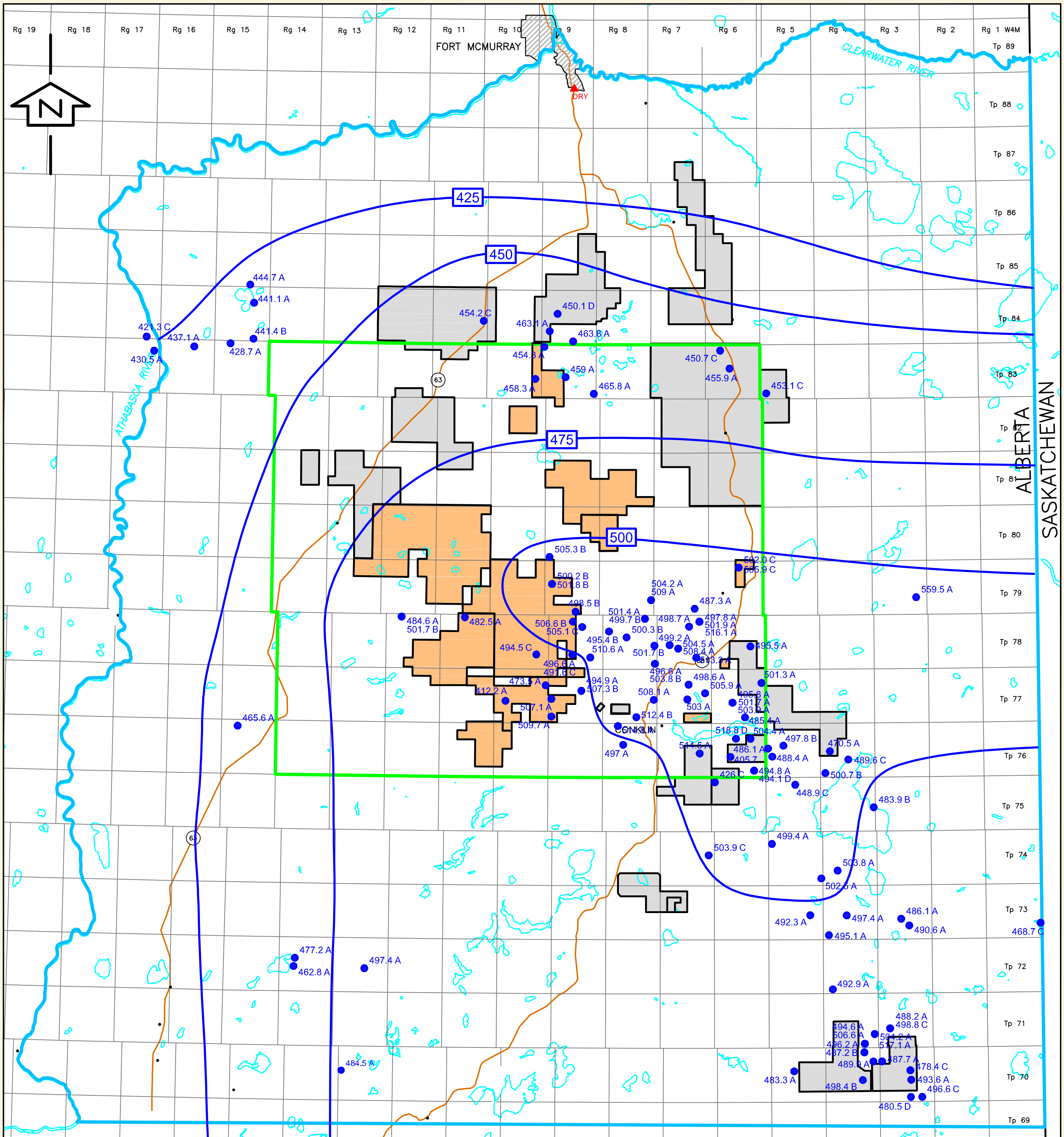
LOWER GRAND RAPIDS AQUIFER SALINITY

NORTH AMERICAN OIL SANDS CORPORATION

Approved: EG	Revision Date: 07/05/22

File: 4455-Struct-07.cdr

Drawn by:	Checked:	Fig. No.:
AP	EG	**5.5-25**



SCALE 1:1000000 kilometres

10 0 10 20

LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- LOCAL STUDY AREA (LSA)
- REGIONAL STUDY AREA (RSA)
- -450- INTERPRETED HYDRAULIC HEAD CONTOUR (masl)
- 444.5 C ● EQUIVALENT HYDRAULIC HEAD (masl), QUALITY CONTROL CODE
- 449.09 ▲ REPORTED HYDRAULIC HEAD VALUES (masl)

REFERENCE

ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

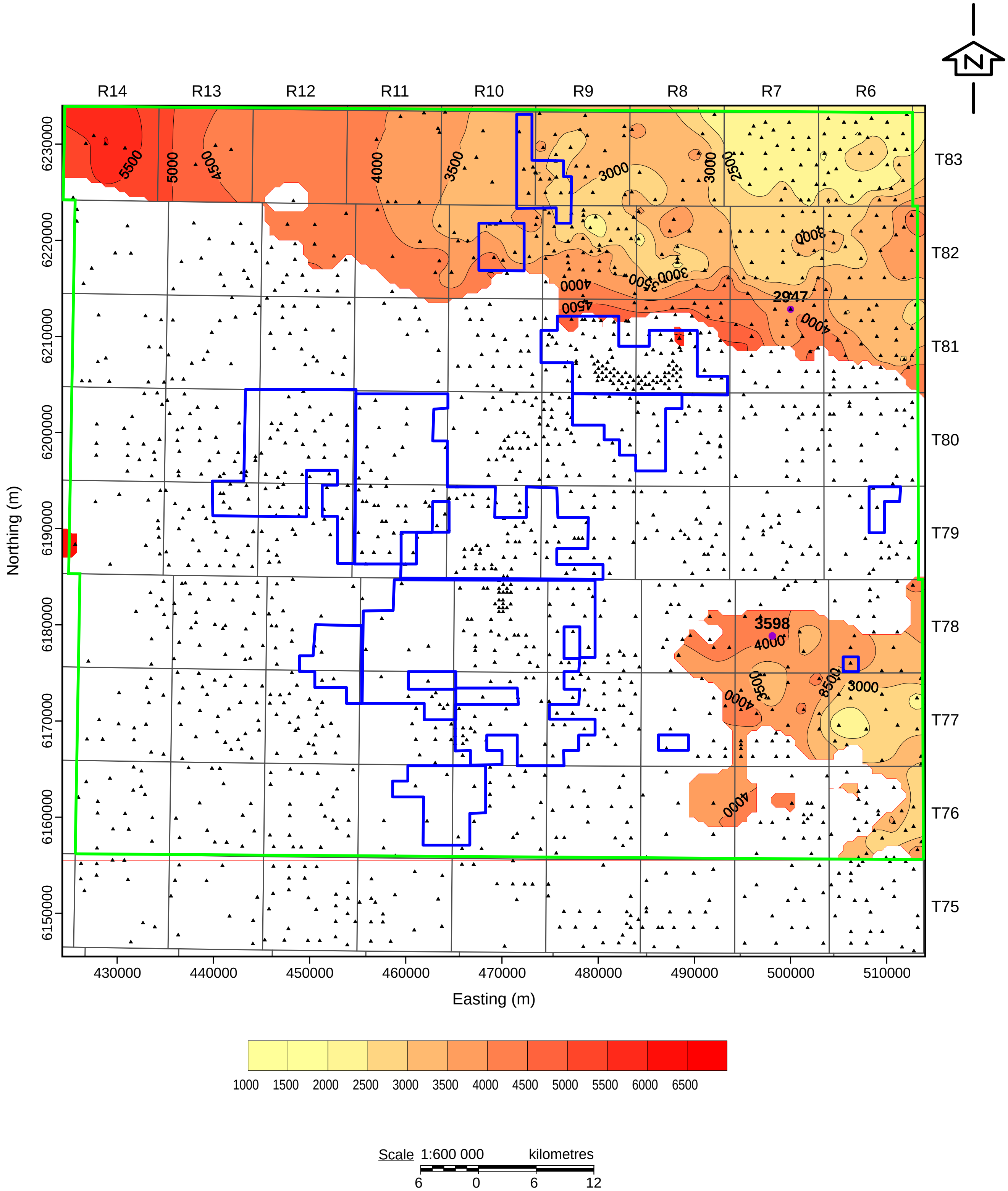
Title:

UNDIFFERENTIATED CLEARWATER FORMATION HYDRAULIC HEAD MAP

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/05/22
File: 4455-STR-ISO-07.DWG	

Drawn by:	Checked:	Fig. No.:
GDE	BW	5.5-26



LEGEND
- KAI KOS DEHSEH PROJECT
- GROUNDWATER SAMPLE
- LOCAL STUDY AREA (LSA)

NOTE:
Groundwater sample points were not honoured in contouring. Value shown for general correlation purposes.

REFERENCE: Regional Aquifer and Geology Mapping Study of the Mannville Group, Ranges 6 to 14, Townships 75 to 83, W4. April 2007, prepared by Westwater Environmental Ltd.

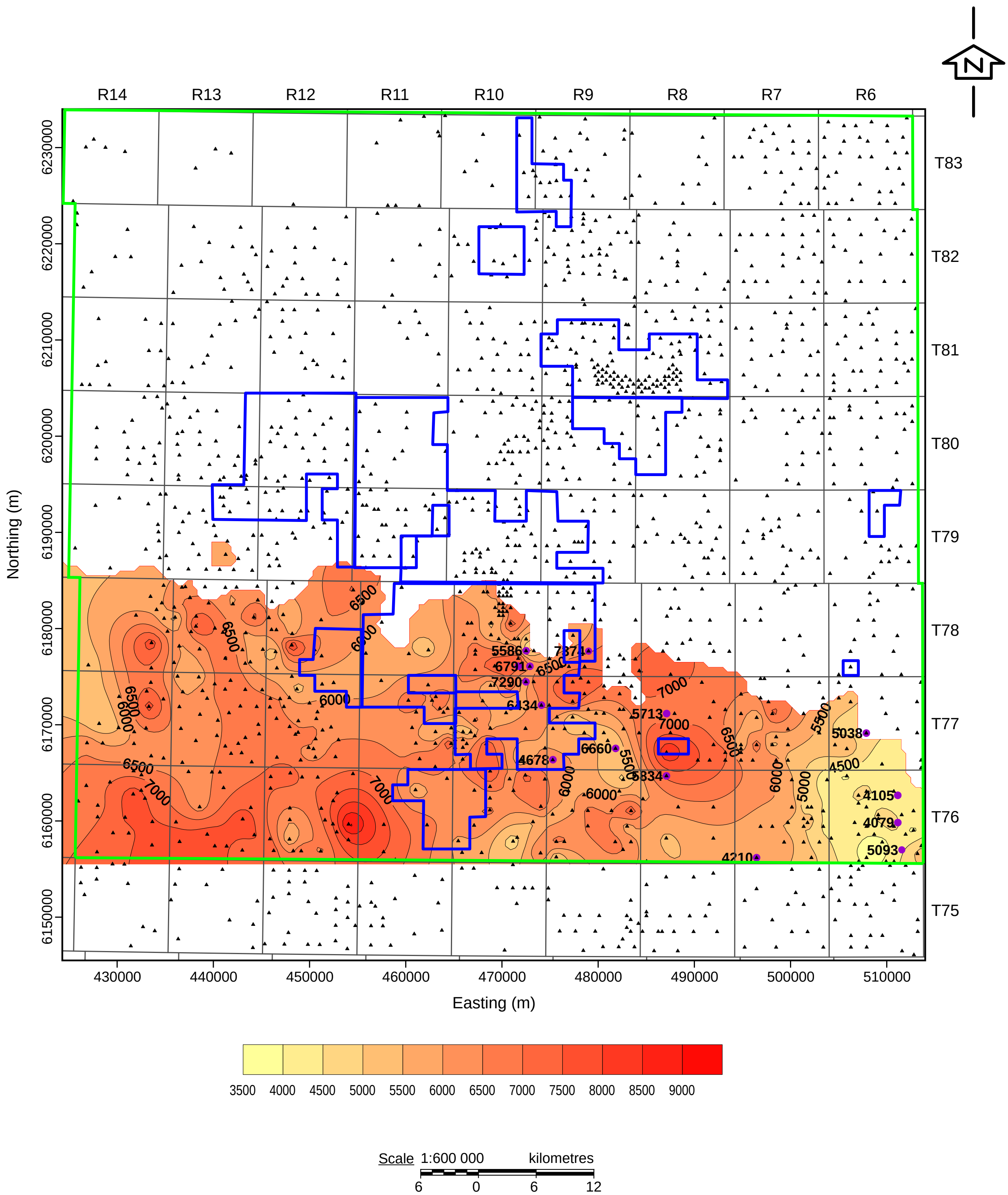
Title:

CLEARWATER A AQUIFER SALINITY

NORTH AMERICAN OIL SANDS CORPORATION

Approved: EG	Revision Date: 07/05/22
File: 4455-Struct-07.cdr	

Drawn by:	Checked:	Fig. No.:
AP	EG	5.5-27



LEGEND

KAI KOS DEHSEH PROJECT

GROUNDWATER SAMPLE

LOCAL STUDY AREA (LSA)

NOTE:
Groundwater sample points were not honoured in contouring. Value shown for general correlation purposes.

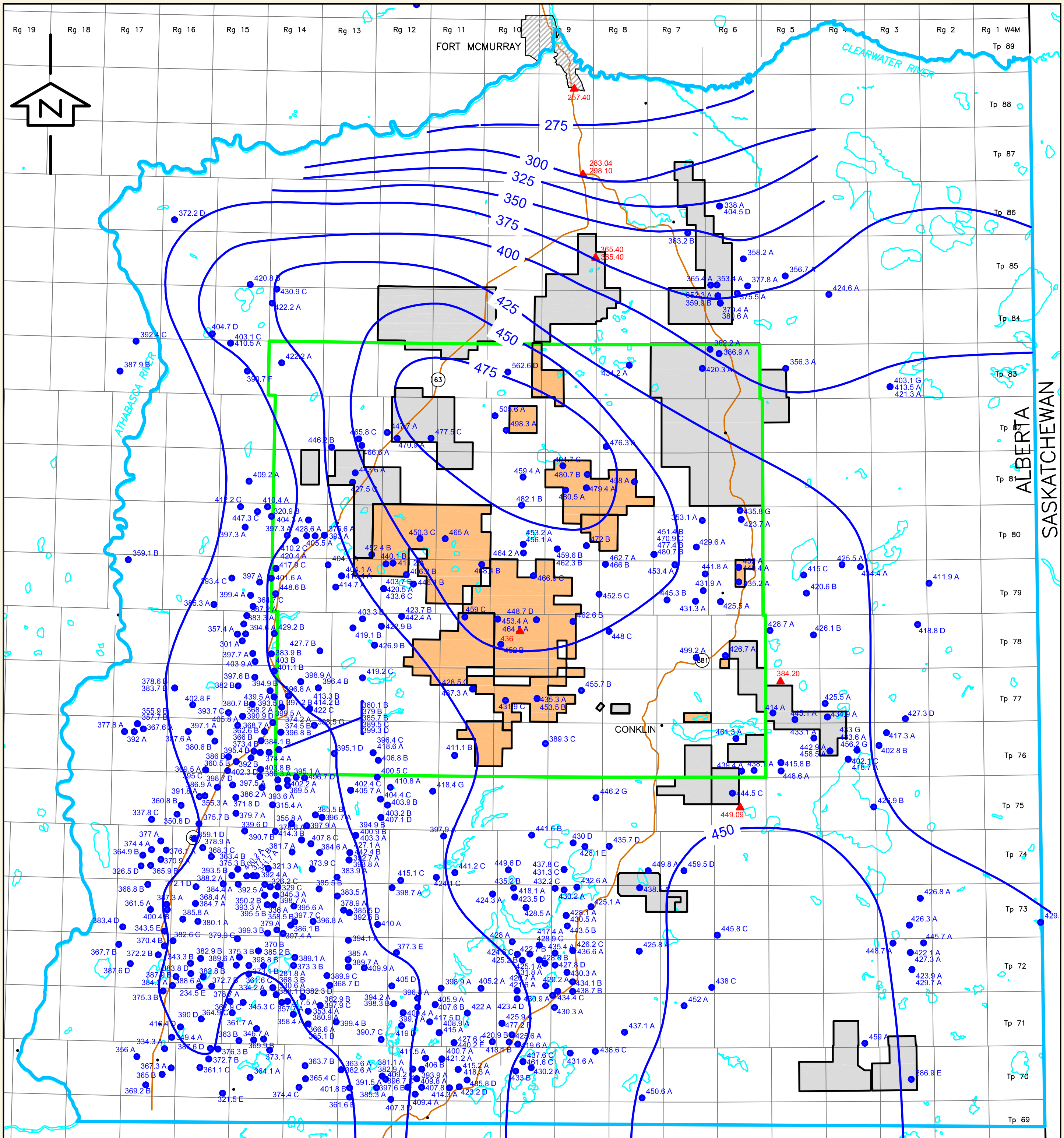
REFERENCE: Regional Aquifer and Geology Mapping Study of the Mannville Group, Ranges 6 to 14, Townships 75 to 83, W4. April 2007, prepared by Westwater Environmental Ltd.

Title:

CLEARWATER B AQUIFER SALINITY

NORTH AMERICAN OIL SANDS CORPORATION

Approved: EG	Revision Date: 07/05/22	
File: 4455-Struct-07.cdr		
Drawn by: AP	Checked: EG	Fig. No.: **5.5-28**



SCALE 1:1000000 kilometres

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LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- LOCAL STUDY AREA (LSA)
- REGIONAL STUDY AREA (RSA)
- -450- INTERPRETED HYDRAULIC HEAD CONTOUR (masl)
- 444.5 C ● EQUIVALENT HYDRAULIC HEAD (masl), QUALITY CONTROL CODE
- 449.09 ▲ REPORTED HYDRAULIC HEAD VALUES (masl)

REFERENCE

ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

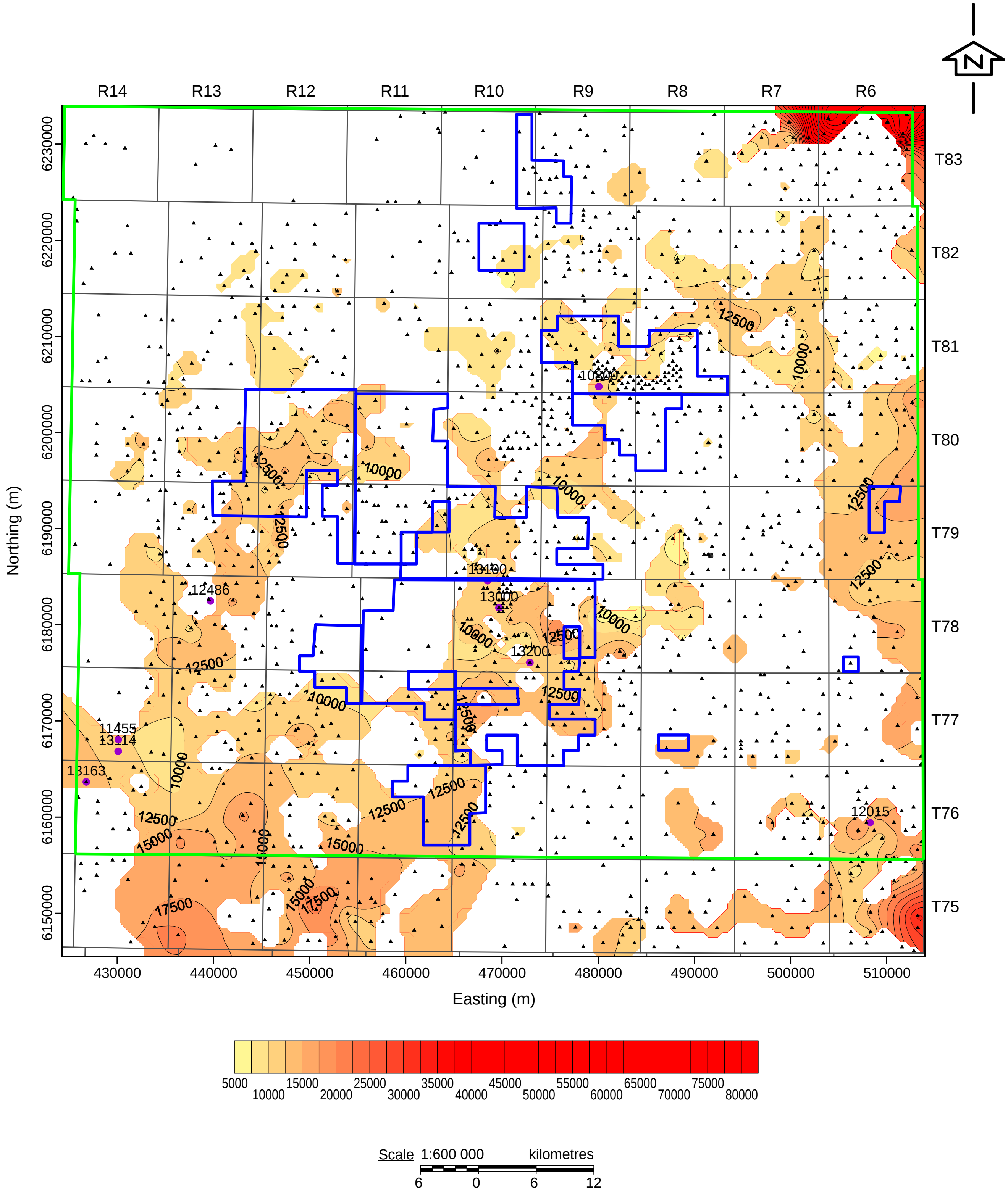
Title:

UNDIFFERENTIATED McMURRAY FORMATION HYDRAULIC HEAD MAP

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/05/22
File: 4455-STR-ISO-07.DWG	

Drawn by:	Checked:	Fig. No.:
GDE	BW	5.5-29



LEGEND

- KAI KOS DEHSEH PROJECT
- GROUNDWATER SAMPLE
- LOCAL STUDY AREA (LSA)

NOTE:
Groundwater sample points were not honoured in contouring. Value shown for general correlation purposes.

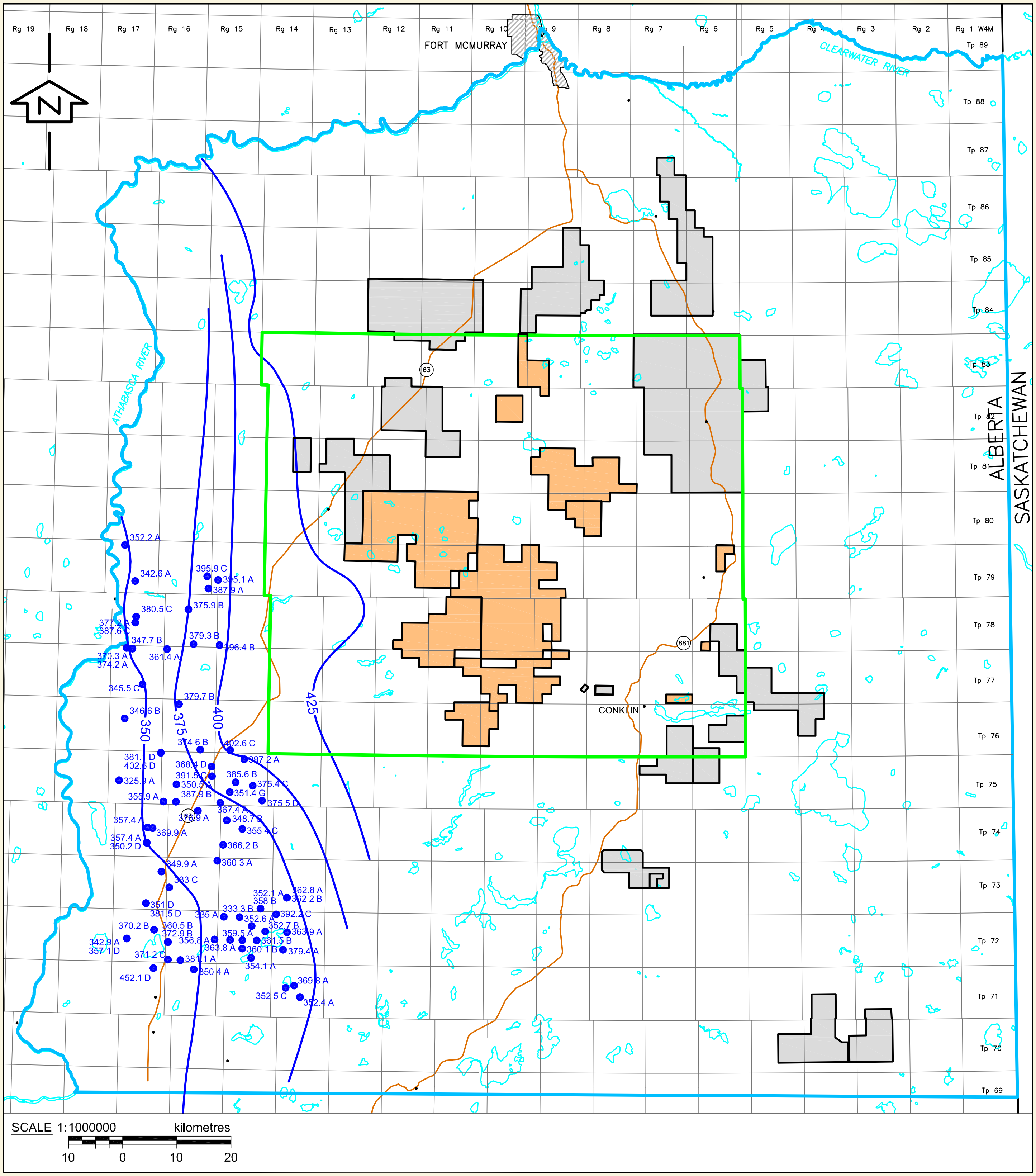
REFERENCE: Regional Aquifer and Geology Mapping Study of the Mannville Group, Ranges 6 to 14, Townships 75 to 83, W4. April 2007, prepared by Westwater Environmental Ltd.

Title:

BASAL McMURRAY AQUIFER SALINITY

NORTH AMERICAN OIL SANDS CORPORATION

Approved: EG	Revision Date: 07/05/22	
File: 4455-Struct-07.cdr		
Drawn by: AP	Checked: EG	Fig. No.: **5.5-30**



LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- LOCAL STUDY AREA (LSA)
- REGIONAL STUDY AREA (RSA)
- 350 INTERPRETED HYDRAULIC HEAD CONTOUR (masl)
- 346.6 B ● EQUIVALENT HYDRAULIC HEAD (masl), QUALITY CONTROL CODE

REFERENCE

ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

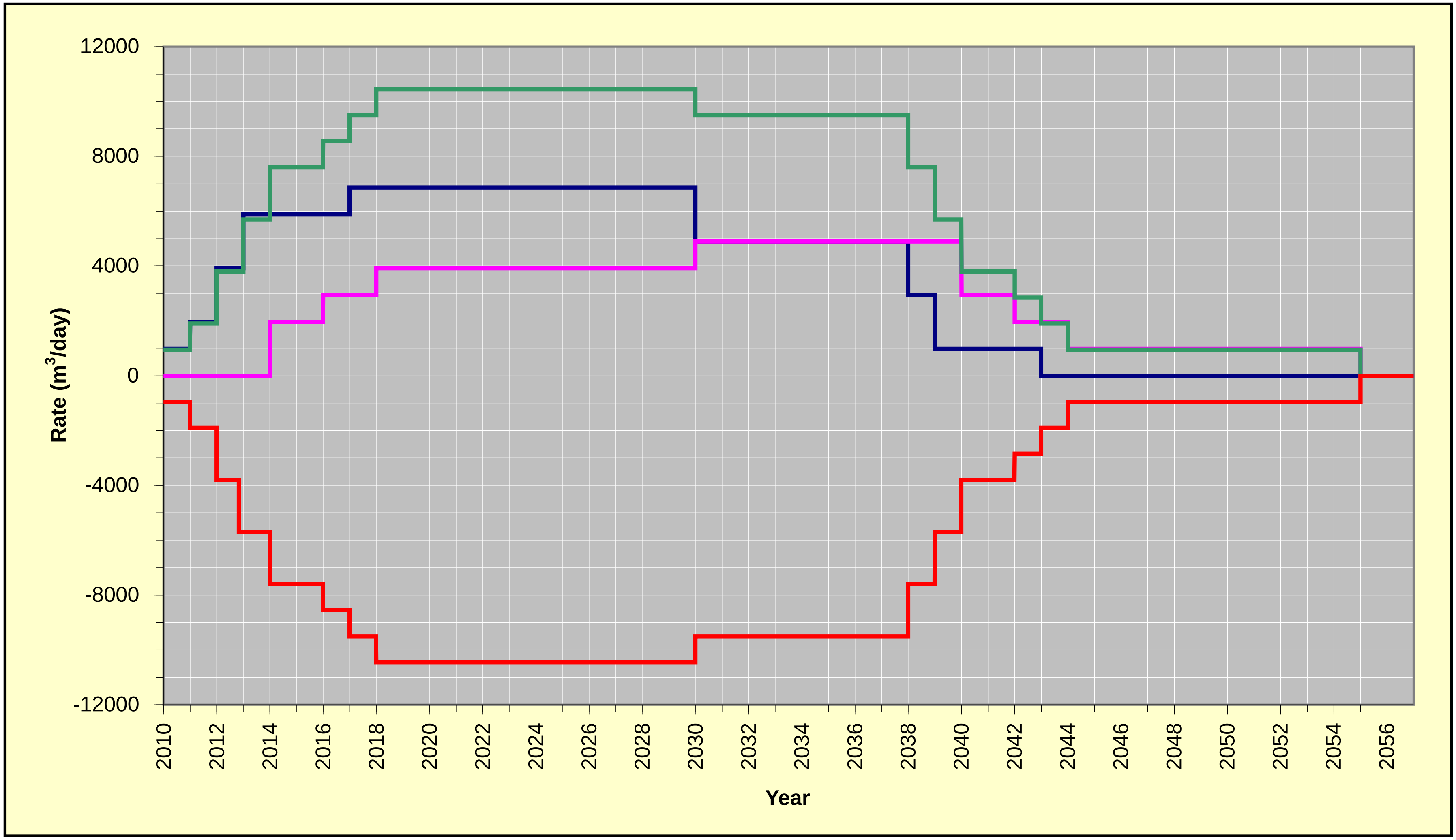
Title:

GROSMONT FORMATION HYDRAULIC HEADS

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/05/22
File: 4455-STR-ISO-07.DWG	

Drawn by:	Checked:	Fig. No.:
GDE	BW	5.5-31

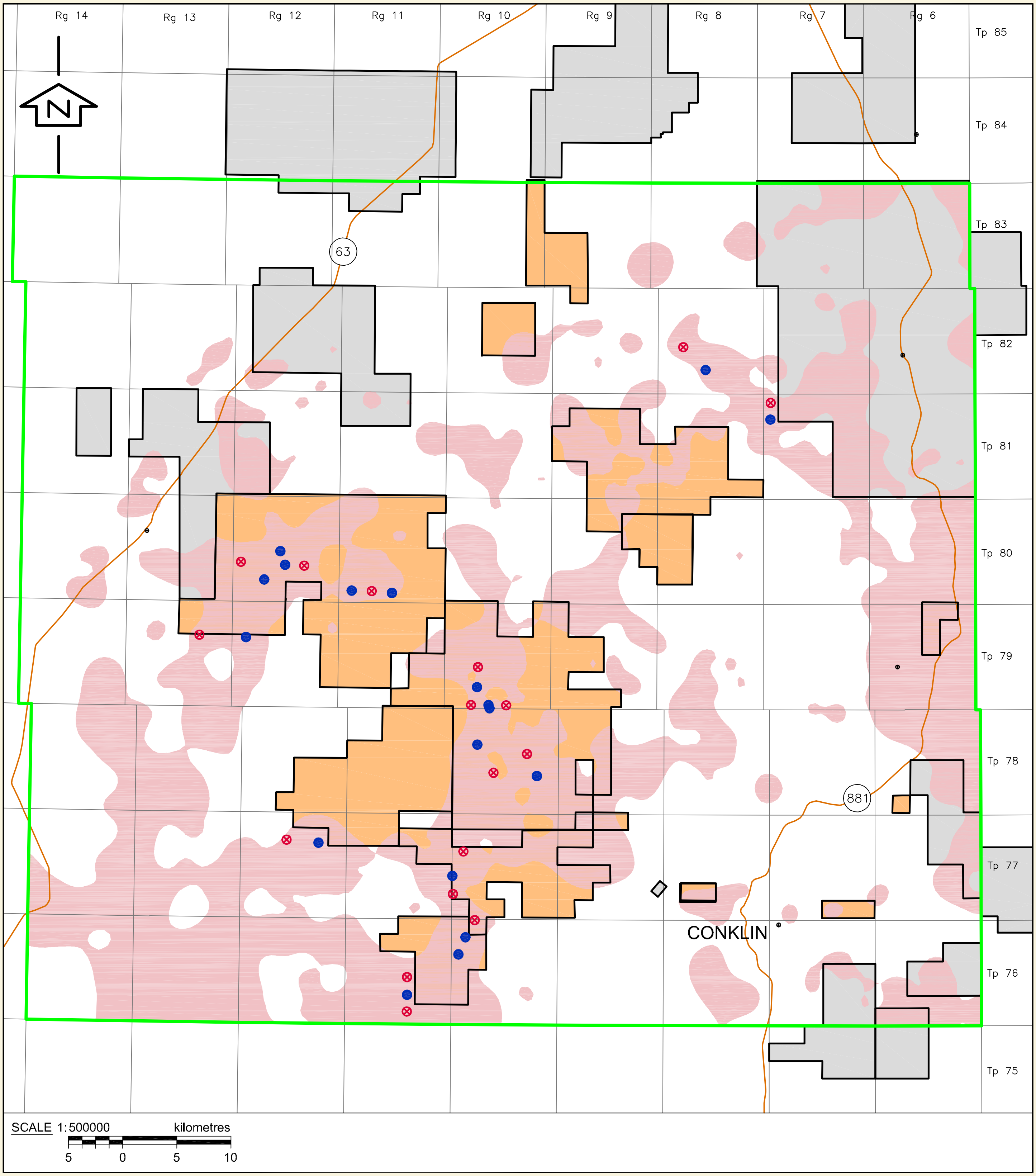


Title:

KAI KOS DEHSEH PUMPING SCHEDULE

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP		Revision Date: 07/06/02
File: 4455-ImpAssess-07.cdr		
Drawn by: GDE	Checked: BW	Fig. No.: **5.6-1**



LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- LOCAL STUDY AREA (LSA)
- SOURCE WELL
- DISPOSAL WELL
- BASAL McMURRAY AQUIFER

REFERENCE

ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

PROPOSED BASAL McMURRAY AQUIFER WELLS

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/03/28
File: 4455-IMPACTASSESS-07.DWG	

Drawn by:	Checked:	Fig. No.:
GDE	BW	5.6-2

*PLOT 1:1 = Letter (P)

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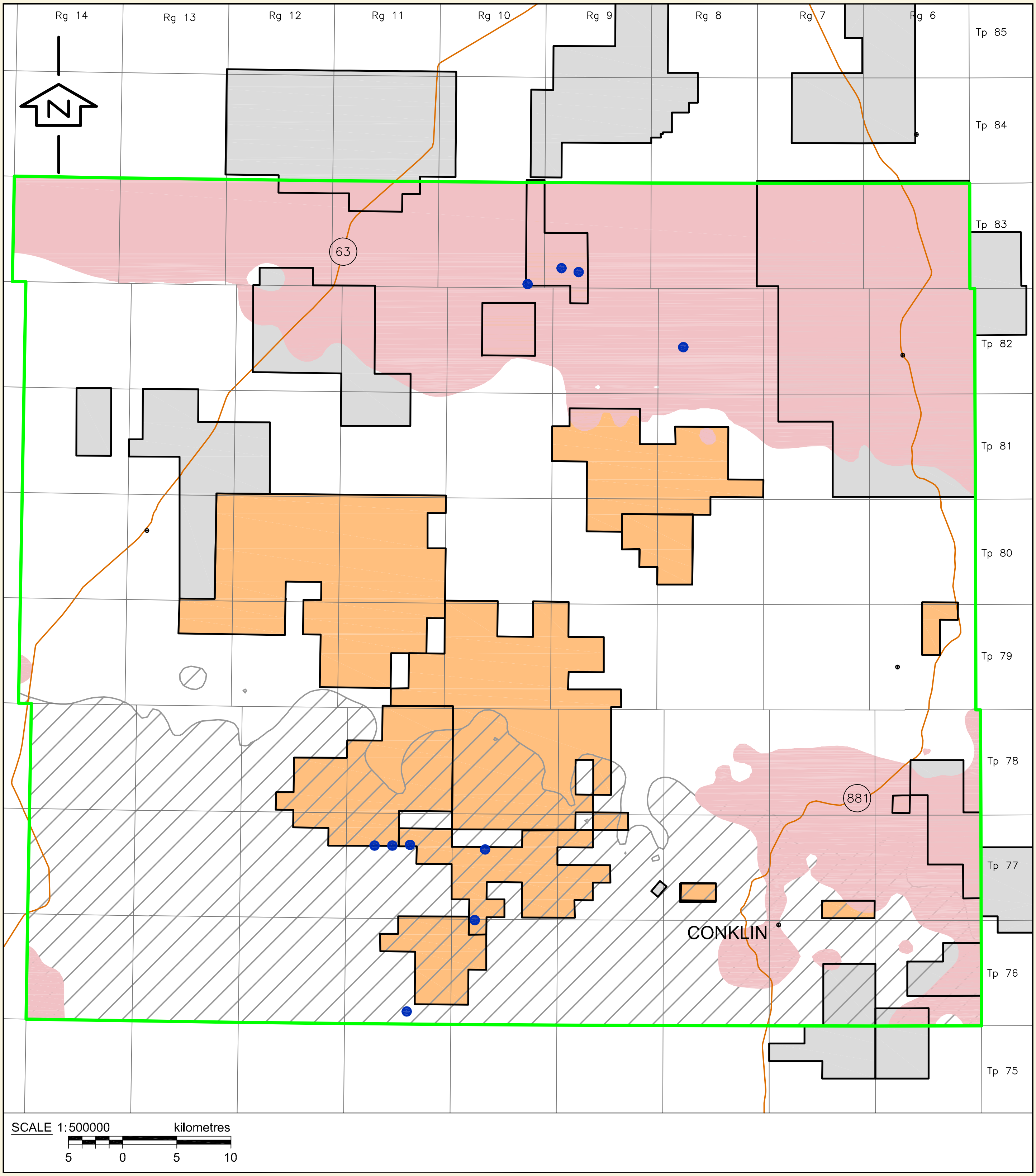


LEGEND
- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- LOCAL STUDY AREA (LSA)
- SOURCE WELL
- CLEARWATER A AQUIFER
- CLEARWATER B AQUIFER

REFERENCE
ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

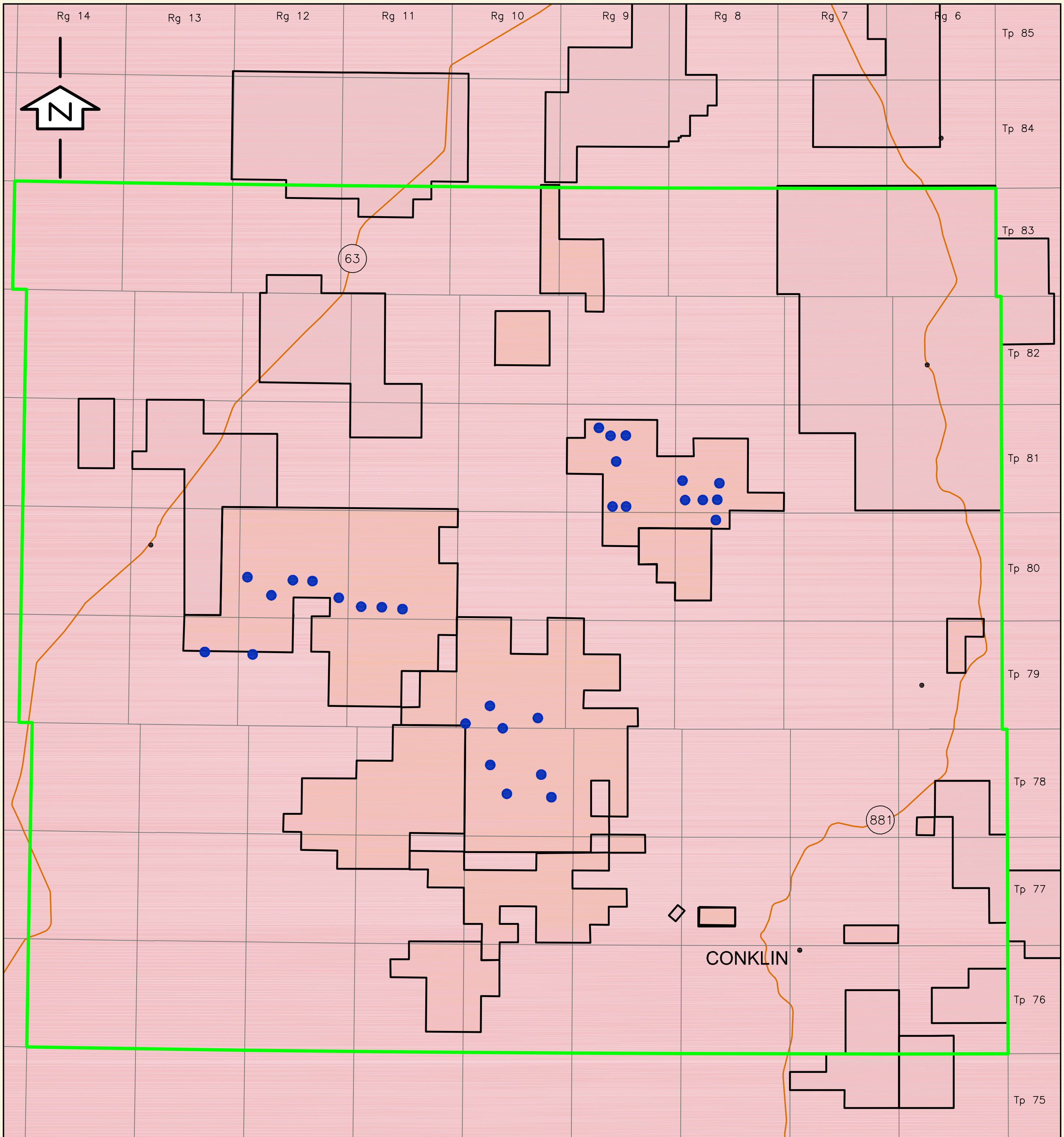
Title:

PROPOSED CLEARWATER A & B AQUIFER WELLS

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/03/28
File: 4455-IMPACTASSESS-07.DWG	

Drawn by:	Checked:	Fig. No.:
GDE	BW	5.6-3



SCALE 1:500000 kilometres

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LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- LOCAL STUDY AREA (LSA)
- LOWER GRAND RAPIDS AQUIFER
- SOURCE WELL

REFERENCE

ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

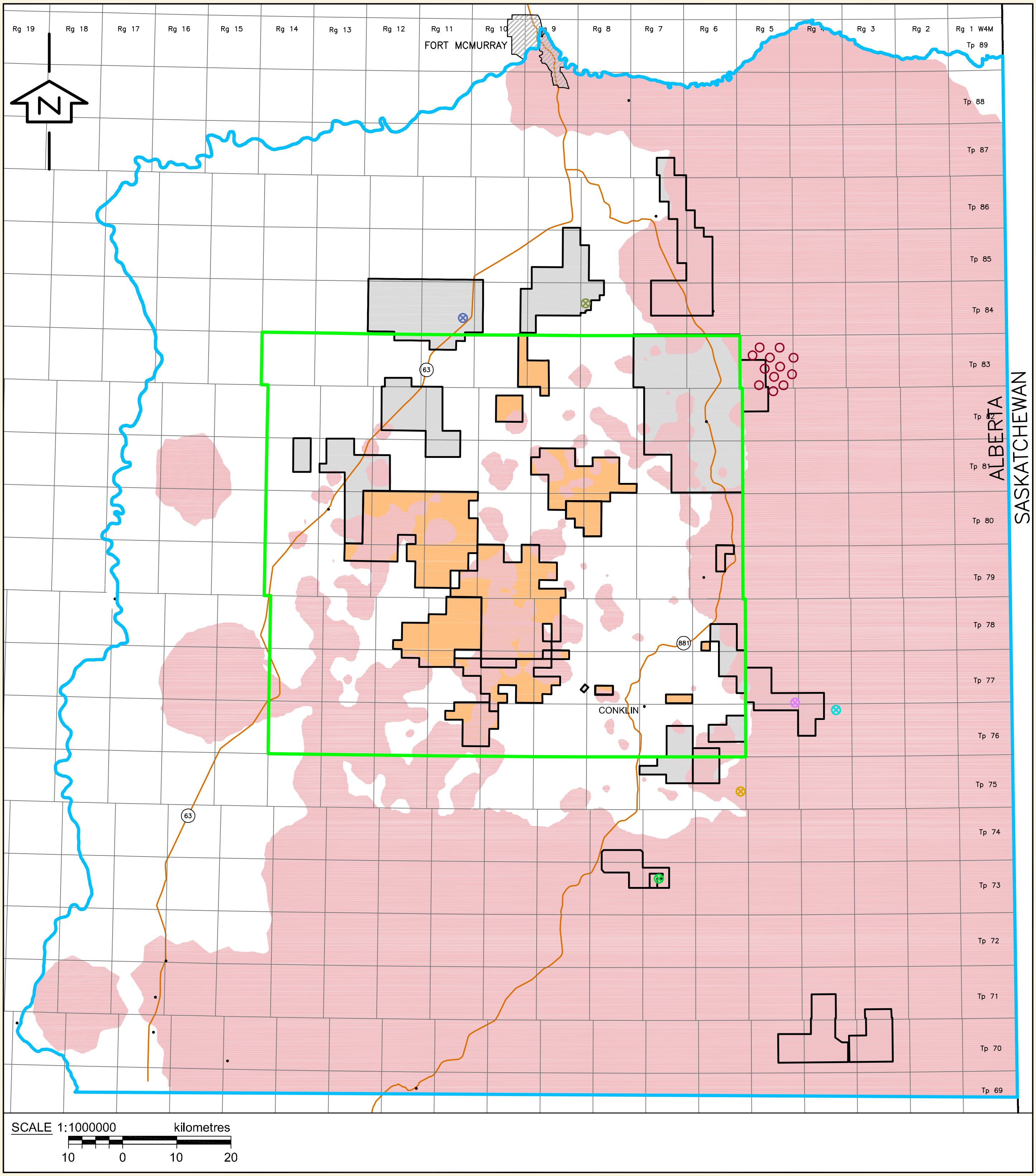
Title:

PROPOSED LOWER GRAND RAPIDS AQUIFER WELLS

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/03/28	
File: 4455-IMPACTASSESS-07.DWG		
Drawn by: GDE	Checked: BW	Fig. No.: **5.6-4**

*PLOT 1:1 = Letter (P)



LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- LOCAL STUDY AREA (LSA)
- REGIONAL STUDY AREA (RSA)
- DISPOSAL/SOURCE WELL - CONOCOPHILLPS
- BASAL McMURRAY AQUIFER
- DISPOSAL WELL - CNRL
- DISPOSAL WELL - DEVON
- DISPOSAL WELL - ENCANA
- DISPOSAL WELL - JACOS
- DISPOSAL WELL - MEG
- DISPOSAL WELL - PETRO-CAN

REFERENCE

ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

GROUNDWATER WELLS USED FOR BASELINE CASE BASAL McMURRAY AQUIFER

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/03/28	
File: 4455-IMPACTASSESS-07.DWG		
Drawn by: GDE	Checked: BW	Fig. No.: **5.6-5**

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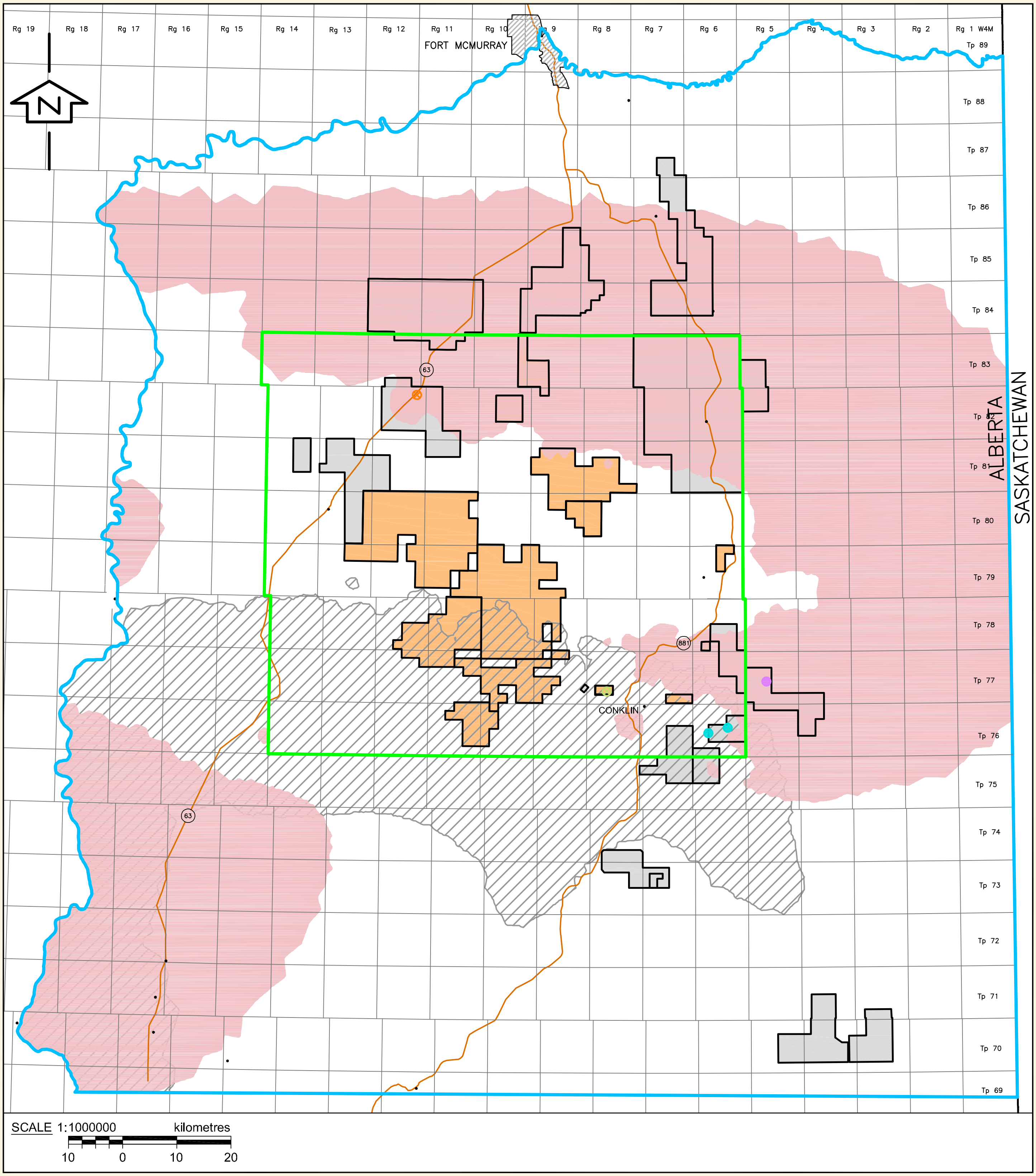

LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- LOCAL STUDY AREA (LSA)
- REGIONAL STUDY AREA (RSA)
- CLEARWATER A AQUIFER
- CLEARWATER B AQUIFER
- DISPOSAL WELL - CONNACHER
- DISPOSAL WELL - PETROBANK
- SOURCE WELL - ENCANA
- SOURCE WELL - MEG

REFERENCE
ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

GROUNDWATER WELLS USED FOR BASELINE CASE CLEARWATER A & B AQUIFER

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP | Revision Date: 07/03/28

File: 4455-IMPACTASSESS-07.DWG

Drawn by: GDE | Checked: BW | Fig. No.: 5.6-6

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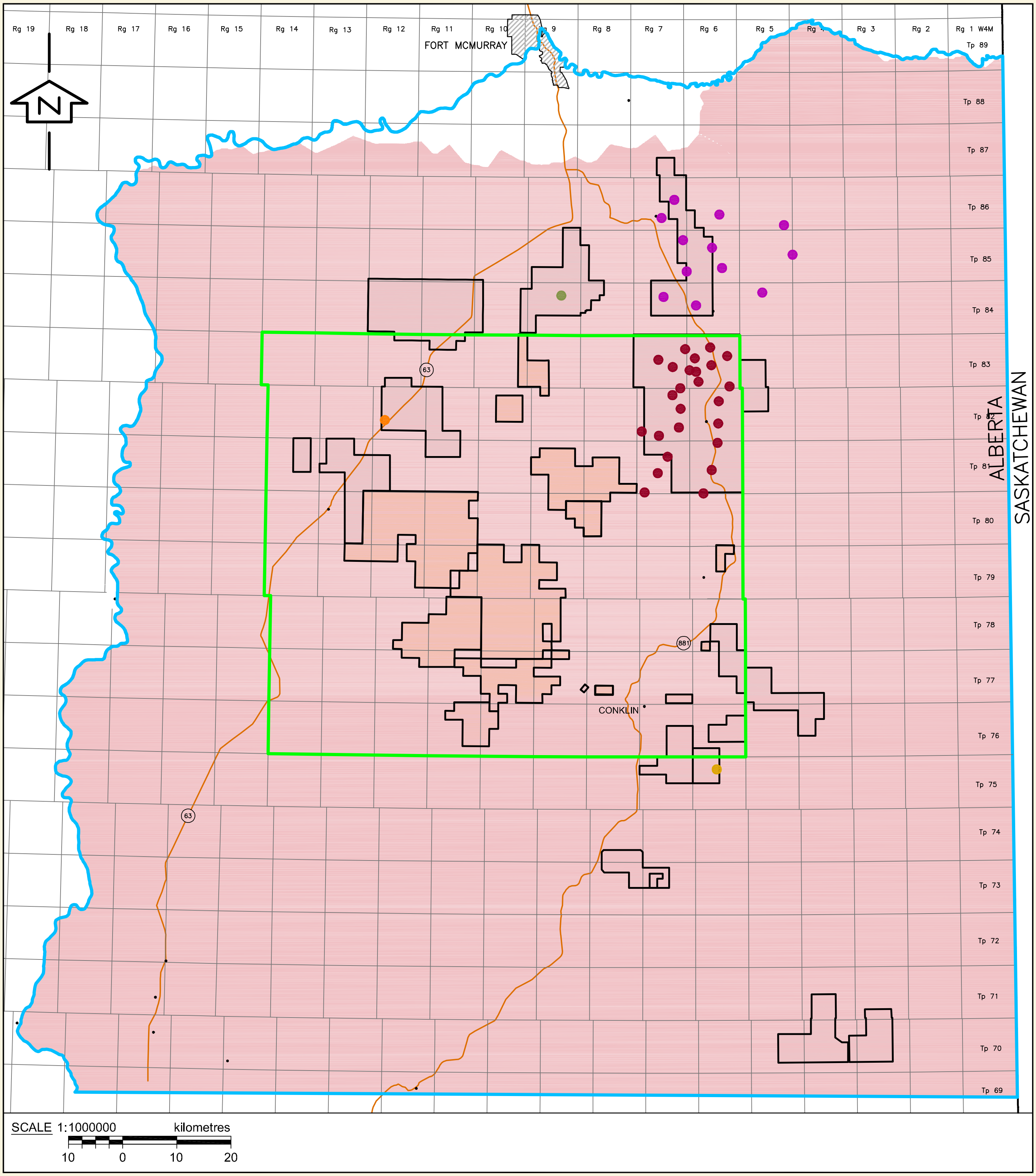
"PLOT 1:1 = Letter (P)



LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- LOCAL STUDY AREA (LSA)
- REGIONAL STUDY AREA (RSA)
- LOWER GRAND RAPIDS AQUIFER
- SOURCE WELL - CONNACHER
- SOURCE WELL - DEVON
- SOURCE WELL - OPTI-NEXEN
- SOURCE WELL - PETRO CANADA
- SOURCE WELL - CONOCOPHILLIPS

REFERENCE
ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

GROUNDWATER WELLS USED FOR BASELINE CASE LOWER GRAND RAPIDS AQUIFER

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/03/28
File: 4455-IMPACTASSESS-07.DWG	

Drawn by:	Checked:	Fig. No.:
GDE	BW	5.6-7

*PLOT 1:1 = Letter (P)

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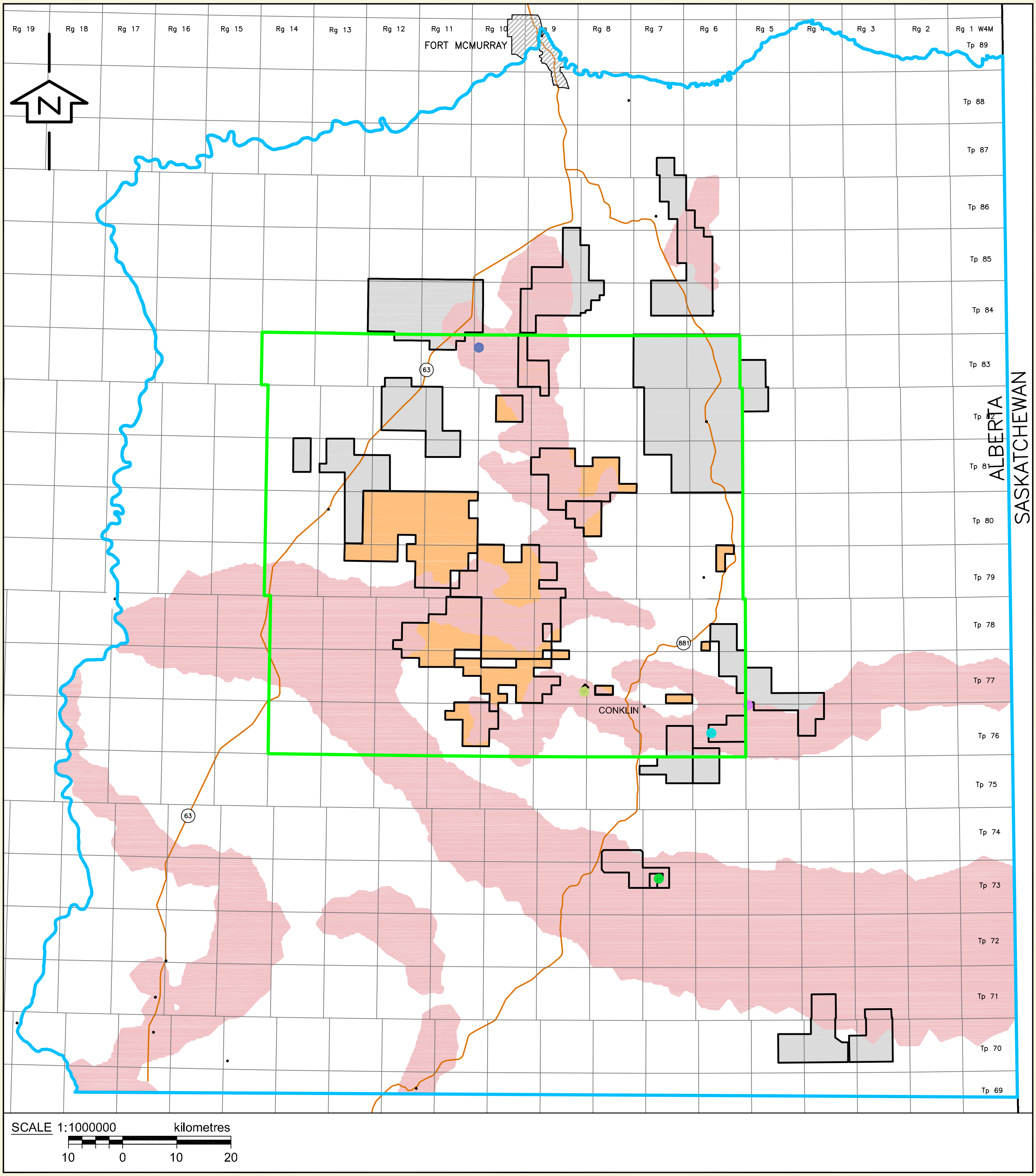


LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- LOCAL STUDY AREA (LSA)
- REGIONAL STUDY AREA (RSA)
- EMPRESS CHANNEL AQUIFER
- SOURCE WELL - CNRL
- SOURCE WELL - ENCANA
- SOURCE WELL - JACOS
- SOURCE WELL - MEG
- SOURCE WELL - PETROBANK

REFERENCE
ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

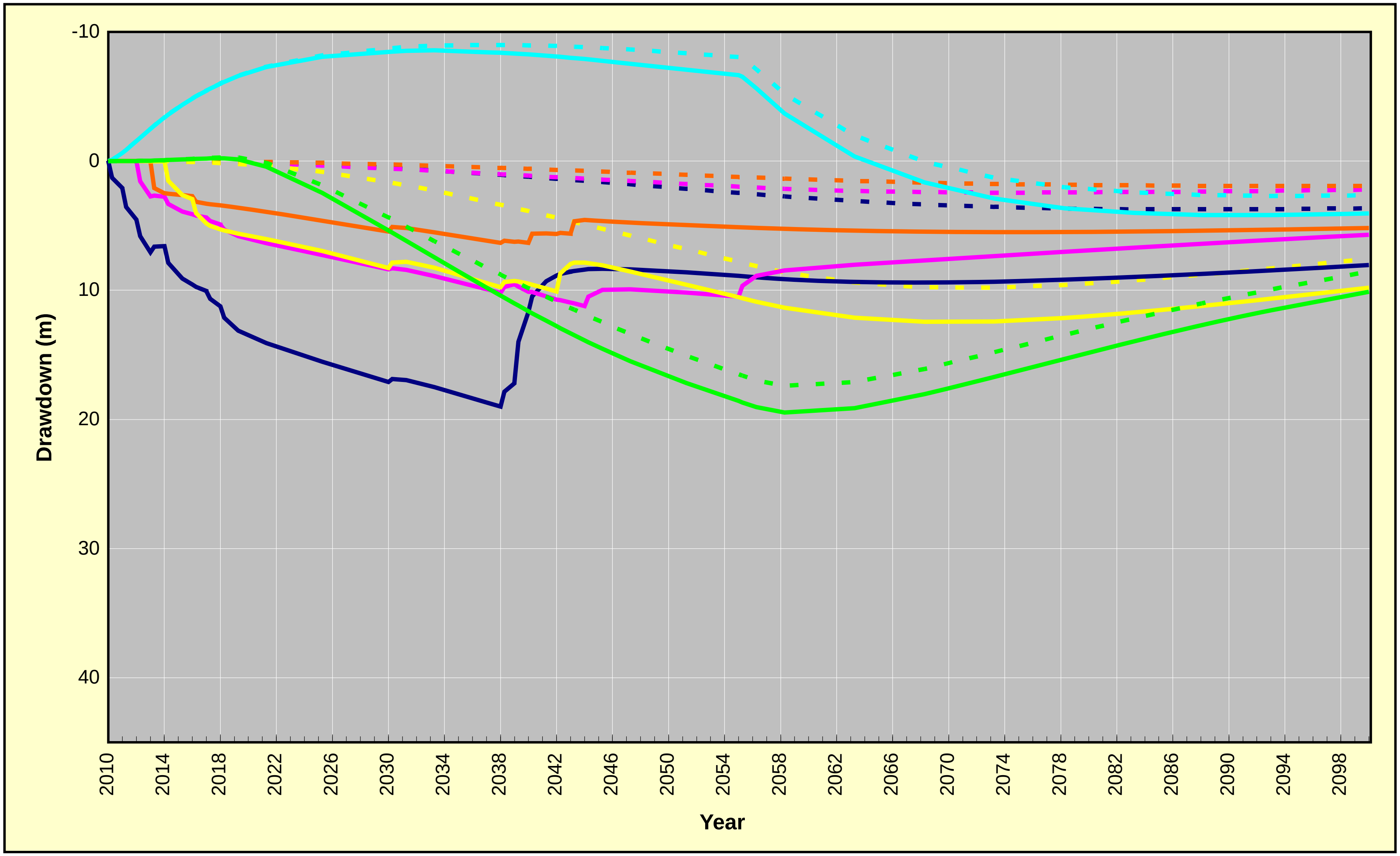
Title:

GROUNDWATER WELLS USED FOR BASELINE CASE EMPRESS CHANNEL AQUIFER

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/03/28
File: 4455-IMPACTASSESS-07.DWG	

Drawn by:	Checked:	Fig. No.:
GDE	BW	**5.6-8**



- Leismer Baseline
- Leismer Application
- EnCana Baseline
- EnCana Application
- South Leismer Baseline
- South Leismer Application
- Thornbury Baseline
- Thornbury Application
- Surmont Baseline
- Surmont Application
- Corner Baseline
- Corner Application

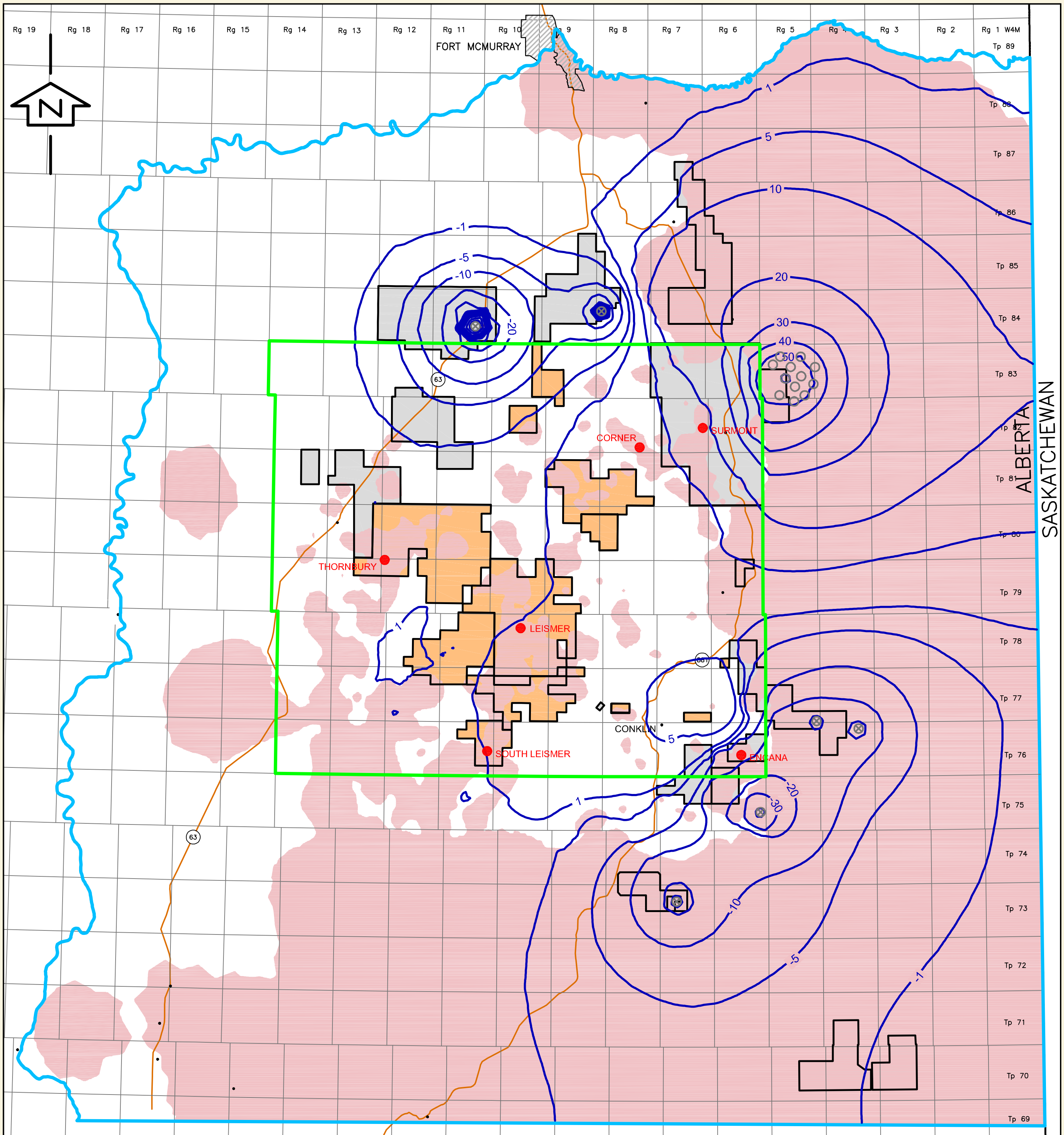
Title:

SIMLULATED DRAWDOWN AT OBSERVATION WELLS BASAL McMURRAY AQUIFER (BASELINE vs. APPLICATION CASE)

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/06/02
File: 4455-ImpAssess-07.cdr	
Drawn by: GDE	Checked: BW
Fig. No.: **5.6-9**	

*PLOT 1:1 = Letter (P)



SCALE 1:1000000 kilometres
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LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- LOCAL STUDY AREA (LSA)
- REGIONAL STUDY AREA (RSA)
- BASAL McMURRAY AQUIFER
- 10 SIMULATED BASELINE DRAWDOWN (m)
- OBSERVATION WELL
- DISPOSAL WELL
- DISPOSAL/SOURCE WELL

REFERENCE
ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

SIMULATED BASELINE DRAWDOWN BASAL McMURRAY AQUIFER (END OF 2037)

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/03/28
File: 4455-IMPACTASSESS-07.DWG	

Drawn by:	Checked:	Fig. No.:
GDE	BW	5.6-10

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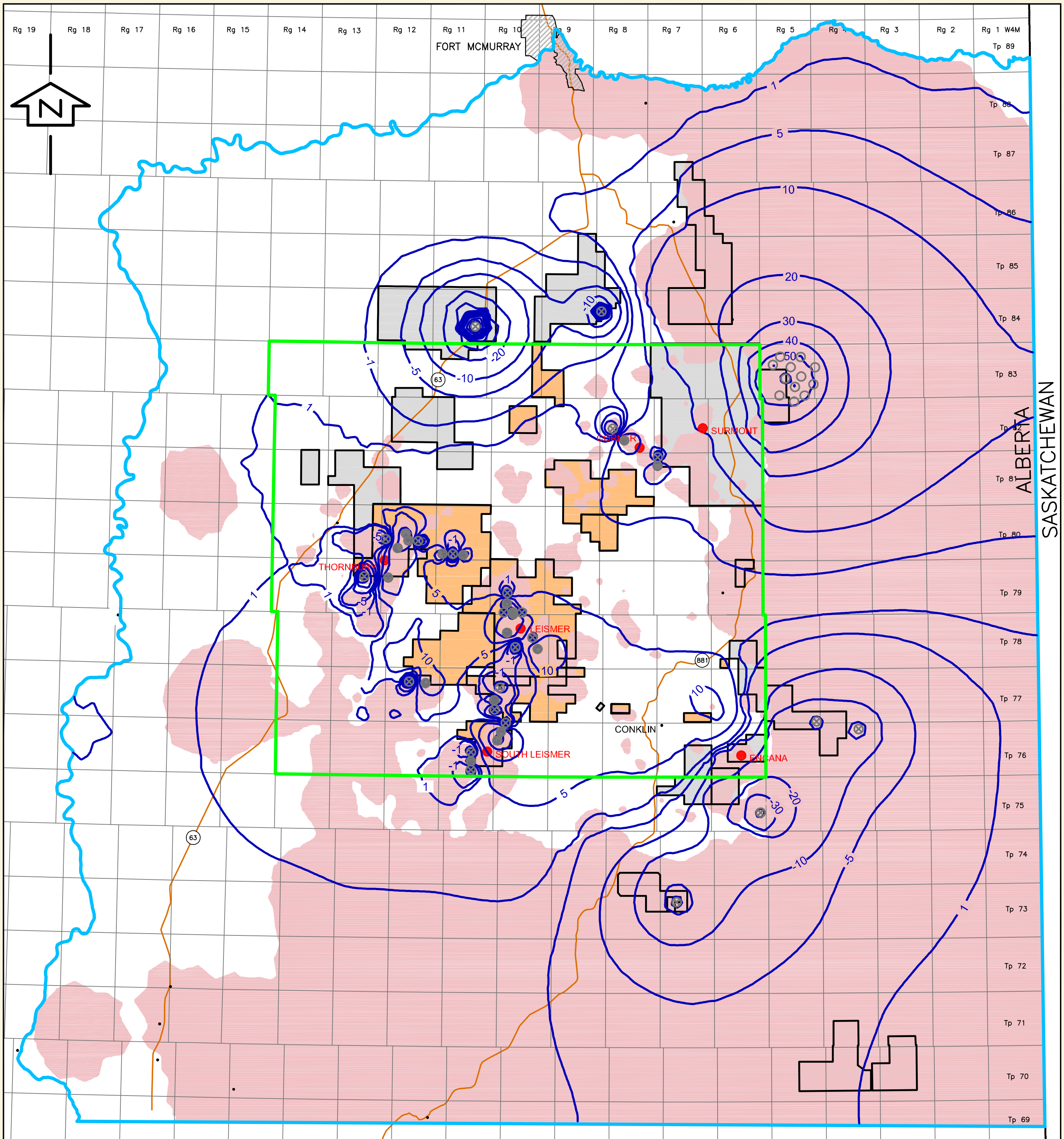


SCALE 1:1000000 kilometres

10 0 10 20

LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- LOCAL STUDY AREA (LSA)
- REGIONAL STUDY AREA (RSA)
- BASAL McMURRAY AQUIFER
- 10 SIMULATED APPLICATION DRAWDOWN (m)
- OBSERVATION WELL
- DISPOSAL WELL
- SOURCE WELL
- DISPOSAL/SOURCE WELL

REFERENCE

ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

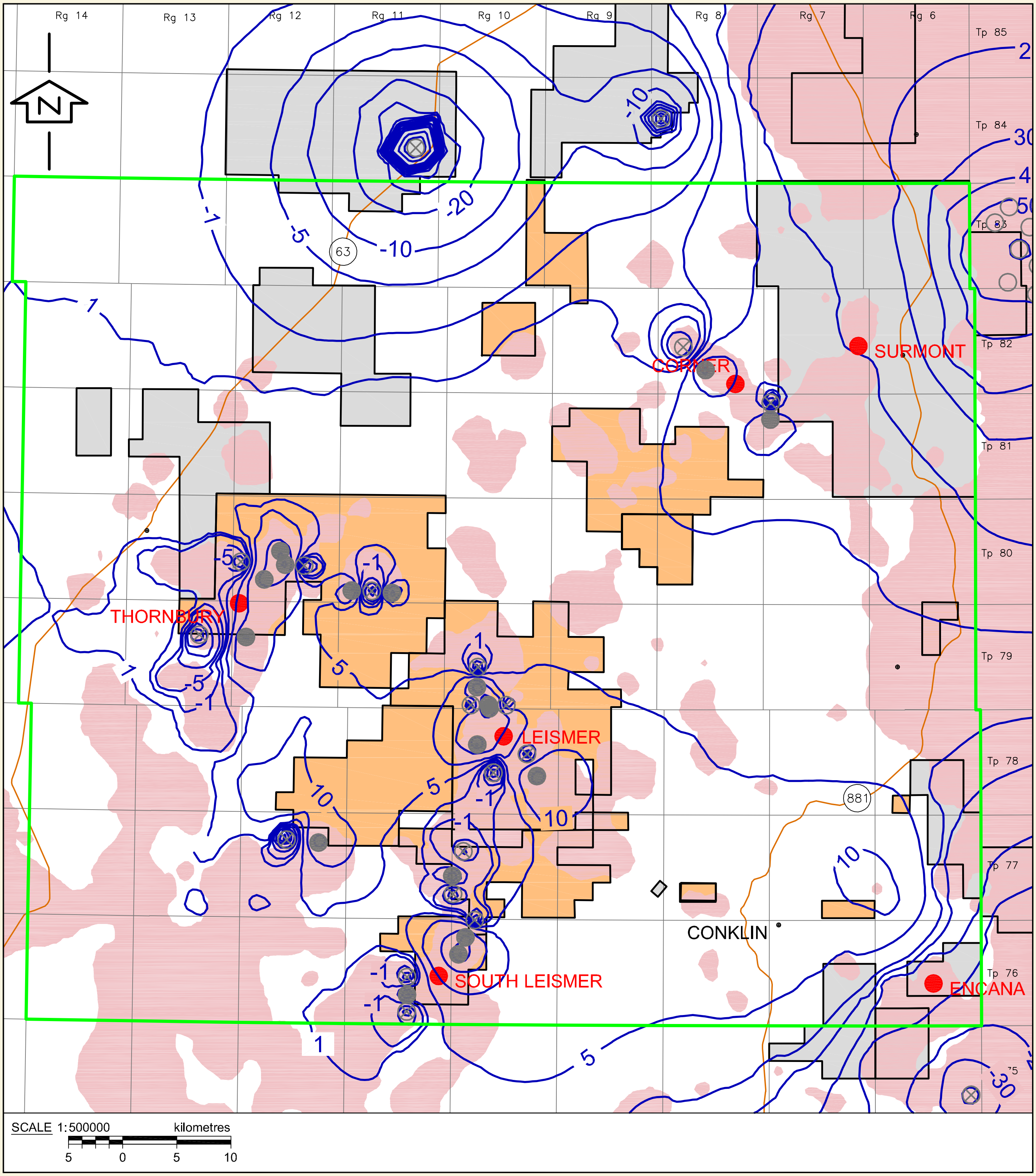
Title:

SIMULATED APPLICATION DRAWDOWN BASAL McMURRAY AQUIFER (END OF 2037)

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/03/28	
File: 4455-IMPACTASSESS-07.DWG		
Drawn by: GDE	Checked: BW	Fig. No.: 5.6-11

*PLOT 1:1 = Letter (P)



LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- LOCAL STUDY AREA (LSA)
- REGIONAL STUDY AREA (RSA)
- BASAL McMURRAY AQUIFER
- 10 SIMULATED APPLICATION DRAWDOWN (m)
- OBSERVATION WELL
- DISPOSAL WELL
- SOURCE WELL
- DISPOSAL/SOURCE WELL

REFERENCE
ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

SIMULATED APPLICATION DRAWDOWN (LSA) BASAL McMURRAY AQUIFER (END OF 2037)

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/03/28
File: 4455-IMPACTASSESS-07.DWG	

Drawn by:	Checked:	Fig. No.:
GDE	BW	5.6-12

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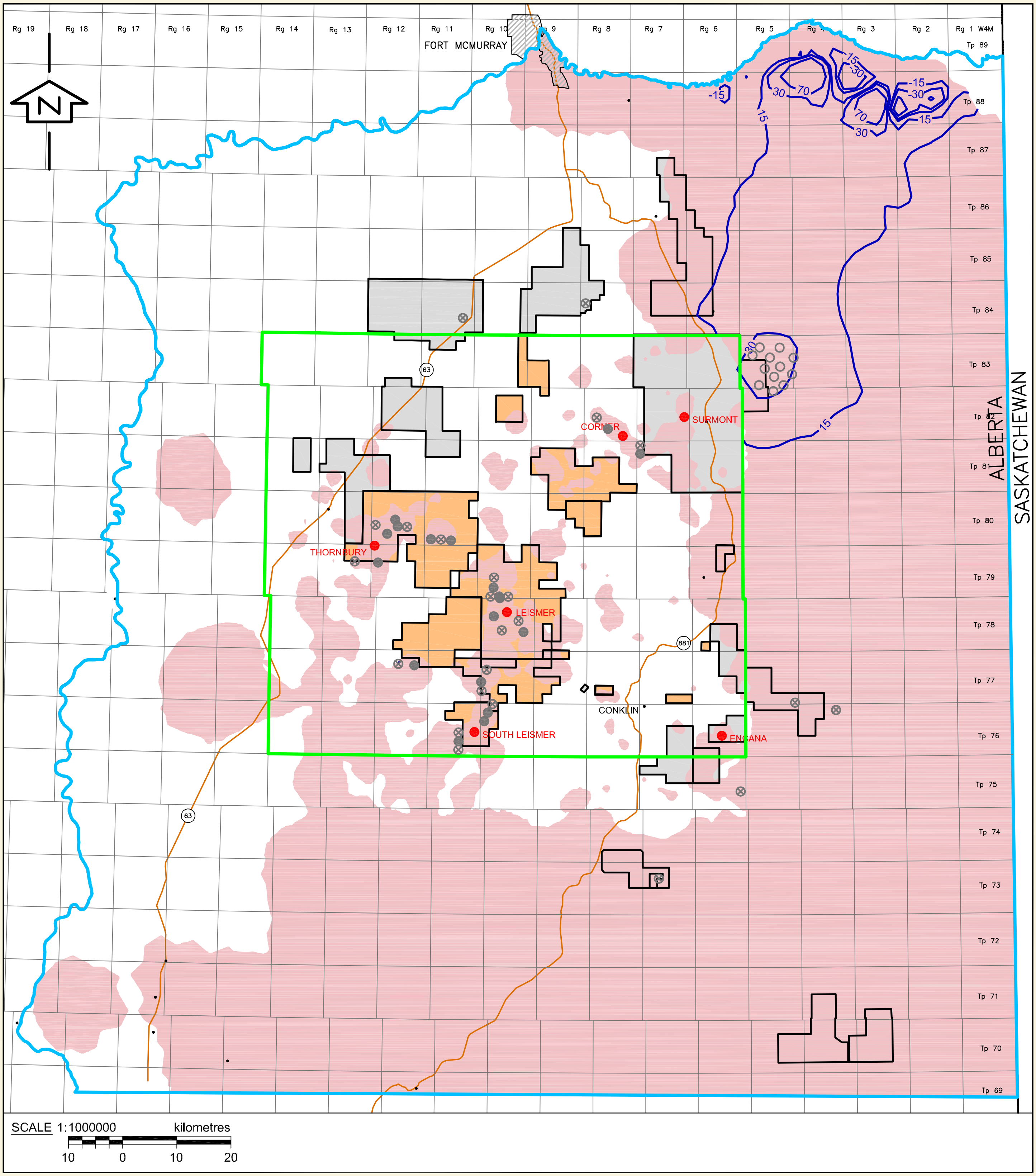

LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- LOCAL STUDY AREA (LSA)
- REGIONAL STUDY AREA (RSA)
- BASAL McMURRAY AQUIFER
- 10 SIMULATED CHANGE %AP
- OBSERVATION WELL
- DISPOSAL WELL
- SOURCE WELL
- DISPOSAL/SOURCE WELL

REFERENCE
ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

SIMULATED CHANGE IN BASAL McMURRAY AQUIFER PRODUCTIVITY - APPLICATION CASE (END OF 2037)

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/03/28
File: 4455-IMPACTASSESS-07.DWG	

Drawn by: GDE	Checked: BW	Fig. No.: 5.6-13

*PLOT 1:1 = Letter (P)

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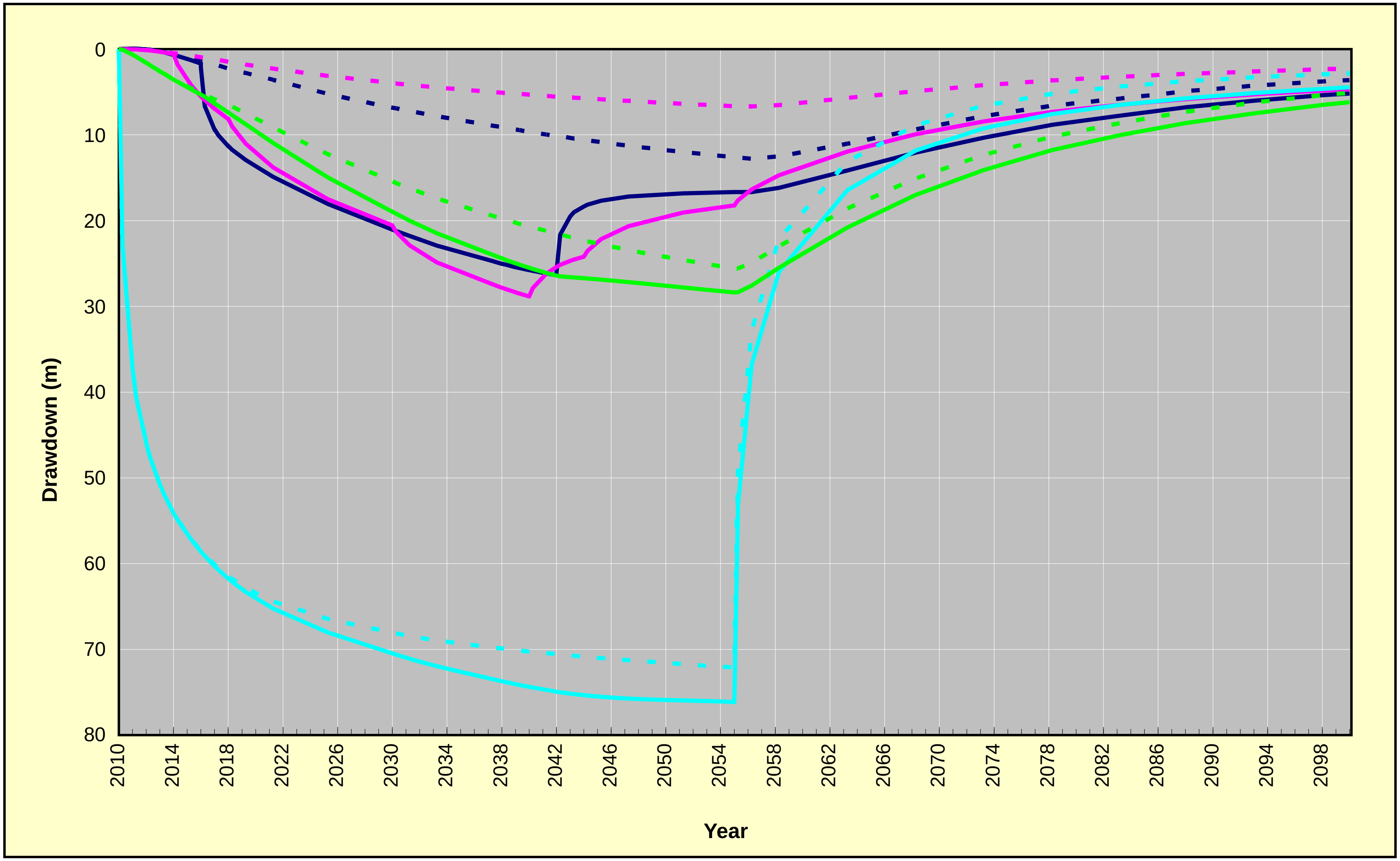
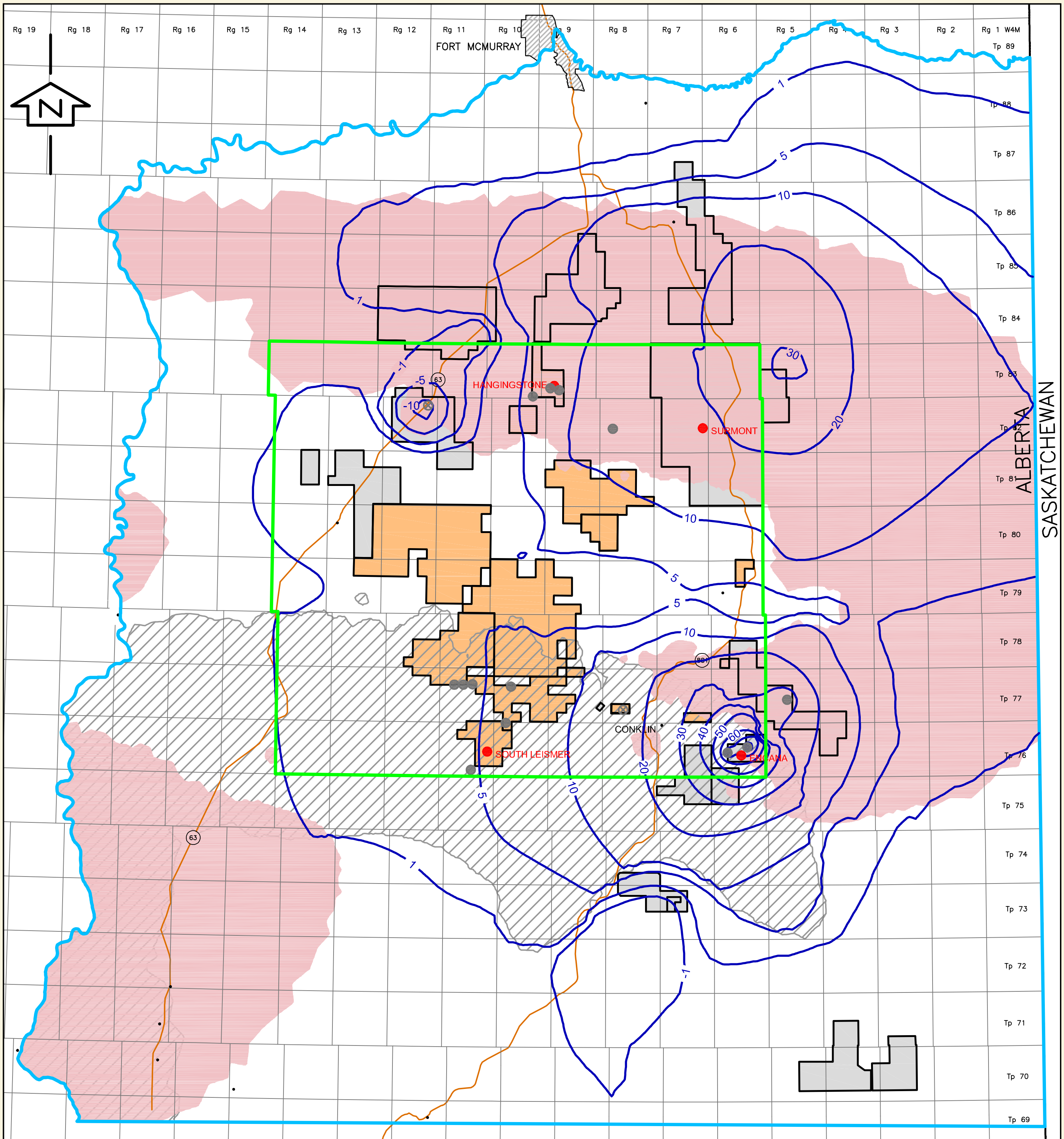


Hangingstone Baseline
Hangingstone Application
EnCana Baseline
EnCana Application
South Leismer Baseline
South Leismer Application
Surmont Baseline
Surmont Application

Title: SIMLULATED DRAWDOWN AT OBSERVATION WELLS CLEARWATER A & B AQUIFERS (BASELINE vs. APPLICATION CASE)	NORTH AMERICAN OIL SANDS CORPORATION	
	Approved: RP	Revision Date: 07/06/02
	File: 4455-ImpAssess-07.cdr	
	Drawn by: GDE	Checked: BW
	Fig. No.: 5.6-14	



LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- LOCAL STUDY AREA (LSA)
- REGIONAL STUDY AREA (RSA)
- CLEARWATER A AQUIFER
- CLEARWATER B AQUIFER
- 10 SIMULATED BASELINE DRAWDOWN (m)
- OBSERVATION WELL
- DISPOSAL WELL
- SOURCE WELL

REFERENCE

ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

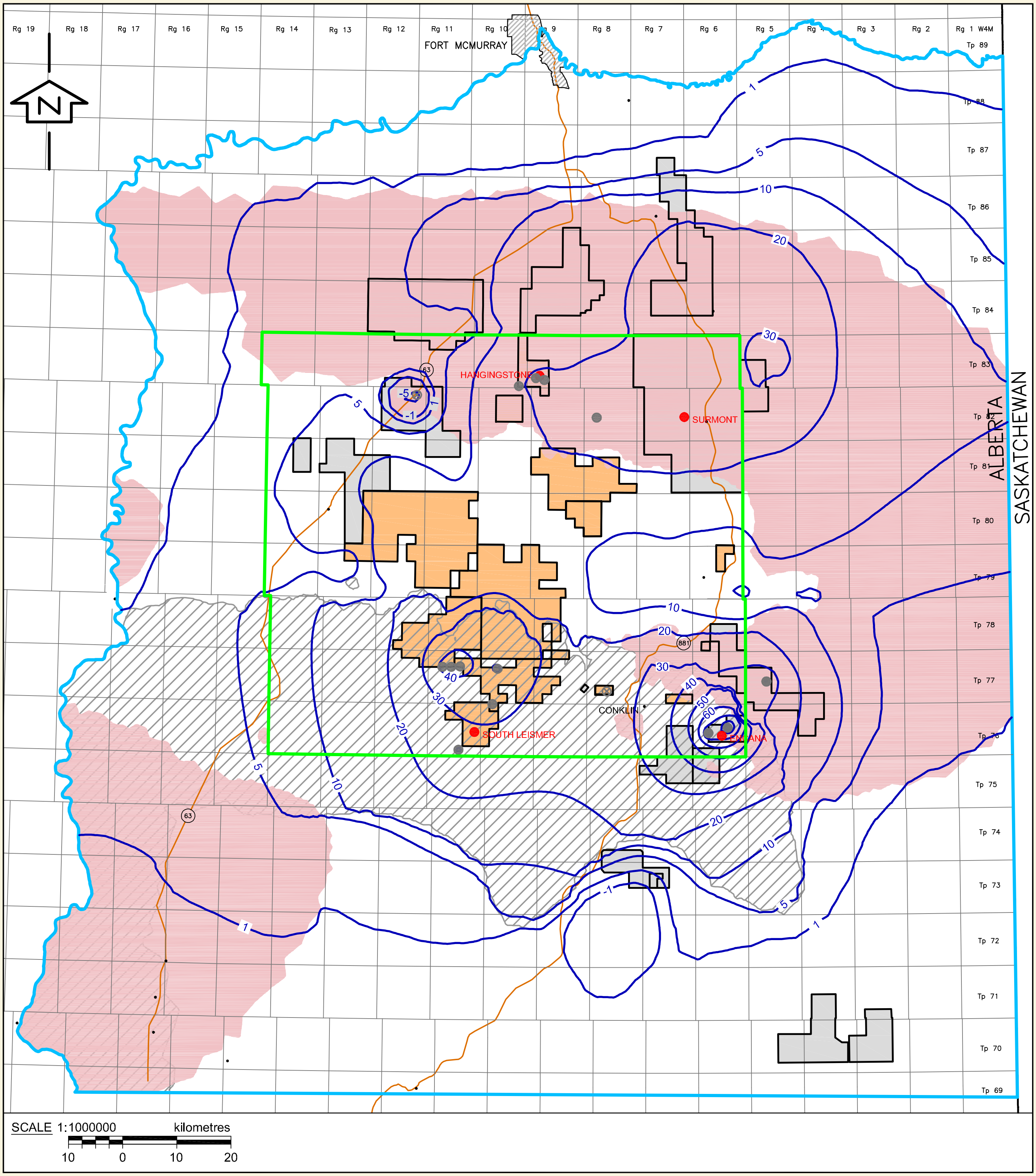
SIMULATED BASELINE DRAWDOWN CLEARWATER A & B AQUIFERS (END OF 2039)

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/03/28
File: 4455-IMPACTASSESS-07.DWG	

Drawn by:	Checked:	Fig. No.:
GDE	BW	5.6-15

*PLOT 1:1 = Letter (P)



LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- LOCAL STUDY AREA (LSA)
- REGIONAL STUDY AREA (RSA)
- CLEARWATER A AQUIFER
- CLEARWATER B AQUIFER
- 10 SIMULATED APPLICATION DRAWDOWN (m)
- OBSERVATION WELL
- DISPOSAL WELL
- SOURCE WELL

REFERENCE
ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

SIMULATED APPLICATION DRAWDOWN CLEARWATER A & B AQUIFERS (END OF 2039)

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/03/28
File: 4455-IMPACTASSESS-07.DWG	

Drawn by:	Checked:	Fig. No.:
GDE	BW	5.6-16

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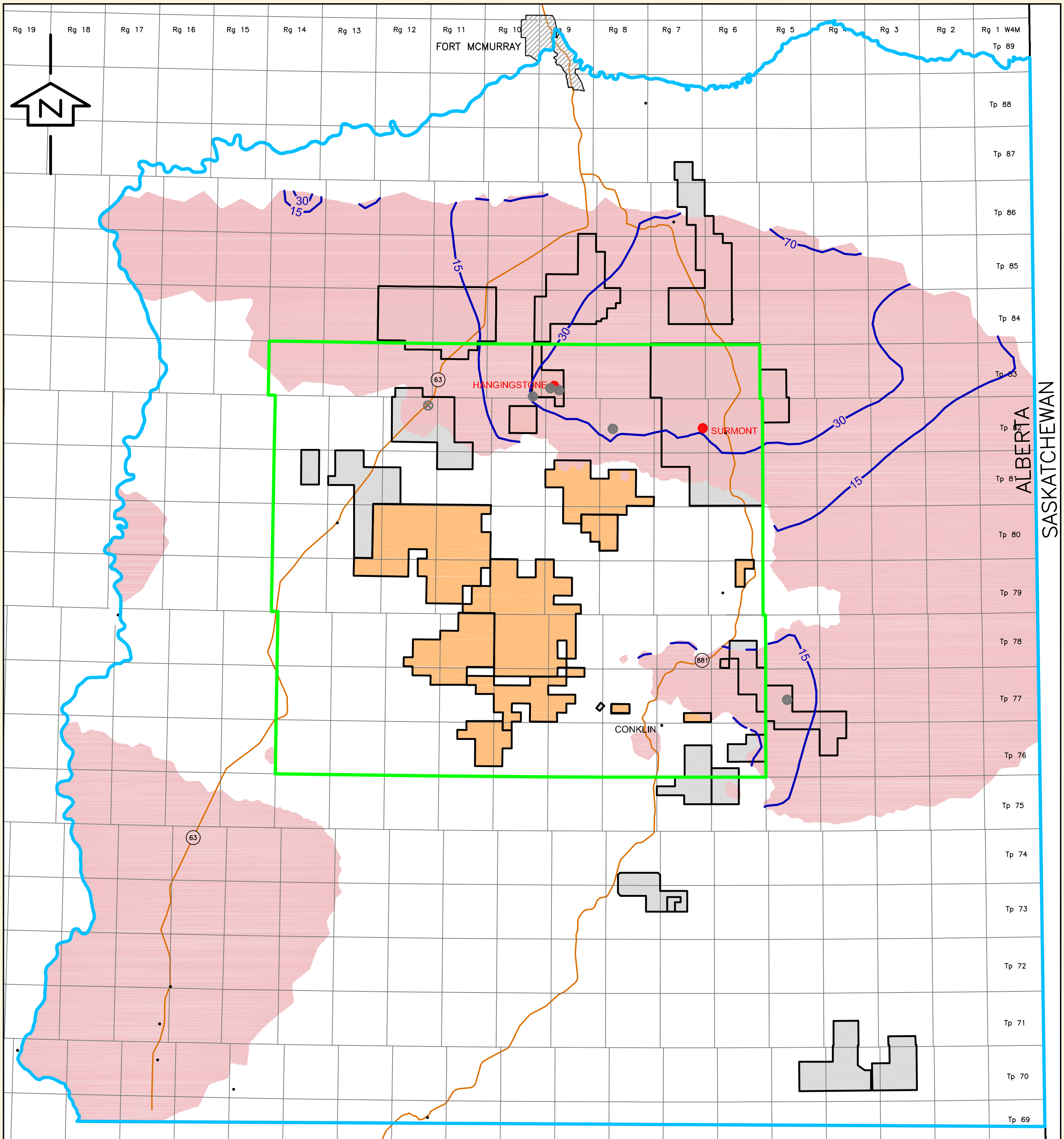
*PLOT 1:1 = Letter (P)



SCALE 1:1000000 kilometres

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LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- LOCAL STUDY AREA (LSA)
- REGIONAL STUDY AREA (RSA)
- CLEARWATER A AQUIFER
- 10 SIMULATED CHANGE % AP
- OBSERVATION WELL
- DISPOSAL WELL
- SOURCE WELL

REFERENCE

ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

SIMULATED CHANGE IN CLEARWATER A AQUIFER PRODUCTIVITY - APPLICATION CASE (END OF 2039)

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/03/28
File: 4455-IMPACTASSESS-07.DWG	

Drawn by:	Checked:	Fig. No.:
GDE	BW	5.6-17

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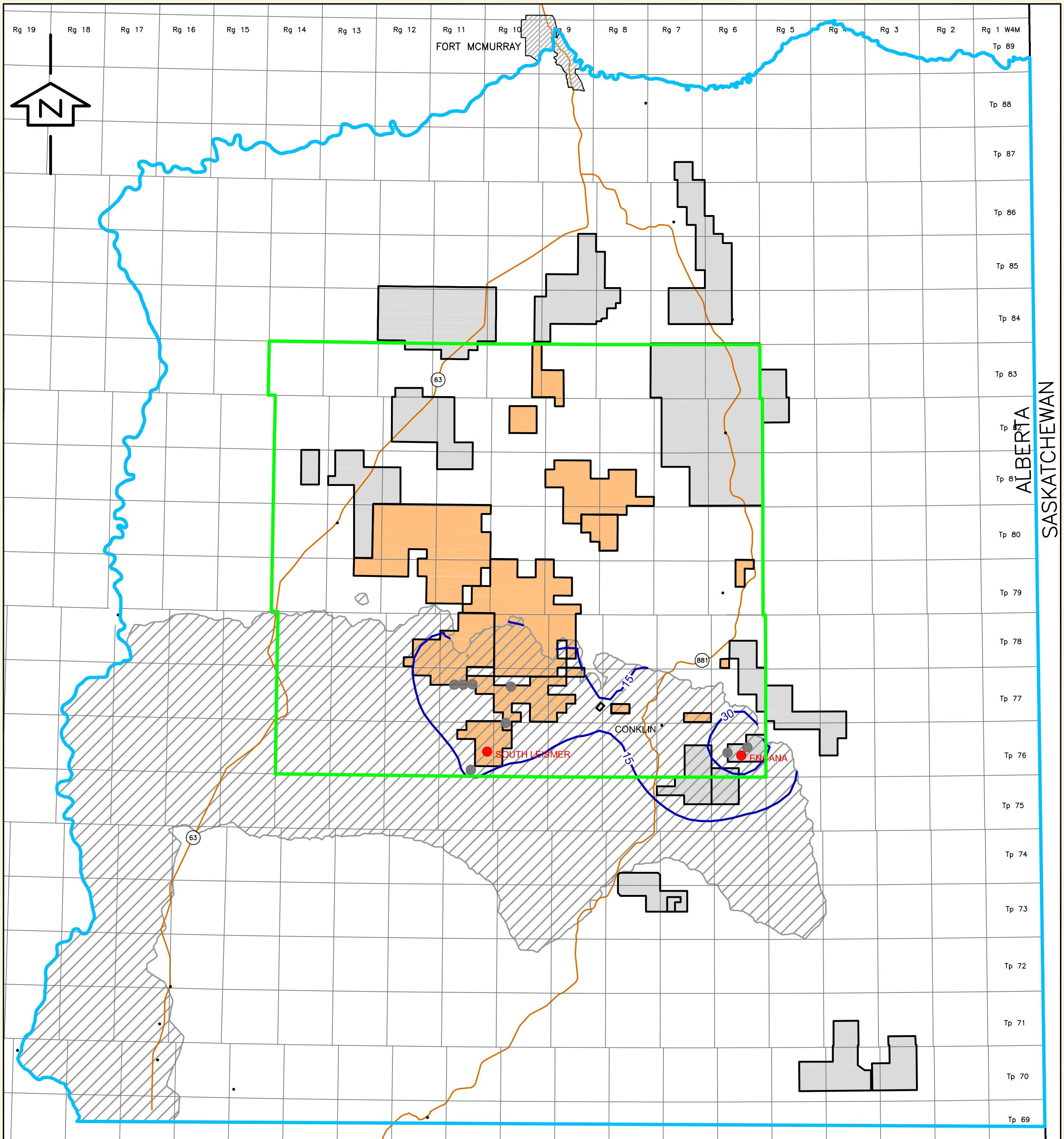

SCALE 1:1000000 kilometres

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LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- LOCAL STUDY AREA (LSA)
- REGIONAL STUDY AREA (RSA)
- CLEARWATER B AQUIFER
- 10 SIMULATED CHANGE % AP
- OBSERVATION WELL
- DISPOSAL WELL
- SOURCE WELL

REFERENCE

ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

SIMULATED CHANGE IN CLEARWATER B AQUIFER PRODUCTIVITY - APPLICATION CASE (END OF 2039)

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/03/28
File: 4455-IMPACTASSESS-07.DWG	
Drawn by: GDE	Checked: BW	Fig. No.: **5.6-18**

*PLOT 1:1 = Letter (P)

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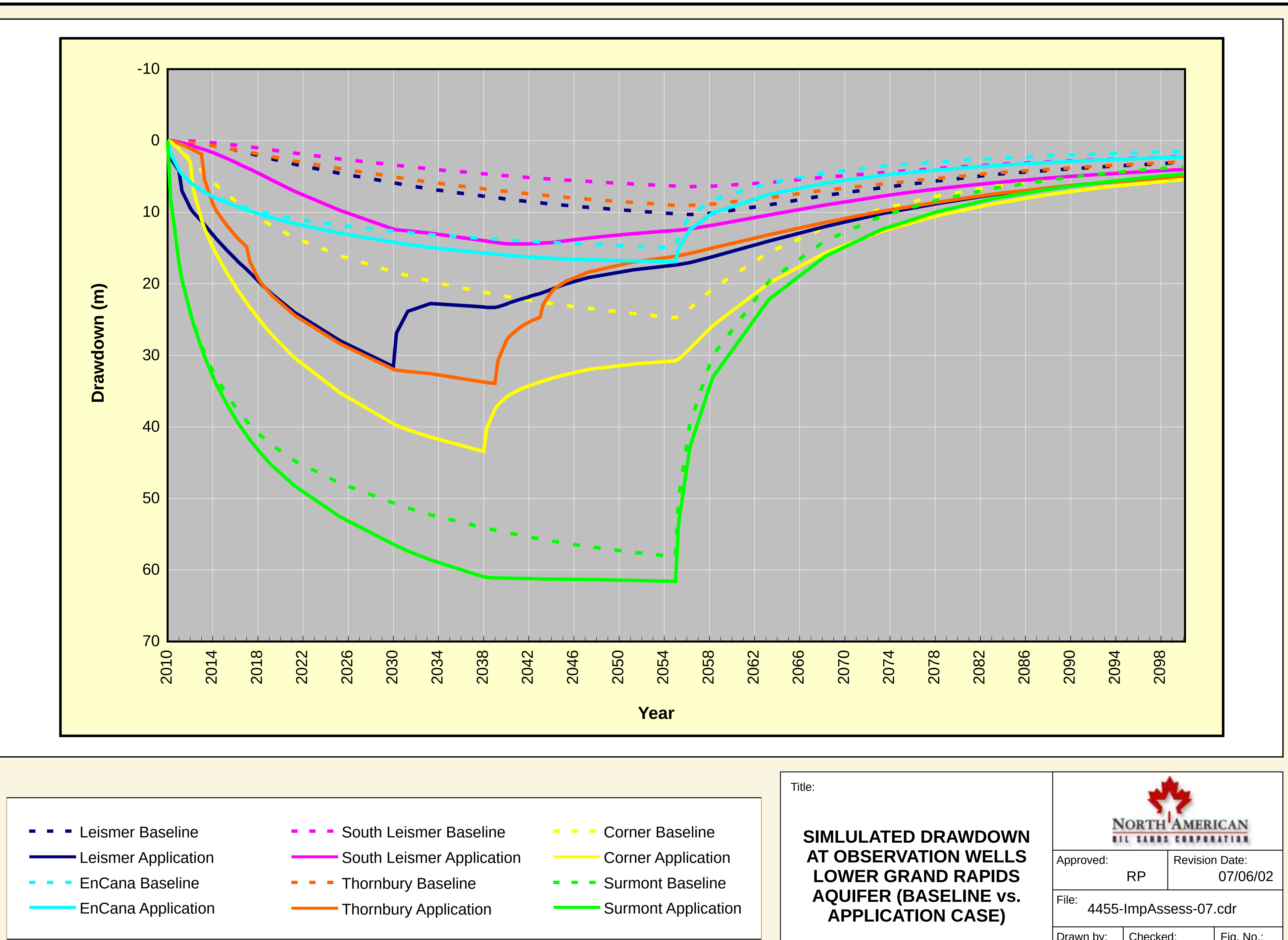
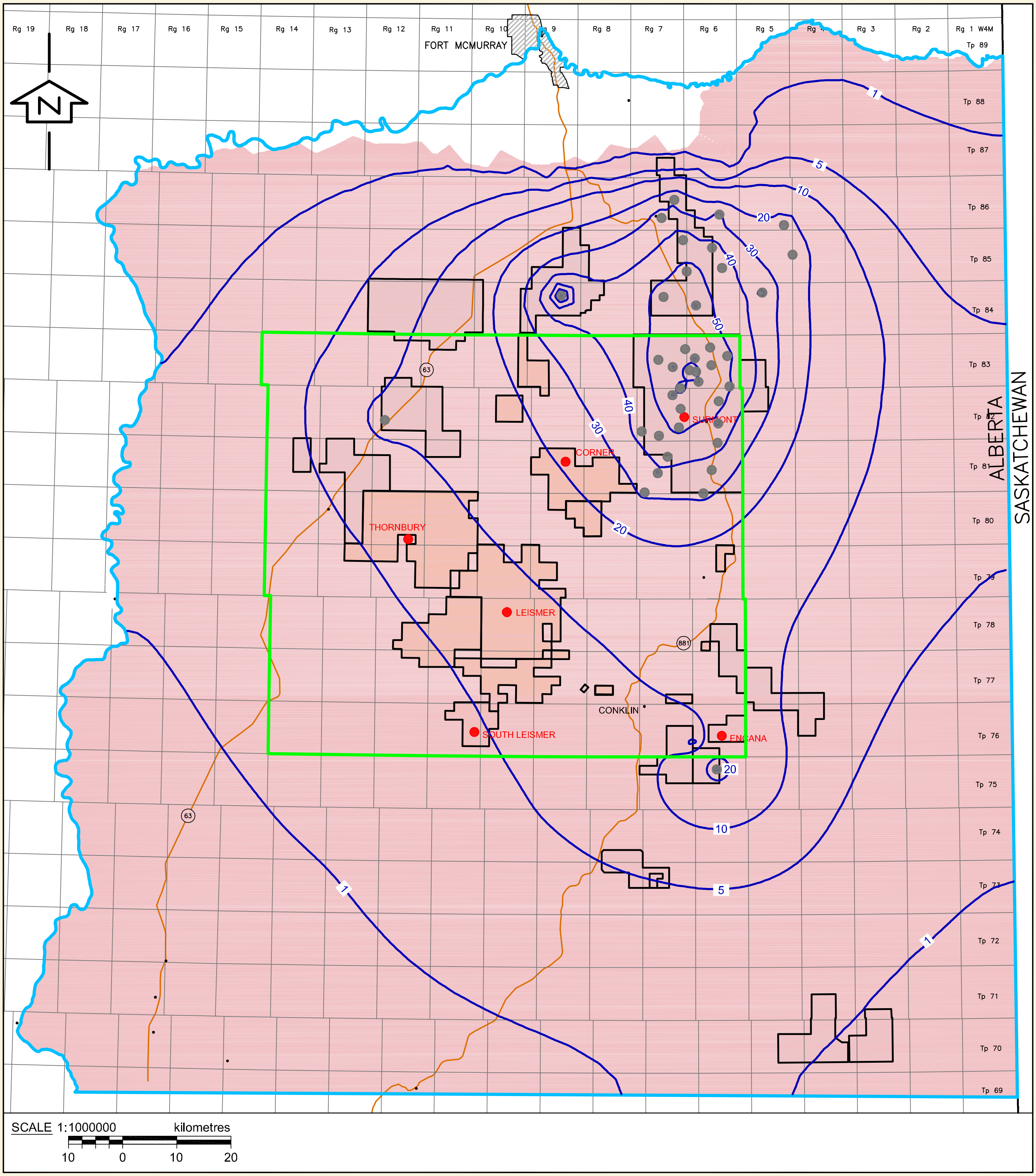


Title:

SIMLULATED DRAWDOWN AT OBSERVATION WELLS LOWER GRAND RAPIDS AQUIFER (BASELINE vs. APPLICATION CASE)

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/06/02	
File: 4455-ImpAssess-07.cdr		
Drawn by: GDE	Checked: BW	Fig. No.: **5.6-19**



LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- LOCAL STUDY AREA (LSA)
- REGIONAL STUDY AREA (RSA)
- LOWER GRAND RAPIDS AQUIFER
- 10 SIMULATED BASELINE DRAWDOWN (m)
- OBSERVATION WELL
- SOURCE WELL

REFERENCE
ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

SIMULATED BASELINE DRAWDOWN LOWER GRAND RAPIDS AQUIFER (END OF 2037)

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/03/28
File: 4455-IMPACTASSESS-07.DWG	

Drawn by:	Checked:	Fig. No.:
GDE	BW	5.6-20

"PLOT 1:1 = Letter (P)"
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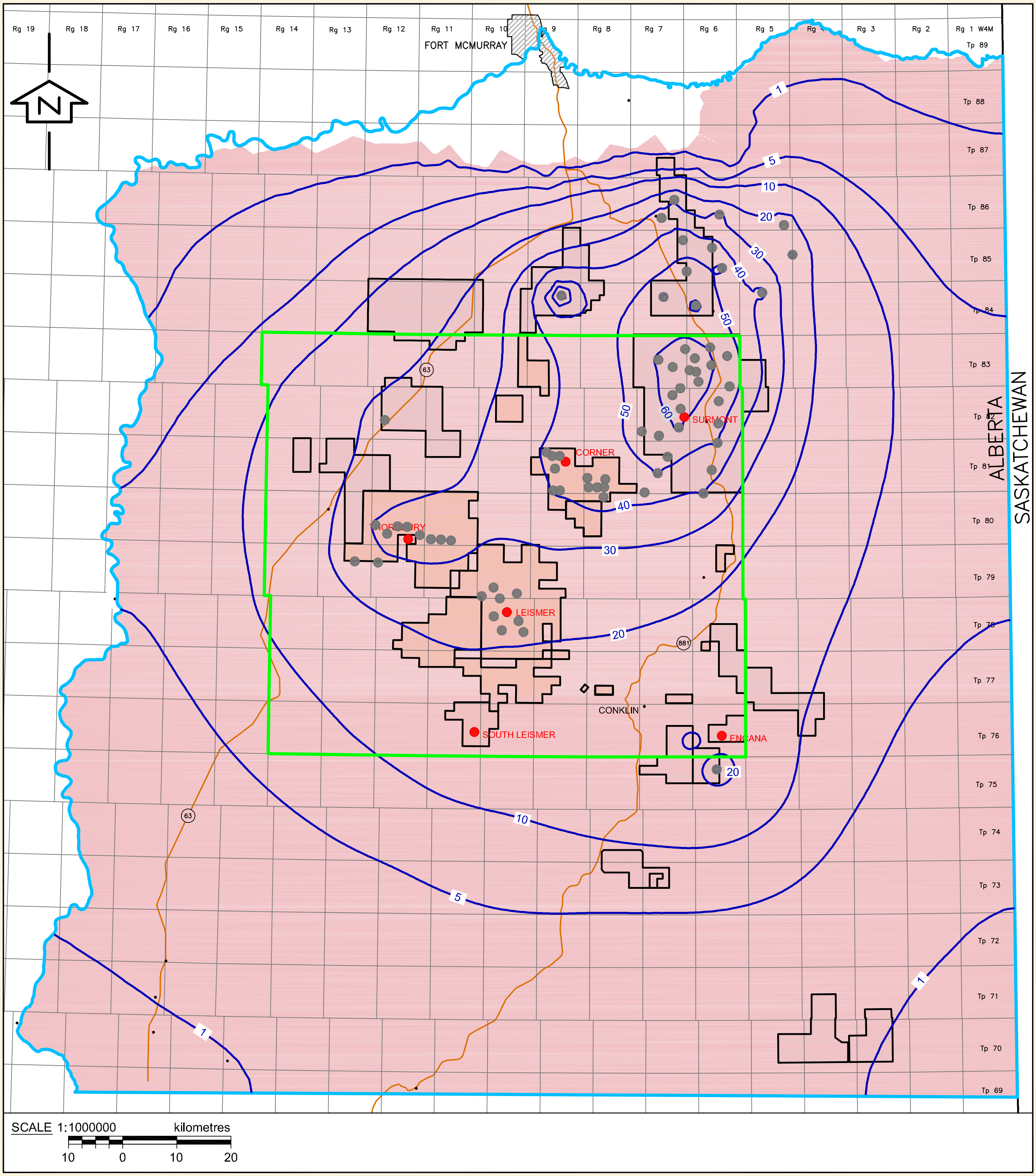

LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- LOCAL STUDY AREA (LSA)
- REGIONAL STUDY AREA (RSA)
- LOWER GRAND RAPIDS AQUIFER
- 10 SIMULATED APPLICATION DRAWDOWN (m)
- OBSERVATION WELL
- SOURCE WELL

REFERENCE
ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

SIMULATED APPLICATION DRAWDOWN LOWER GRAND RAPIDS AQUIFER (END OF 2037)

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/03/28
File: 4455-IMPACTASSESS-07.DWG	

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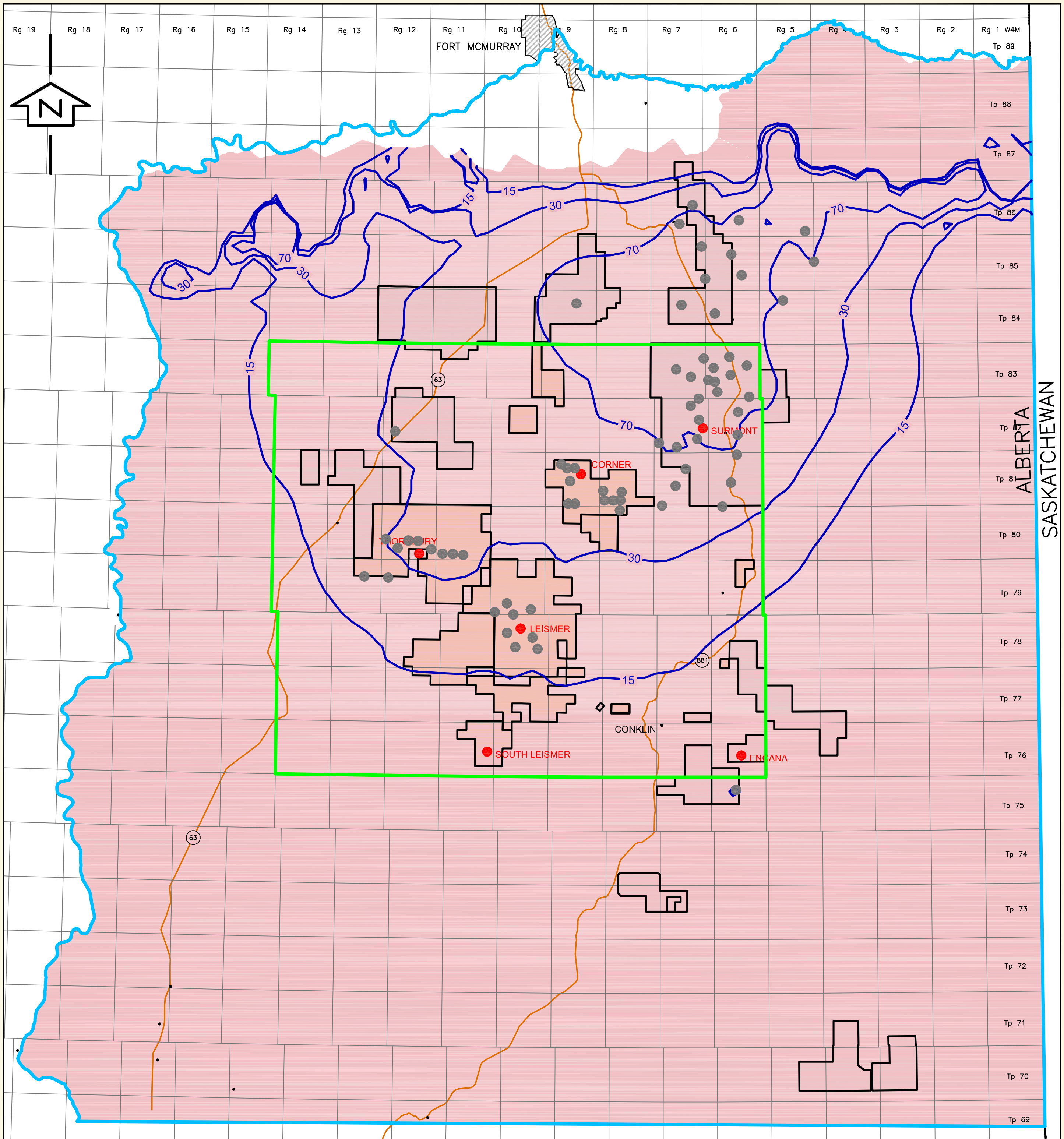
GDE	BW	5.6-21



SCALE 1:1000000 kilometres

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LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- LOCAL STUDY AREA (LSA)
- REGIONAL STUDY AREA (RSA)
- LOWER GRAND RAPIDS AQUIFER
- 10 SIMULATED CHANGE % AP
- OBSERVATION WELL
- SOURCE WELL

REFERENCE
ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

SIMULATED CHANGE IN LOWER GRAND RAPIDS AQUIFER PRODUCTION APPLICATION CASE (END OF 2037)

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/03/28
File: 4455-IMPACTASSESS-07.DWG	
Drawn by: GDE	Checked: BW	Fig. No.: 5.6-22

*PLOT 1:1 = Letter (P)

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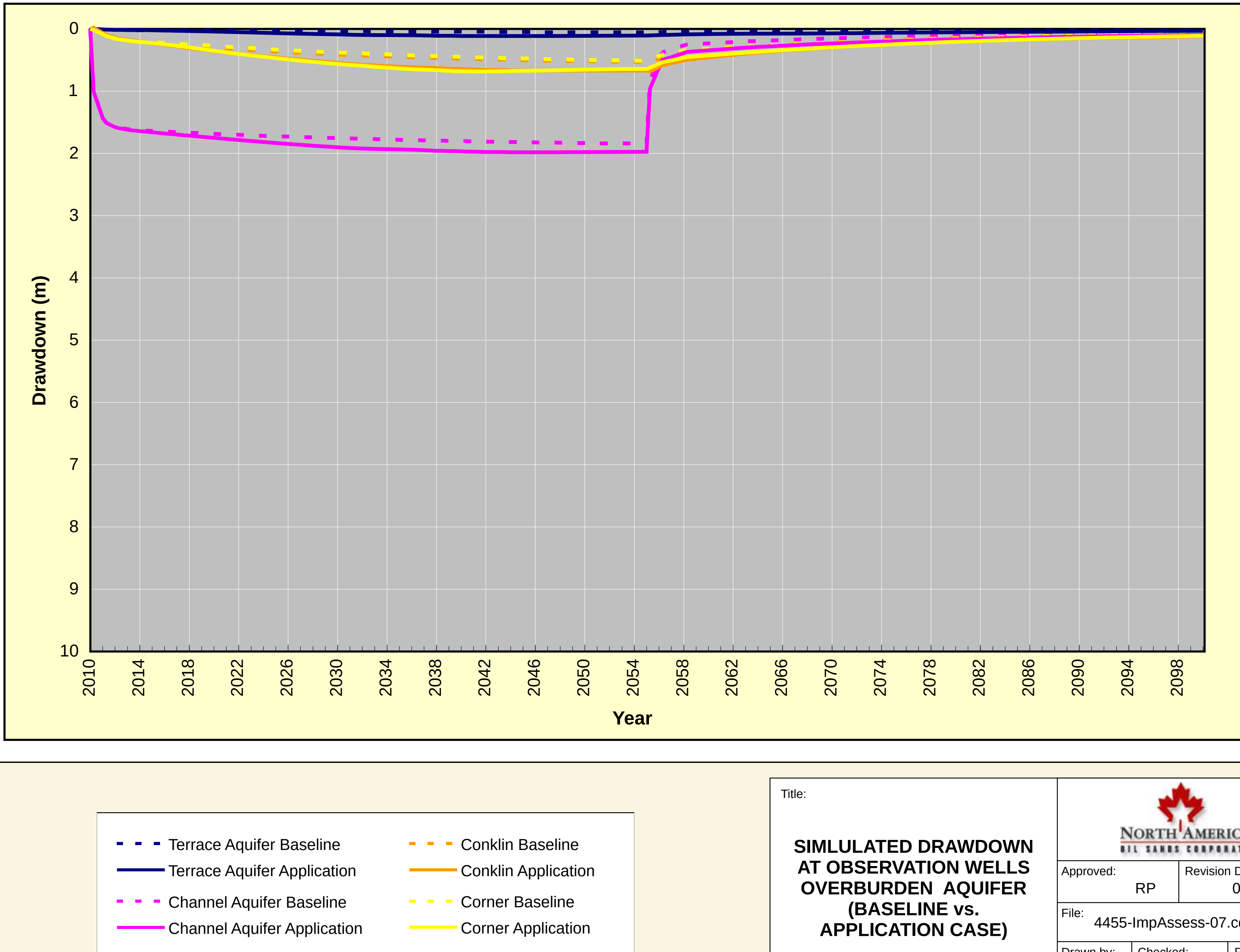
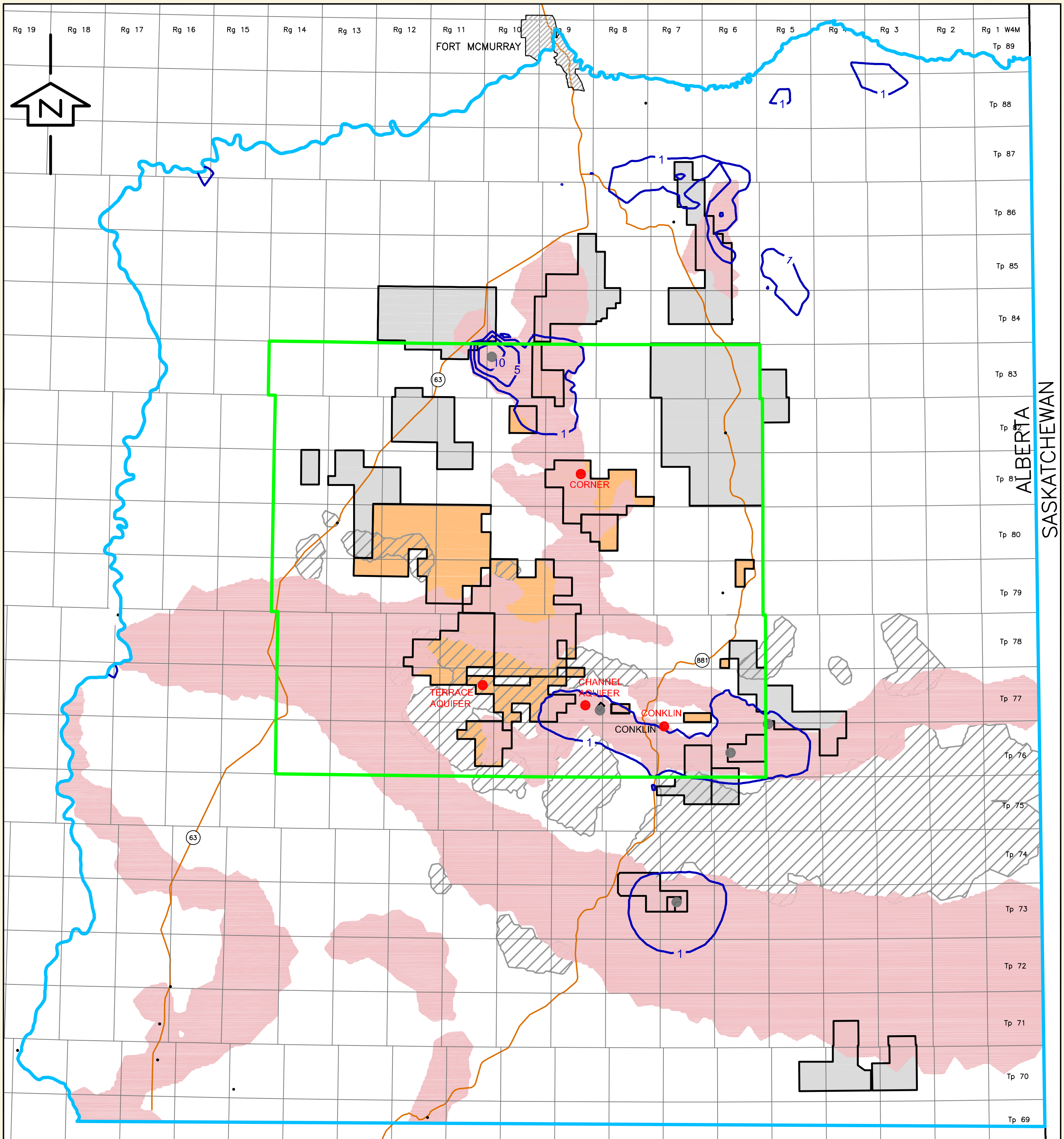


Title: SIMLULATED DRAWDOWN AT OBSERVATION WELLS OVERBURDEN AQUIFER (BASELINE vs. APPLICATION CASE)	NORTH AMERICAN OIL SANDS CORPORATION		
	Approved: RP	Revision Date: 07/06/02	
	File: 4455-ImpAssess-07.cdr		
	Drawn by: GDE	Checked: BW	Fig. No.: **5.6-23**

*PLOT 1:1 = Letter (P)



SCALE 1:1000000 kilometres

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LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- LOCAL STUDY AREA (LSA)
- REGIONAL STUDY AREA (RSA)
- EMPRESS CHANNEL AQUIFER
- EMPRESS TERRACE AQUIFER
- 10 SIMULATED BASELINE DRAWDOWN (m)
- OBSERVATION WELL
- SOURCE WELL

REFERENCE

ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

SIMULATED BASELINE DRAWDOWN OVERBURDEN AQUIFERS (END OF 2054)

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/03/28
File: 4455-IMPACTASSESS-07.DWG	

Drawn by:	Checked:	Fig. No.:
GDE	BW	**5.6-24**

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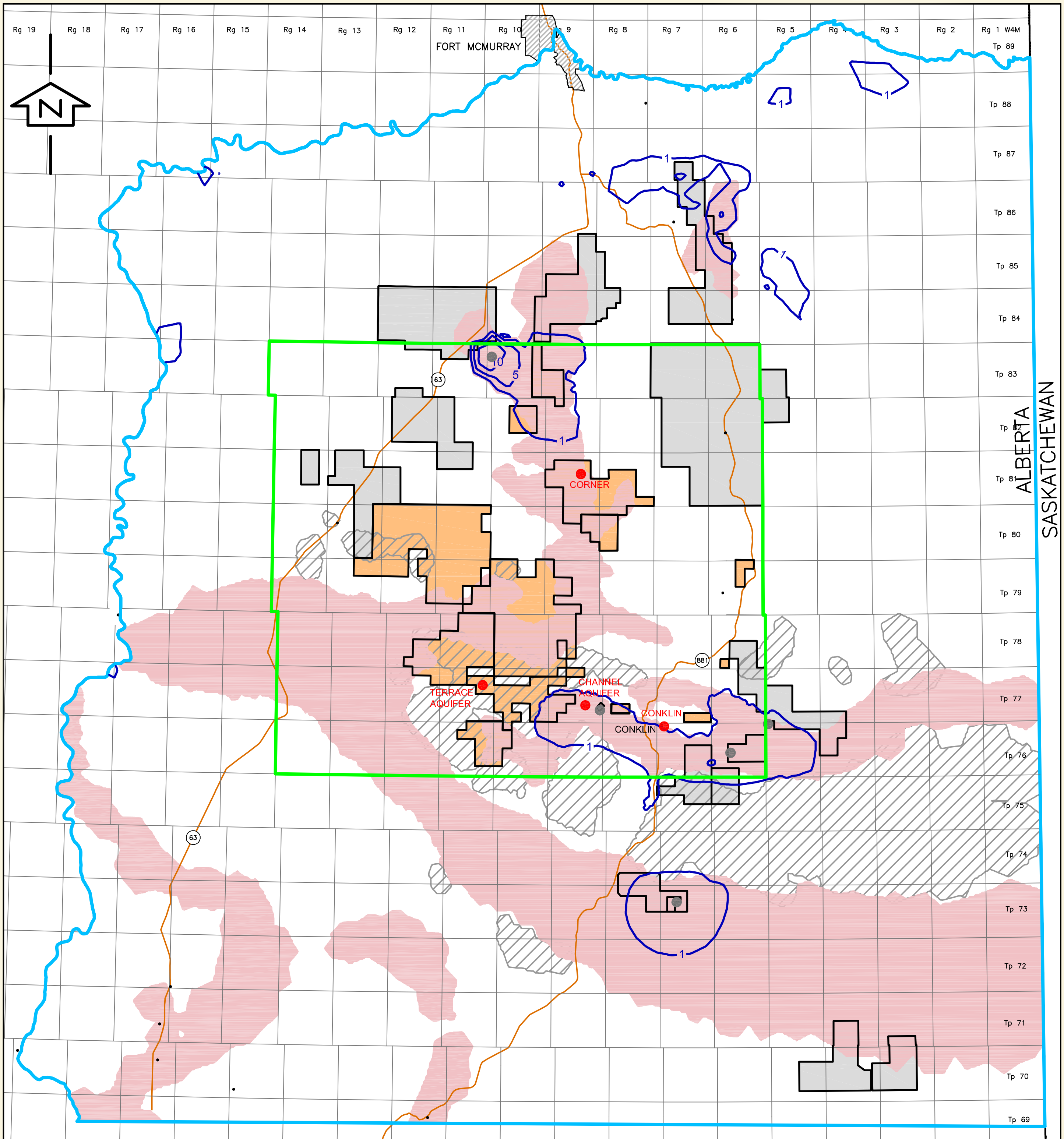

SCALE 1:1000000 kilometres

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LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- LOCAL STUDY AREA (LSA)
- REGIONAL STUDY AREA (RSA)
- EMPRESS CHANNEL AQUIFER
- EMPRESS TERRACE AQUIFER
- 10 SIMULATED APPLICATION DRAWDOWN (m)
- OBSERVATION WELL
- SOURCE WELL

REFERENCE

ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

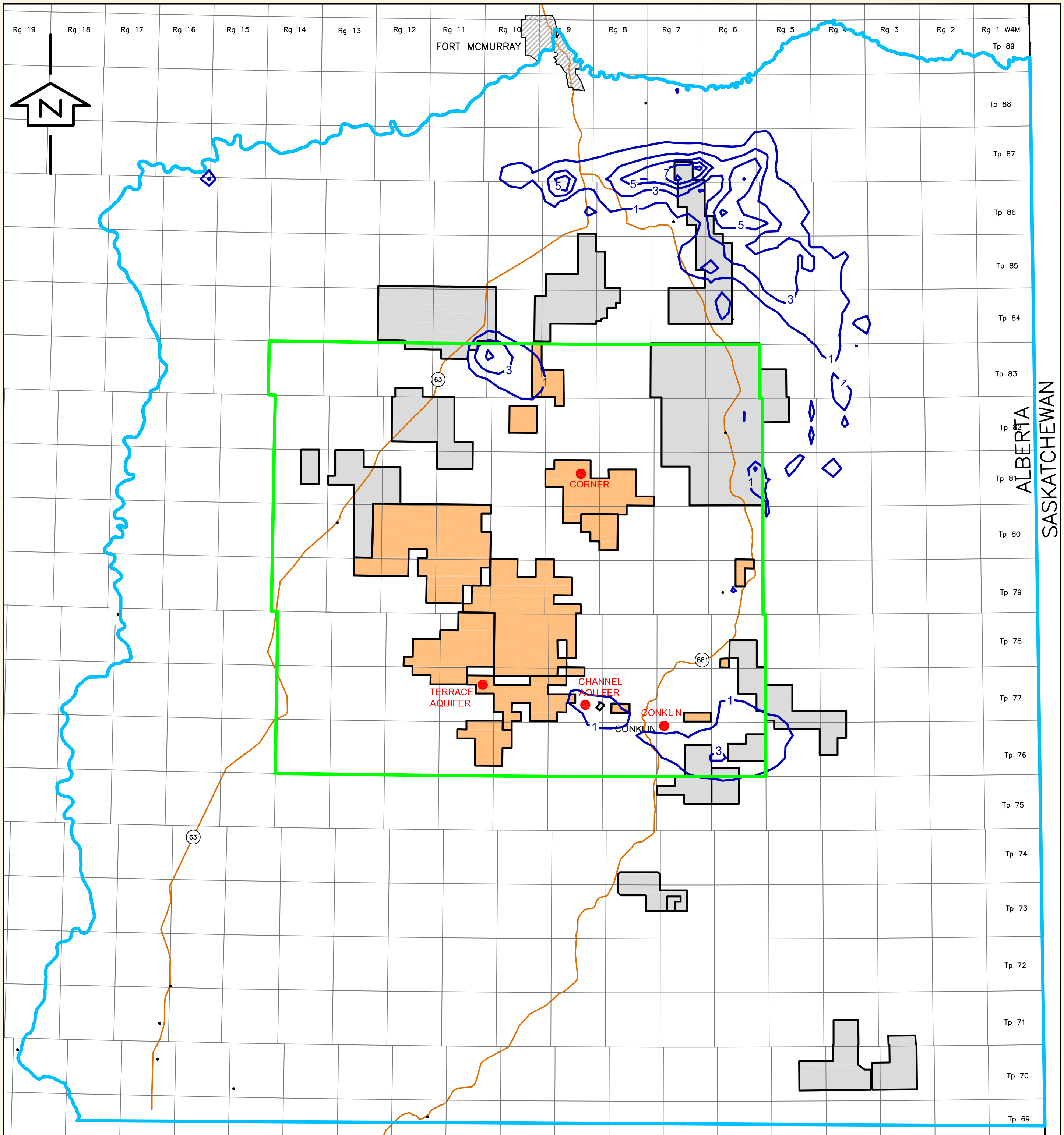
SIMULATED APPLICATION DRAWDOWN OVERBURDEN AQUIFERS (END OF 2054)

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/03/28
File: 4455-IMPACTASSESS-07.DWG	

Drawn by:	Checked:	Fig. No.:
GDE	BW	5.6-25

*PLOT 1:1 = Letter (P)



SCALE 1:1000000 kilometres

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LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- LOCAL STUDY AREA (LSA)
- REGIONAL STUDY AREA (RSA)
- 10 SIMULATED CHANGE IN SURFACE FLUX (mm/yr)
- OBSERVATION WELL

REFERENCE

ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

SIMULATED CHANGE IN SURFACE FLUX BASELINE CASE (END OF 2054)

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/03/28
File: 4455-IMPACTASSESS-07.DWG	

Drawn by:	Checked:	Fig. No.:
GDE	BW	5.6-26

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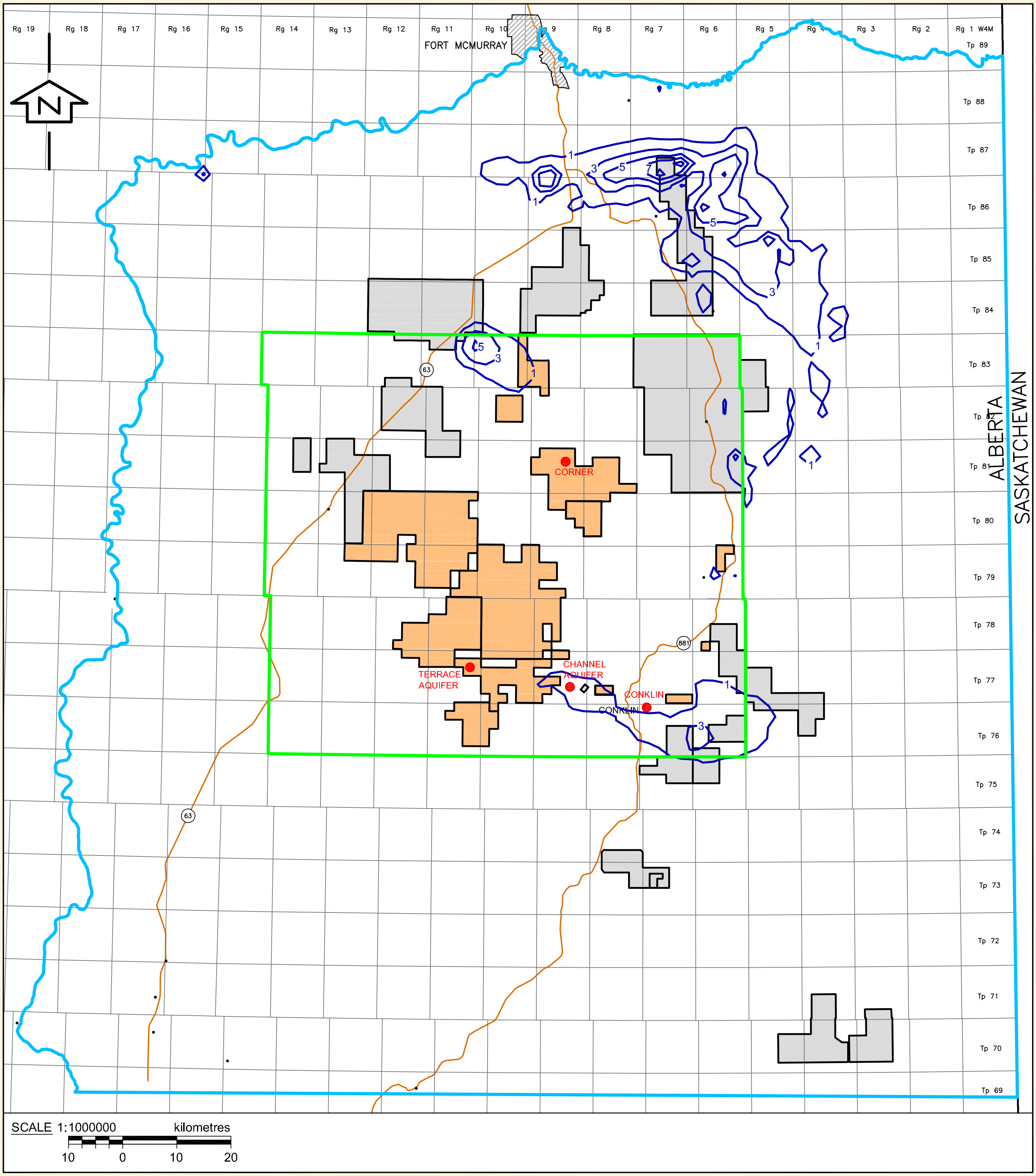

LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- LOCAL STUDY AREA (LSA)
- REGIONAL STUDY AREA (RSA)
- 10 SIMULATED CHANGE IN SUFACE FLUX (mm/yr)
- OBSERVATION WELL

REFERENCE

ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

SIMULATED CHANGE IN SURFACE FLUX APPLICATION CASE (END OF 2054)

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/03/28	
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*PLOT 1:1 = Letter (P)

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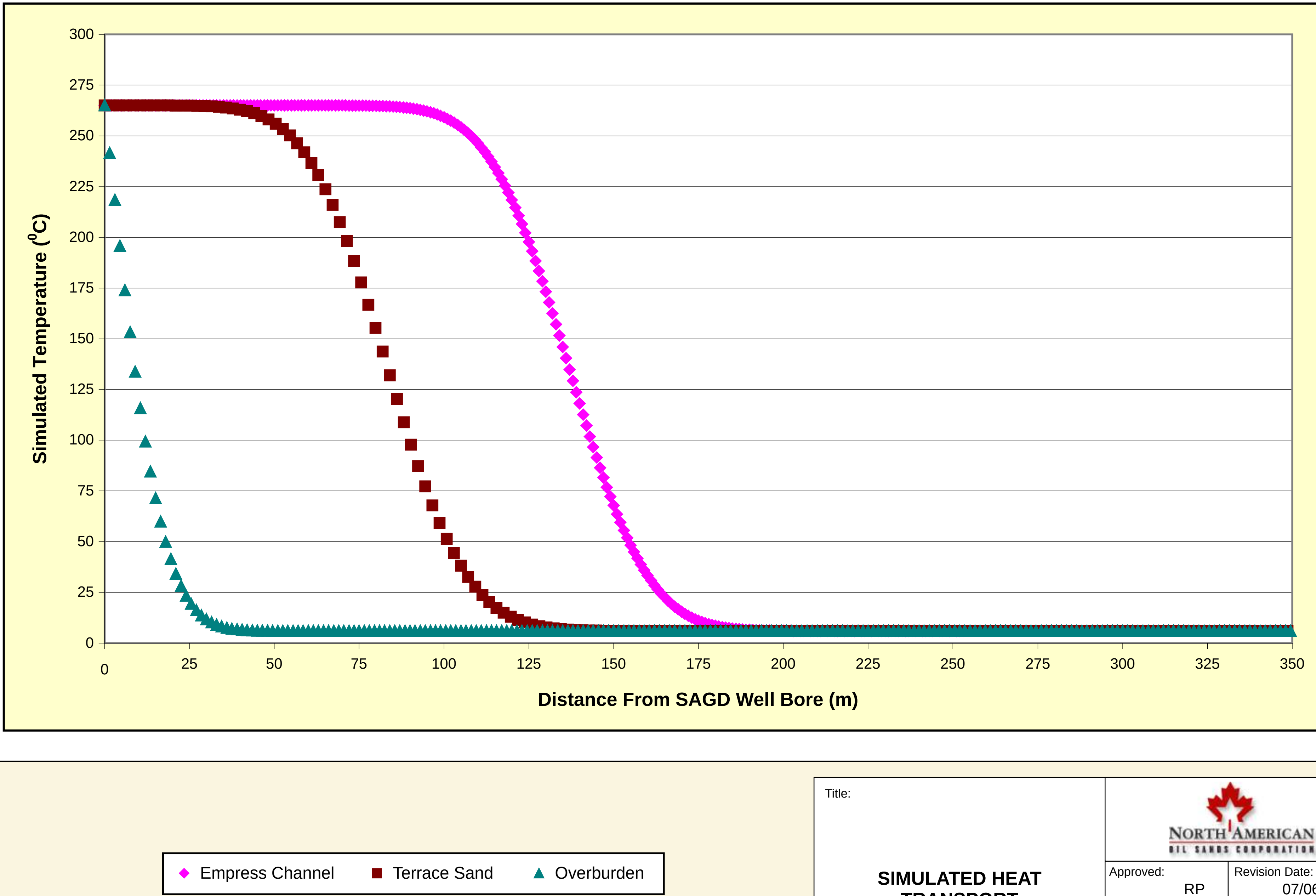

Title:

SIMULATED HEAT TRANSPORT

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/06/02
File: 4455-ImpAssess-07.cdr	

Drawn by:	Checked:	Fig. No.:
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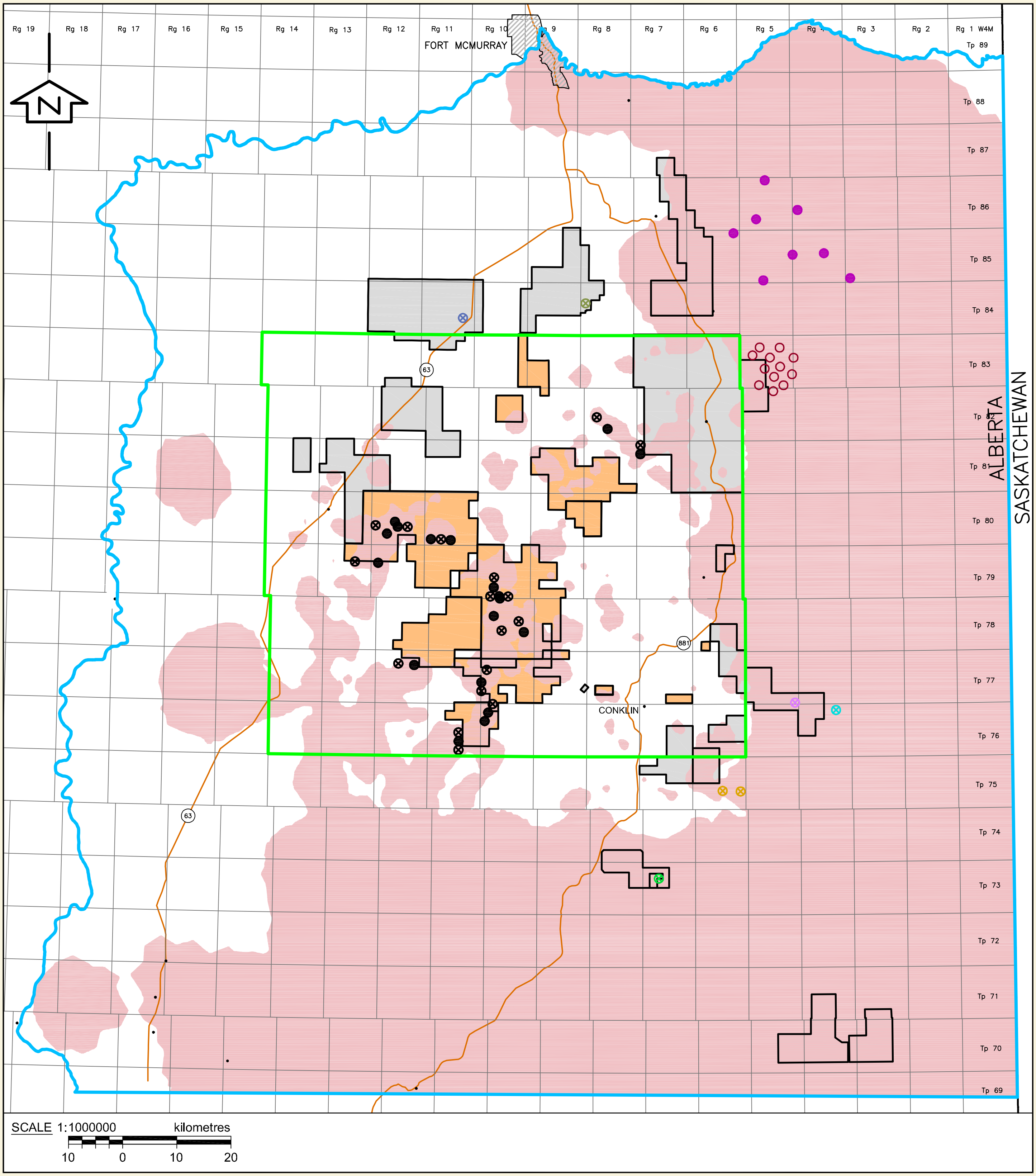
*PLOT 1:1 = Letter (P)



LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- LOCAL STUDY AREA (LSA)
- REGIONAL STUDY AREA (RSA)
- DISPOSAL/SOURCE WELL - CONOCOPHILLPS
- BASAL McMURRAY AQUIFER
- DISPOSAL WELL - CNRL
- DISPOSAL WELL - DEVON
- DISPOSAL WELL - ENCANA
- DISPOSAL WELL - JACOS
- DISPOSAL WELL - MEG
- DISPOSAL WELL - NORTH AMERICAN
- SOURCE WELL - NORTH AMERICAN
- DISPOSAL WELL - PETRO-CAN
- SOURCE WELL - OPTI-NEXEN

REFERENCE

ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

GROUNDWATER WELLS USED FOR CUMULATIVE EFFECTS CASE BASAL McMURRAY AQUIFER

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/03/28
File: 4455-IMPACTASSESS-07.DWG	
Drawn by: GDE	Checked: BW
Fig. No.: 5.7-1	

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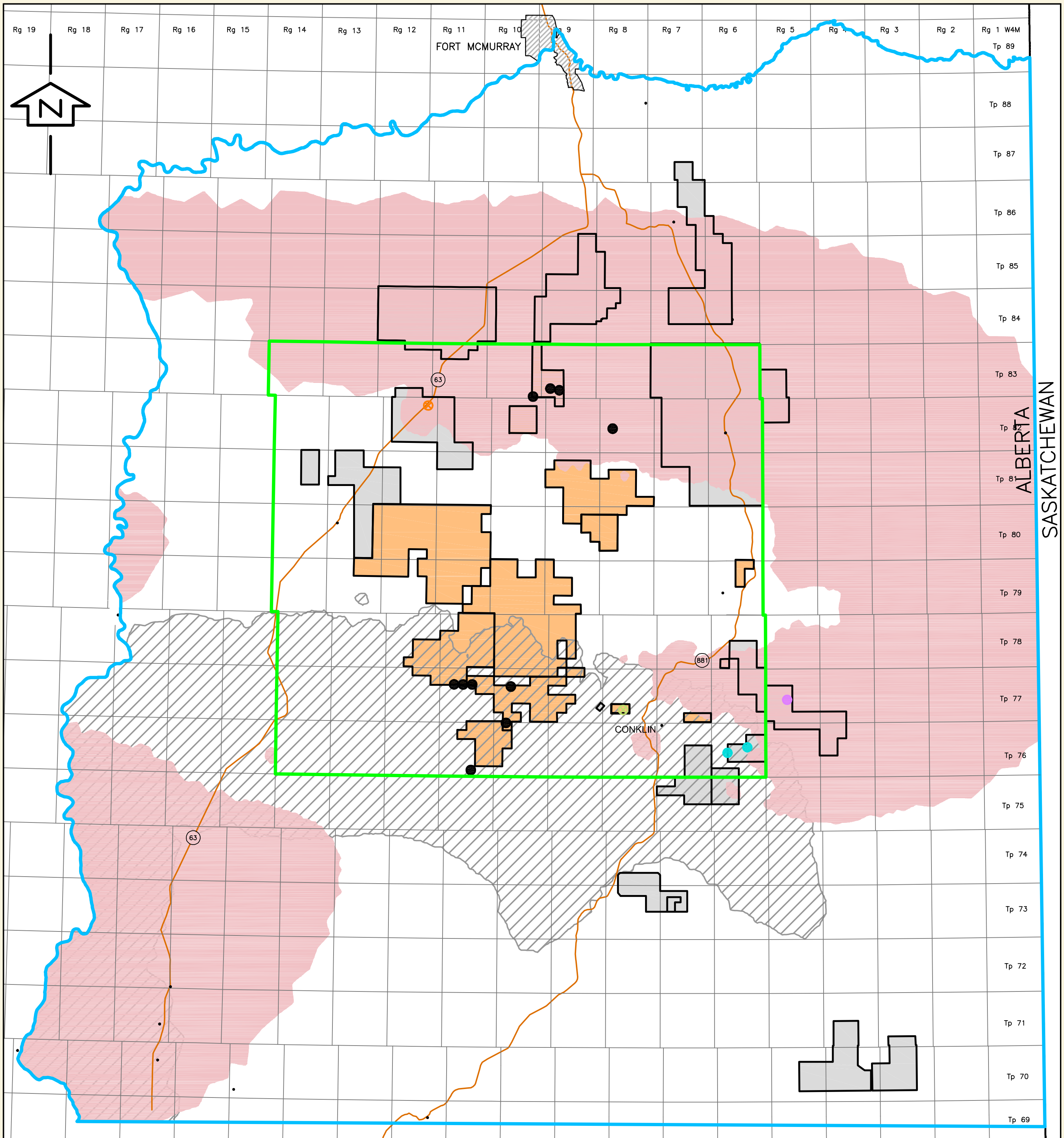

SCALE 1:1000000 kilometres

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LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- LOCAL STUDY AREA (LSA)
- REGIONAL STUDY AREA (RSA)
- CLEARWATER A AQUIFER
- CLEARWATER B AQUIFER
- DISPOSAL WELL - CONNACHER
- DISPOSAL WELL - PETROBANK
- SOURCE WELL - ENCANA
- SOURCE WELL - MEG
- SOURCE WELL - NORTH AMERICAN

REFERENCE

ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

GROUNDWATER WELLS USED FOR CUMULATIVE EFFECTS CASE - CLEARWATER A&B AQUIFERS

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	RP	Revision Date:	07/03/28
File:	4455-IMPACTASSESS-07.DWG		
Drawn by: GDE	Checked: BW	Fig. No.:	**5.7-2**

*PLOT 1:1 = Letter (P)

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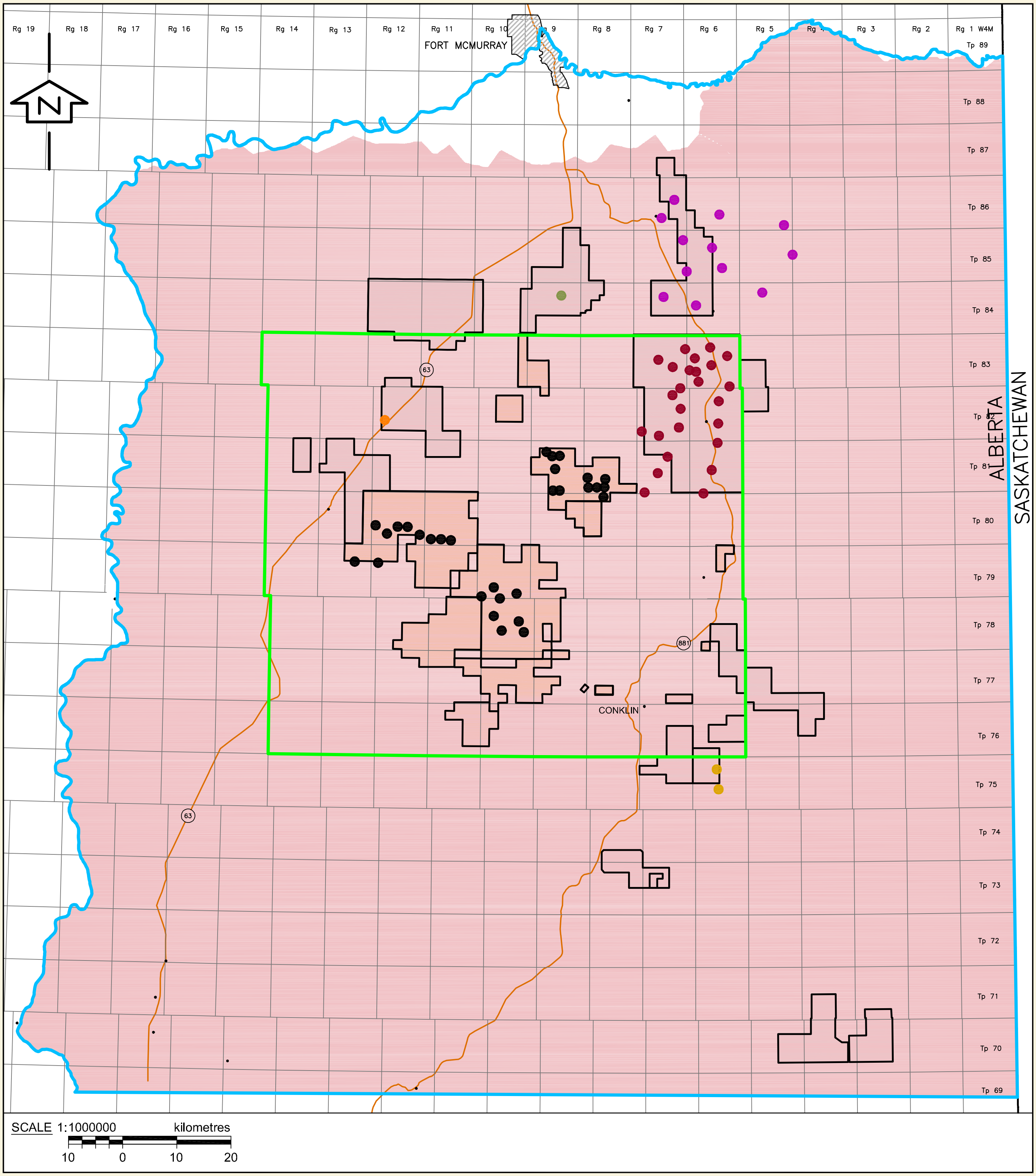

LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- LOCAL STUDY AREA (LSA)
- REGIONAL STUDY AREA (RSA)
- LOWER GRAND RAPIDS AQUIFER
- SOURCE WELL - CONNACHER
- SOURCE WELL - DEVON
- SOURCE WELL - OPTI-NEXEN
- SOURCE WELL - PETRO CANADA
- SOURCES WELL - NORTH AMERICAN
- SOURCE WELL - CONOCOPHILLIPS

REFERENCE

ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

GROUNDWATER WELLS USED FOR CUMULATIVE EFFECTS CASE - LOWER GRAND RAPIDS AQUIFER

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/03/28
File: 4455-IMPACTASSESS-07.DWG	

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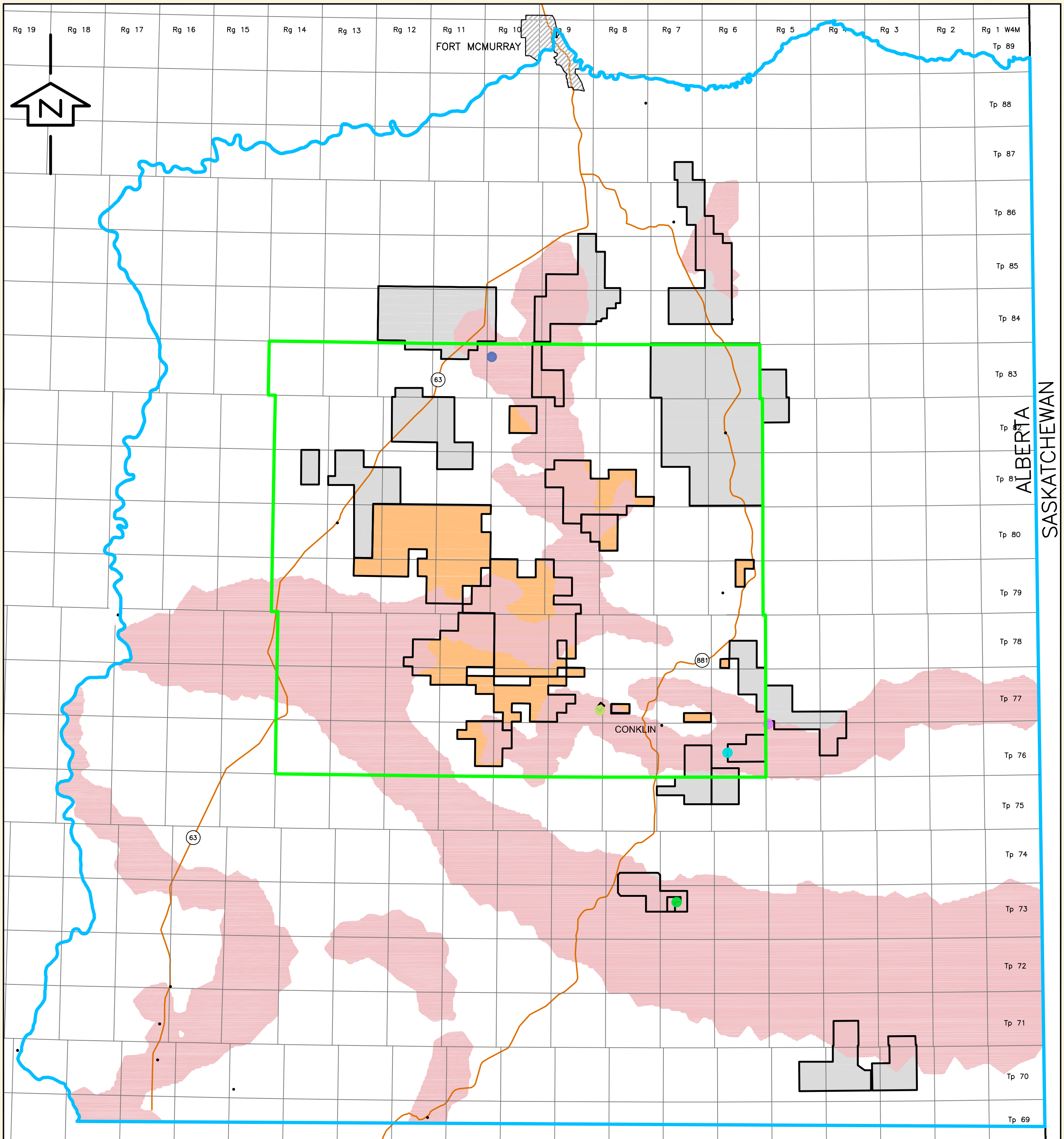

SCALE 1:1000000 kilometres

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LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- LOCAL STUDY AREA (LSA)
- REGIONAL STUDY AREA (RSA)
- EMPRESS CHANNEL AQUIFER
- SOURCE WELL - CNRL
- SOURCE WELL - ENCANA
- SOURCE WELL - JACOS
- SOURCE WELL - MEG
- SOURCE WELL - PETROBANK

REFERENCE

ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

GROUNDWATER WELLS USED FOR CUMULATIVE EFFECTS CASE - EMPRESS CHANNEL AQUIFER

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/03/28
File: 4455-IMPACTASSESS-07.DWG	
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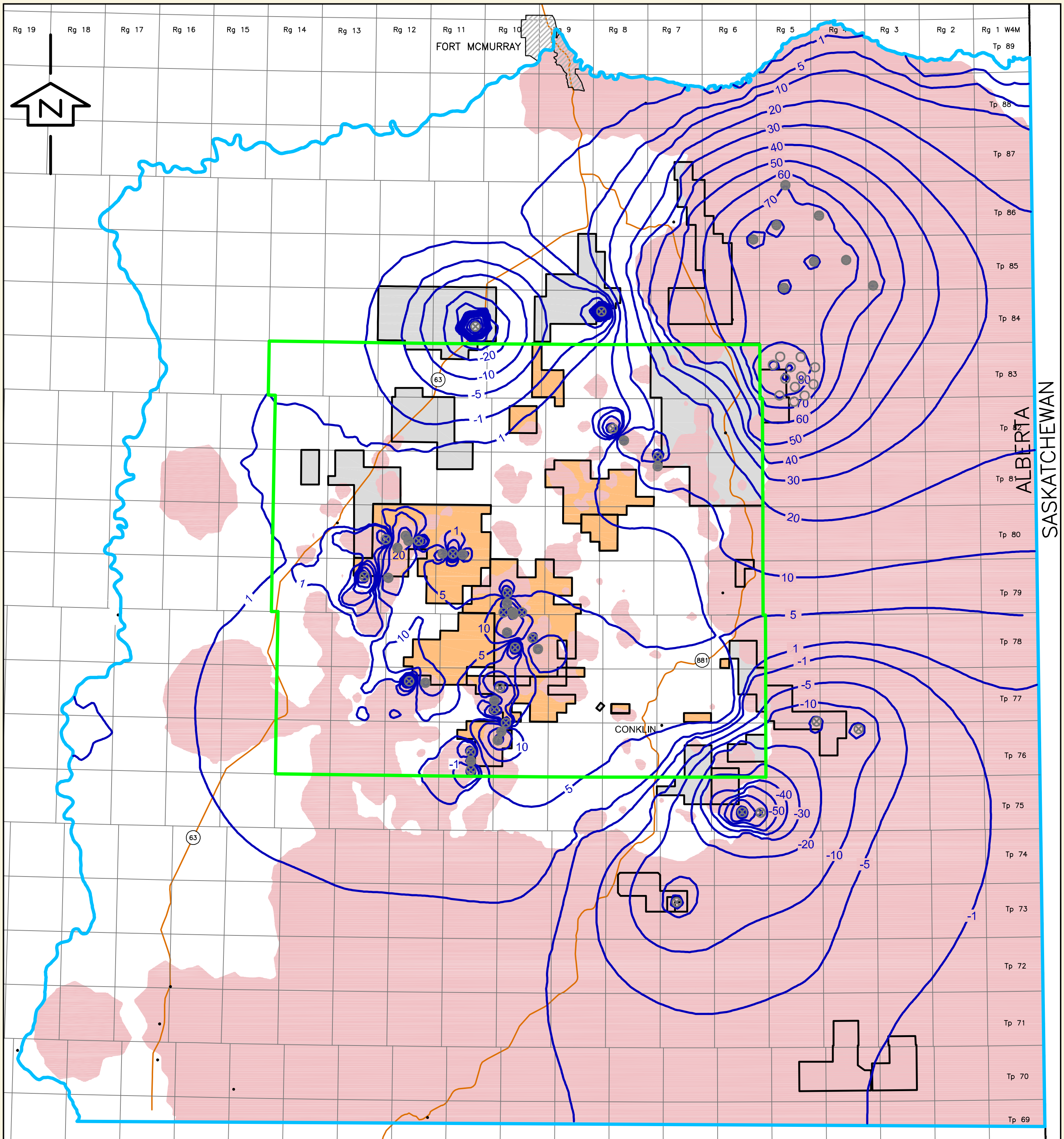

SCALE 1:1000000 kilometres

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LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- LOCAL STUDY AREA (LSA)
- REGIONAL STUDY AREA (RSA)
- BASAL McMURRAY AQUIFER
- 10 SIMULATED CUMULATIVE BASELINE DRAWDOWN
- DISPOSAL WELL
- SOURCE WELL
- DISPOSAL/SOURCE WELL

REFERENCE
ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

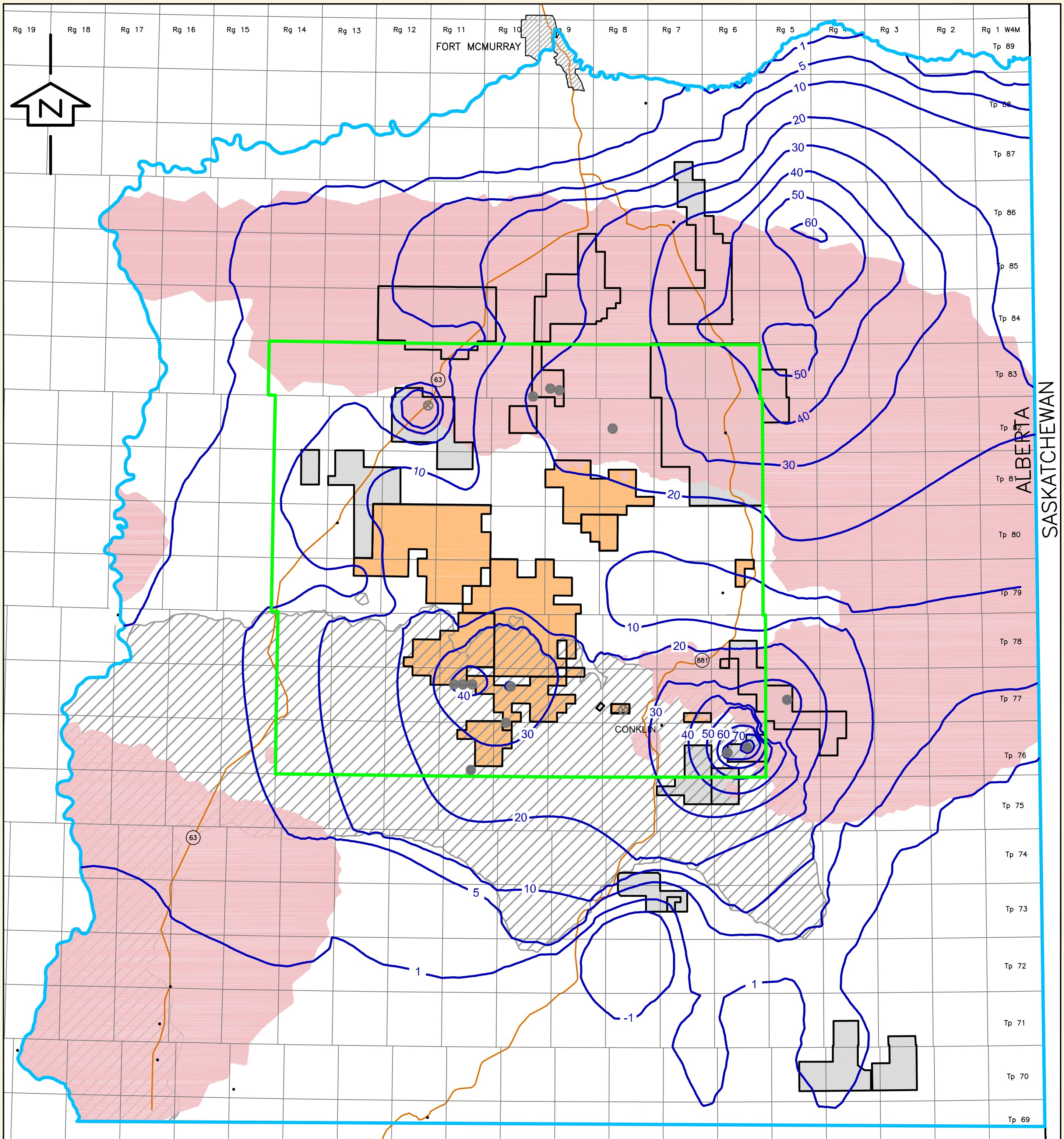
Title:

SIMULATED CUMULATIVE DRAWDOWN BASAL McMURRAY AQUIFER (END OF 2037)

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/03/28
File: 4455-IMPACTASSESS-07.DWG	

Drawn by:	Checked:	Fig. No.:
GDE	BW	**5.7-5**



SCALE 1:1000000 kilometres

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LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- LOCAL STUDY AREA (LSA)
- REGIONAL STUDY AREA (RSA)
- CLEARWATER A AQUIFER
- CLEARWATER B AQUIFER
- 10 SIMULATED CUMULATIVE BASELINE DRAWDOWN
- DISPOSAL WELL
- SOURCE WELL

REFERENCE

ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

SIMULATED CUMULATIVE DRAWDOWN - CLEARWATER A&B AQUIFERS (END OF 2039)

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/03/28	
File: 4455-IMPACTASSESS-07.DWG		
Drawn by: GDE	Checked: BW	Fig. No.: **5.7-6**

*PLOT 1:1 = Letter (P)

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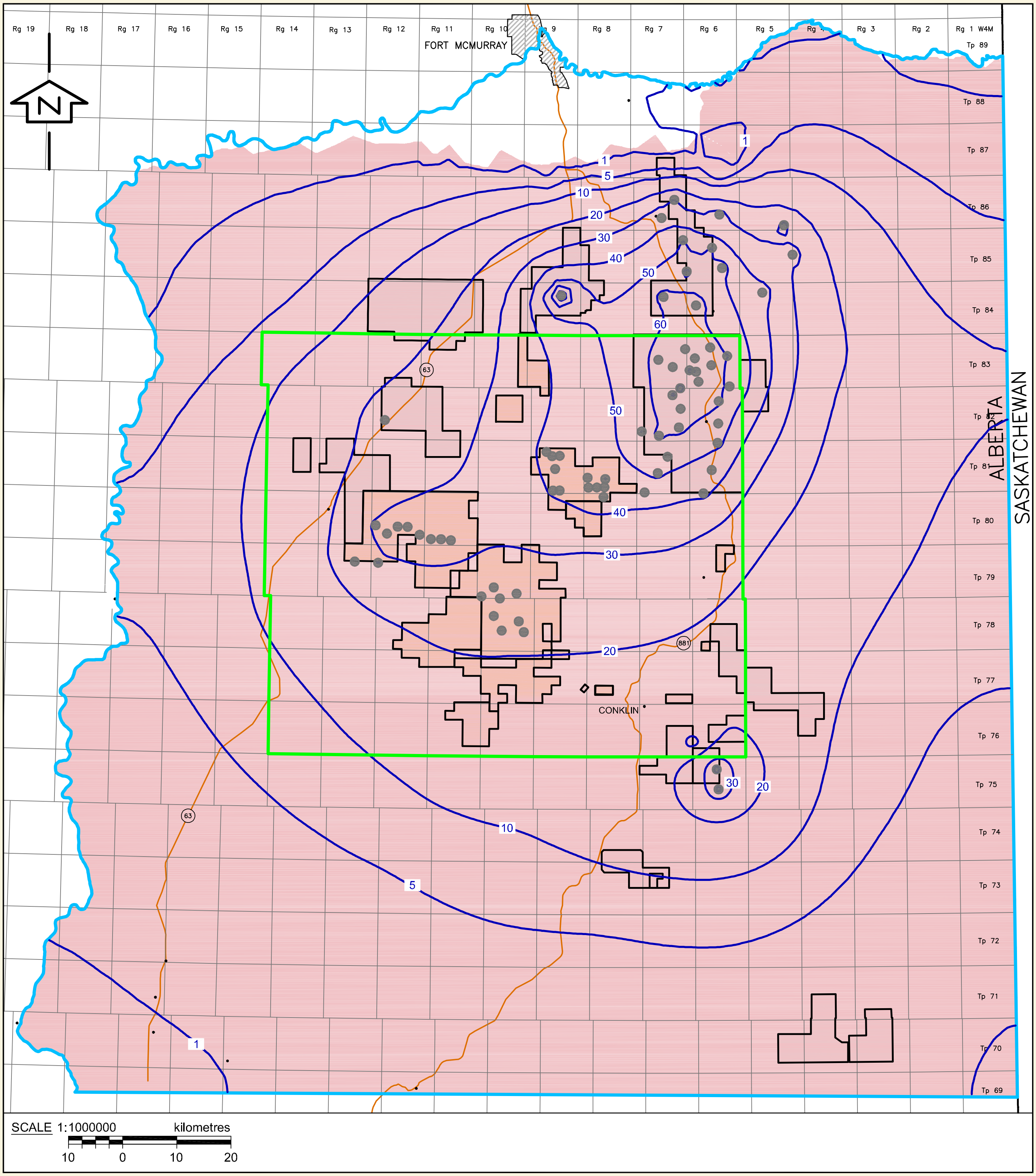

LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- LOCAL STUDY AREA (LSA)
- REGIONAL STUDY AREA (RSA)
- LOWER GRAND RAPIDS AQUIFER
- 10 SIMULATED CUMULATIVE BASELINE DRAWDOWN
- SOURCE WELL

REFERENCE

ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

SIMULATED CUMULATIVE DRAWDOWN - LOWER GRAND RAPIDS AQUIFER (END OF 2037)

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/03/28	
File: 4455-IMPACTASSESS-07.DWG		
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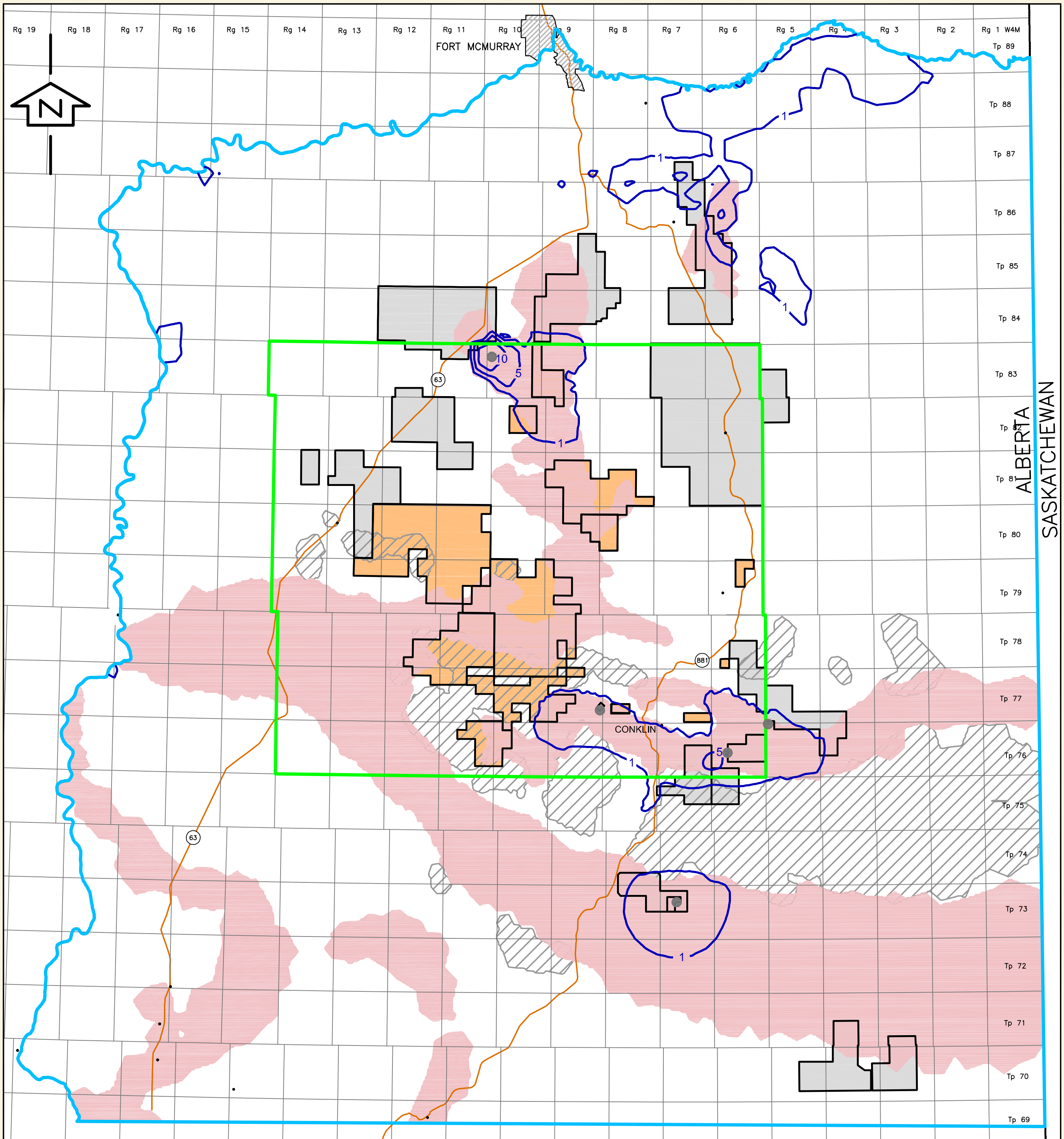

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LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- LOCAL STUDY AREA (LSA)
- REGIONAL STUDY AREA (RSA)
- EMPRESS CHANNEL AQUIFER
- EMPRESS TERRACE AQUIFER
- 10 SIMULATED CUMULATIVE DRAWDOWN
- SOURCE WELL

REFERENCE

ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

SIMULATED CUMULATIVE DRAWDOWN - OVERBURDEN AQUIFERS (END OF 2054)

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/03/28
File: 4455-IMPACTASSESS-07.DWG	

Drawn by:	Checked:	Fig. No.:
GDE	BW	5.7-8

*PLOT 1:1 = Letter (P)

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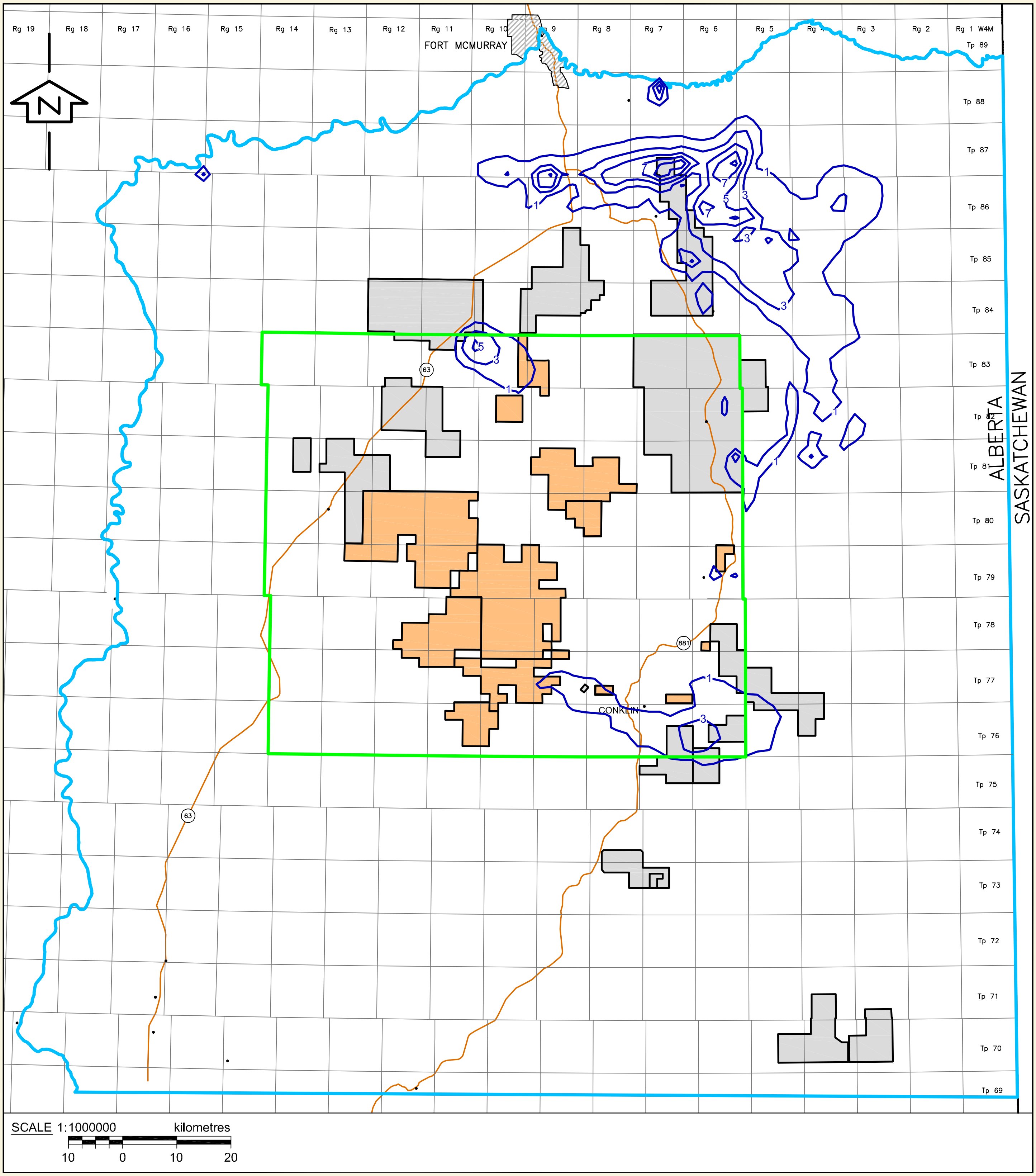

LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- LOCAL STUDY AREA (LSA)
- REGIONAL STUDY AREA (RSA)
- 10 SIMULATED CHANGE % AP (mm/yr)

REFERENCE
ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

SIMULATED CHANGE IN SURFACE FLUX CUMULATIVE EFFECTS CASE (END OF 2054)

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/03/28
File: 4455-IMPACTASSESS-07.DWG	
Drawn by: GDE	Checked: BW
Fig. No.: 5.7-9	

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TABLE OF CONTENTS

TABLES

FIGURES

6 HYDROLOGY

6.1 Introduction

This section describes the regional hydrology of the study area, and the potential hydrologic impact caused by the Project to the creeks, rivers, lakes, wetlands and waterbodies within the Project area.

A primary objective is to characterize the baseline hydrologic conditions within the Project study area by providing available local and regional surface flow data, including low, average and peak values of the flows in the rivers and water levels in the lakes. The data and information presented are based upon historical data available in the RSA, information from previous studies in the region and data from site-specific field surveys conducted in 2005 and 2006. Assessments were based on this information, recognizing that unique locations may require additional site-specific sampling as the Project develops.

Another objective is to assess the impact of the Project on surface hydrology based on an analysis of the Project's water uses, operations and surface facilities. This includes assessments of potential future impacts and cumulative effects, plus discussions on future monitoring.

6.2 Study Areas

To document the baseline hydrologic conditions and assess the potential hydrologic effects of the Project, two study areas were selected: a Regional Study Area (RSA) and, on a more detailed local level, a Local Study Area (LSA). The RSA and LSA are shown in Figure 6.2-1 along with the Hangingstone, Corner, and Leismer (the latter includes the Northwest and South Leismer leases) lease areas. A field program was conducted in the LSA to characterize the hydrology of waterbodies and watercourses that may be directly or indirectly affected by Project activities. The RSA includes areas outside of the LSA where the surface hydrology may be indirectly (e.g., cumulative effects of the Project and nearby projects) affected by all activities associated with the Project (e.g., groundwater withdrawals).

The LSA and RSA used in the assessment of surface water hydrology are the same as those used to assess fish and fish habitat and surface water quality.

6.2.1 Regional Study Area

The areal extent upon which the cumulative effects of the Project will be assessed is based on flows and levels in regional watercourses and waterbodies in the RSA. Consideration was given to locations where potential for impacts to surface water/groundwater interactions exists. Beyond the RSA, there is expected to be negligible water resource impacts attributable to the Project.

The Christina River watershed forms the south and east borders of the RSA boundary, the House River watershed delimits the southwest boundary, the Horse River watershed defines the west and northwest limits, and the Clearwater River is the northeast border.

The RSA is located in the Boreal Forest Natural Region of Alberta (Natural Regions Committee, 2006) with a mix of deciduous, mixedwood and coniferous forest. The seasonal climate is characterized by long cold winters and short warm summers, with a pronounced summer-high continental precipitation pattern. Winter climate is strongly influenced by dry, cold continental and continental arctic air masses.

The topography is hummocky and largely subdued; however, the Stony Mountain Uplands located along the Northwestern portion of the Christina River Watershed represent the largest of several major hill complexes in the region. Drainage is generally south to north to the confluence of the Athabasca and Clearwater Rivers. The total area of the RSA is approximately 19,474 km^2.

6.2.2 Local Study Area

The LSA was established to assess the potential for localized effects on surface water hydrology and was delineated based on the areas of the Project leases and local drainage basin boundaries. The LSA covers 4,341 km^2, encompassing the lease areas related to Project disturbance activities including pads, roads, pipelines and disposal wells. Major watersheds in the LSA are the Christina, Hangingstone and the House rivers (Figure 6.2-1).

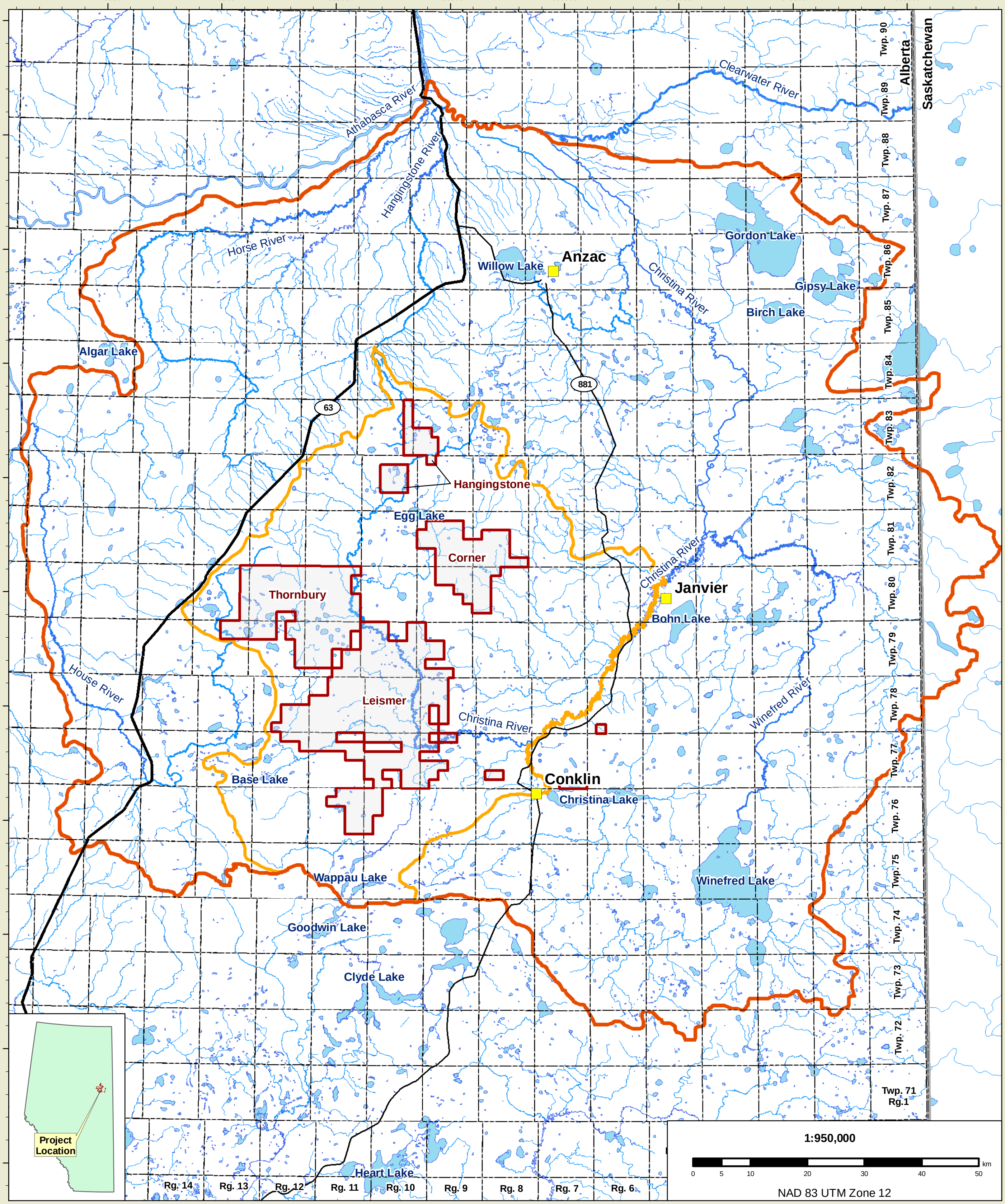
The LSA is almost entirely located within the Lower Boreal Highlands Natural Subregion with extensive low lying terrain, particularly in the upper plateau of the Christina River watershed where most of the lease areas are located. Forest types include aspen, balsam poplar, black and white spruce, white birch and jack pine. A small portion of the southeast LSA is in the Central Mixedwood Natural Subregion.

The majority of the LSA including the Hangingstone, Leismer and Corner areas sits within the Christina River watershed. A portion of the north Hangingstone lease drains northwest to a tributary of the Hangingstone River and a small area of the northwest corner of the Leismer lease drains south from the headwaters of the House River watershed.

In the Christina River watershed portion of the LSA the stream courses are low gradient (<1%), irregular and flow through many small, unnamed lakes and wetlands in a deranged drainage pattern. Deranged drainage patterns are characterized by an unsorted irregular stream network and are typically found in areas which experienced ‘recent’ glacial activity. Stream channel slopes in the Christina River watershed portion of the LSA range from flat to typically less than 5%, with dispersed steeper pitches up to 20% flanking headwater tributaries. Elevations range from 730 m above sea level (masl) in the headwaters of the May River to 450 masl near the mouth of the Kettle River for a total relief of about 280 m.

Within the LSA, the headwaters of the sub-basin of the Hangingstone River watershed and the House River are also nearly flat and with a deranged drainage pattern similar to the Christina River watershed and consist of small streams connecting wetlands and lakes. Slopes increase slightly to about 1% in the lower elevations of the Hangingstone River watershed near the confluence with the mainstem and to 2% at the southwestern border of the LSA in the House River watershed. Within the LSA, the total relief in the Hangingstone River watershed is about 200 m with elevations ranging from 520 masl to 720 masl. The relief in the House River portion of the LSA is approximately 140 m and has elevations ranging from 580 masl to 720 masl.

Twenty-three watercourses and ten lakes were selected to monitor fluctuations in local flow and lake levels. The sites were chosen based on their proximity (i.e., location within or near) to the leases. Section 6.7.4 provides details of the monitoring results plus a description of site characteristics.



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Legend

- North American Lease Boundary
- Regional Study Area (19,470 km²)
- Local Study Area (4,341 km²)
- Lake
- Stream
- Provincial Boundary

Title:

AQUATIC AND HYDROLOGIC REGIONAL AND LOCAL STUDY AREAS

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:
GH/LZ	May 15, 2007

File: Fig 6.2-1_Aquatic_and_Hydrologic_RSA_LSA_LP_950k_20070515.mxd

Drawn by:	Checked:	Fig. No.:
JC/LZ	LZ/GH	6.2-1

6.3 Issues and Assessment Criteria

Construction and operation of the Project may potentially affect the surface water flow regime in watercourses and waterbodies within the Project area. The specific surface water study requirements are identified in the TOR for the Project.

Potential surface water quantity and quality impacts may occur as a result of:

- Project water use;
- Subsurface operations; and
- Construction and operation of surface facilities including plants, roads, pads, pipelines and ponds.

The potential impacts of the above are discussed, and where appropriate, analyzed for local sub-basins within the Project study areas. Variations in stream flow and lake and wetland water levels have the potential to affect vegetation, aquatic habitat, wildlife habitat, and recreational activities/opportunities. Therefore, this assessment attempts to determine if the impacts are likely to be measurable, and proposes appropriate mitigation measures.

6.4 Methods

The surface water and climatic environmental setting is primarily a compilation of existing long-term regional data supplemented with short-term, site-specific information on streams located within the LSA. Historical long-term regional data along with site-specific data comparisons, where appropriate, provided the basis for characterizing the climate and hydrology of the area.

6.4.1 Data Sources

6.4.1.1 Climate

Climate data were compiled from long-term climatic stations in the region operated by the Meteorological Service of Canada (MSC), a division of Environment Canada, and forestry lookout stations (Environment Canada 1990 and 2004a). Published Canadian Climate Normals Data (1971-2000) were also used in this compilation. All of the climate stations considered in this study are listed in Table 6.4-1 and shown in Figure 6.4-1.

Year-round stations often collect a more complete range of climate parameters throughout the year. However, no year-round stations fall within the RSA. The nearest year-round (continuous) stations are at Cold Lake and Fort McMurray. These stations each have a significant period of record and are regionally applicable to the Project site. Another continuous climate monitoring station exists at Lac La Biche; however, it was not considered in this analysis because the station has changed locations several times during its operational period. There is also no intensity duration frequency (IDF) or depth duration frequency (DDF) rainfall data available for the station, nor is there any evaporation and evapotranspiration data.

The forestry lookout stations are seasonally operated and primarily collect summer rainfall and temperature data. There are eight such stations scattered within the RSA. Two others (Muskeg Lookout and Algar Lookout) located just north and northwest, respectively, of the RSA are also included in the analysis.

Supplemental local climate information is available from other EIA studies, including Nexen/OPTI, EnCana, Conoco Surmount, and others. However, the short duration of the data collection period of these studies limits their comparative value.

Table 6.4-1 Climate Monitoring Stations

MSC[1] Station ID	WMO[2] ID	Station Name	Latitude	Longitude	Record Start	Record End	Record Length	Record Type	Station Elevation (masl)
3060110	-	ALGAR LO[3]	56°2'12"	-111°46'48"	1959	2006	48 years	Seasonal	780.3
3061580	-	CHRISTINA LO	55°34'48"	-111°51'0"	1967	2002	36 years	Seasonal	823
3081680	71120	COLD LAKE A[4]	54°25'12"	-110°16'48"	1953	2006	54 years	Continuous	541
3061800	-	CONKLIN LO	55°37'12"	-111°10'48"	1954	2006	53 years	Seasonal	670.6
3061930	-	COWPAR LO	55°49'48"	-110°22'48"	1957	2006	50 years	Seasonal	563.3
3062693	71932	FORT MCMURRAY A	56°39'0"	-111°13'12"	1944	2006	63 years	Continuous	369.1
3062889	-	GORDON LAKE LO	55°37'12"	-110°3'0"	1964	2006	43 years	Seasonal	487.7
3064740	-	MUSKEG LO	57°7'48"	-110°5'24"	1959	2005	47 years	Seasonal	652.3
3065560	-	ROUND HILL LO	55°1'48"	-111°58'48"	1952	2006	55 years	Seasonal	749.8
3066160	-	STONEY MOUNTAIN LO	56°22'48"	-111°13'48"	1954	2006	53 years	Seasonal	762
3067590	-	WINEFRED LO	55°19'48"	-110°1'12"	1957	2006	50 years	Seasonal	743.7

[1] MSC = Meteorological Service Canada
[2] WMO = World Meteorological Organization
[3] A = Airport
[4] LO = Forestry Lookout Station

6.4.1.2 Hydrology

Hydrologic data were primarily compiled from the Water Survey of Canada (WSC) hydrometric stations located in and near the RSA as shown in Figure 6.4.1 (Environment Canada 2004b and http://www.wsc.ec.gc.ca). The location, gross and effective drainage area, and type and period of record available at these stations are summarized in Table 6.4.2. Other data sources include the Atlas of Alberta Lakes (Mitchell and Prepas, 1990).

Short-term streamflow, geomorphic descriptions and lake level data have been collected at rivers and lakes, respectively, as part of this assessment and other monitoring programs in the area. A list of the short-term streamflow stations are presented in Table 6.4-3 and lake level stations are summarized in Table 6.4-4. The locations of all the short-term stations are shown in Figure 6.4-2.

Table 6.4-2 Environment Canada Hydrometric Stations Used in the Study

Station ID	Name	Location			Gross Drainage Area	Effective Drainage Area[1]	Period of Record	Years of Record	Type of Record
		Latitude	Longitude	Elev. (masl)	km^2	km^2			
06AA001	Beaver River near Goodridge	54.44	-111.35	560	4,710	3,780	1967 - 2005	39	Seasonal
06AA002	Amisk` River at Highway No. 36	54.47	-112.02	560	2,510	1890	1971 - 2005	35	Seasonal
06AA004	Columbine Creek near the Mouth	54.36	-111.14	570	241	229	1979 - 1996	18	Seasonal
06AB001	Sand River near the Mouth	54.47	-111.19	550	4,910	4,730	1967 - 2005	39	Seasonal
06AB002	Wolf River at Outlet of Wolf Lake	54.71	-111.00	600	725	564	1968 - 2004	37	Continuous
06AB003	Punk Creek near the Mouth	54.54	-111.23	570	395	384	1981 - 1990	10	Seasonal
06AC001	Jackfish Creek near La Corey	54.44	-110.69	550	489	333	1972 - 2005	34	Seasonal
06AC006	Mooselake River near Franchere	54.32	-110.96	540	1,010	627	1980 - 1993	14	Seasonal
06AC009	Manatokan Creek near Iron River	54.45	-110.94	560	449	359	1981 - 1990	10	Seasonal
06AD006	Beaver River at Cold Lake Reserve	54.35	-110.20	500	14,500	11,600	1955 - 2004	50	Continuous
06AD013	Reita Creek near Outlet of Angling Lake	54.23	-110.33	--	161	161	1981 - 1991	11	Continuous
06AF001	Cold River at Outlet of Cold Lake	54.56	-109.83	550	6,520	6,260	1952 - 1959 & 1993 - 2005	21	Continuous
06AF008	Martineau River above Cold Lake	54.69	-110.03	555	5,350	5,340	1981 - 1995	15	Continuous
07CA001	Flat Creek near Donatville	54.76	-112.87	570	666	488	1920 - 1931	12	Seasonal
07CA003	Flat Creek near Boyle	54.59	-112.91	570	184	88	1919 - 1931 & 1980 - 2006	40	Seasonal
07CA005	Pine Creek near Grassland	54.82	-112.78	550	1,450	933	1966 - 2005	40	Seasonal
07CA006	Wandering River near Wandering River	55.20	-112.47	575	1,110	1,110	1971 - 2005	35	Continuous
07CA008	Babette Creek near Colinton	54.65	-113.08	570	222	68	1978 - 2005	28	Seasonal
07CA011	La Biche River at Highway No. 63	54.94	-112.50	540	4,860	4,740	1982 - 1995	14	Continuous
07CA012	Logan River near the Mouth	55.18	-111.73	585	425	425	1984 - 2005	22	Seasonal
07CA013	Owl River below Piche River	55.01	-111.85	565	3,080	3,040	1984 - 2005	22	Seasonal
07CB002	House River at Highway No. 63	55.64	-112.16	665	764	764	1982 - 2006	25	Seasonal
07CC001	Horse River at Abasands Park	56.71	-111.39	255	2,130	2,130	1931 & 1976 - 1979	5	Continuous
07CD001	Clearwater River at Draper	56.69	-111.25	250	30,800	30,800	1931 & 1957- 2005	50	Continuous
07CD004	Hangingstone River at Fort McMurray	56.71	-111.36	250	959	959	1965 - 2005	41	Continuous
07CD005	Clearwater River above Christina River	56.66	-110.93	255	17,000	17,000	1966 - 2005	40	Continuous
07CE002	Christina River near Chard	55.84	-110.85	475	4,860	4,830	1982 - 2006	25	Seasonal
07CE003	Pony Creek near Chard	55.87	-110.90	495	278	278	1982 - 2005	24	Seasonal
07CE004	Robert Creek near Anzac	56.38	-111.03	465	54	54	1982 - 1995	14	Seasonal
07CE005	Jackfish River below Christina Lake	55.67	-111.10	550	1,290	1,270	1982 - 1995	14	Seasonal
07CE006	Birch Creek near Conklin	55.62	-111.09	565	232	232	1984 - 1995	12	Seasonal
07DA001	Athabasca River below McMurray	56.78	-111.38	240	133,000	131,000	1957 - 2004	48	Continuous
07DA006	Steepbank River near Fort McMurray	57.01	-111.42	260	1320	1,320	1972 - 2005	34	Continuous
07DA007	Poplar Creek near Fort McMurray	56.91	-111.46	235	151	151	1973 - 1986	14	Continuous
07DA011	Unnamed Creek near Fort Mackay	57.66	-111.52	250	274	274	1975 - 1993	19	Continuous
07DA018	Beaver River above Syncrude	56.94	-111.57	318	165	165	1975 - 2005	31	Continuous
07DB001	Mackay River near Fort Mackay	57.21	-111.69	250	5,570	5,570	1972 - 2005	34	Continuous
07DB005	Mackay River above Dunkirk River	56.76	-112.61	250	1,010	1,010	1983 - 1991	9	Seasonal
07JA003	Willow River near Wabasca	55.92	-113.92	470	1,030	1,030	1985 - 2005	21	Seasonal
07JB002	Wabasca River below Trout River	56.32	-113.79	555	14,300	14,300	1985 - 1994	10	Continuous

[1] The effective drainage area is that portion of a basin which might be expected to entirely contribute runoff to the main stream during a flood with a return period of two years. This area excludes marsh and slough areas and other natural storage which would prevent runoff from reaching the main stream in a year of average runoff.

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Table 6.4-3 Short-Term Watercourse Monitoring Stations

Stream ID	Stream Name	Location		Period of Record[1]
		Easting (m)	Northing (m)	
WCC1	East trib to Christina River	484253	6211504	Aug 2005 to May 2006
WCC2	East trib to Christina River	477385	6211024	Aug 2005 to May 2006
WCC3	East trib to Christina River	477546	6206582	Aug 2005 to May 2006
WCH1	Hangingstone River	471136	6229758	May 2005 to Aug 2005
WCH2	Hangingstone River	471172	6228332	Aug 2005 to May 2006
WCH3	Christina River	477437	6224349	Aug 2005 to Feb 2006
WCH4	Christina River	481578	6222806	Aug 2005 to May 2006
WCH5	Christina River	486353	6222149	Aug 2005 to May 2006
WCH6	Christina River	468847	6216553	Aug 2005 to May 2006
WCL1	Christina River	464171	6201591	Aug 2005 to May 2006
WCL2	West trib to Christina River	454134	6198898	Aug 2005 to May 2006
WCL3	House River	442515	6191507	May 2006
WCL4	Christina River	470431	6190933	Aug 2005 to May 2006
WCL5	Waddell Creek	484440	6192371	Aug 2005 to May 2006
WCL6	Waddell Creek	484370	6185273	Aug 2005 to May 2006
WCL7	Christina River	474119	6184326	Sep 2005 to May 2006
WCL8	Christina River	470442	6182976	Aug 2005 to May 2006
WCL9	Christina River	473396	6182053	Sep 2005 to May 2006
WCL10	Christina River	473415	6178659	May 2005 to Aug 2006
WCL11	Christina River	482528	6175937	Sep 2005 to Feb 2006
WCL12	West trib to Christina River	469593	6174937	Aug 2005 to May 2006
WCL13	May River	477695	6171918	Feb 2005 to May 2006
WCL14	West trib to Christina River	459378	6173854	Aug 2005 to May 2006

[1] Spot flows were measured three to four times over the period of record by Matrix Solutions Inc.

Table 6.4-4 Short-Term Lake Level Monitoring Stations

Lake Name	Lake ID	Location		Sampling Season*
		Easting (m)	Northing (m)	
Egg Lake	LC1	474318	6213929	Spring- Fall-Summer 2005/Summer 2006
Unnamed	LC2	471488	6199513	Fall 2005/Summer 2006
Unnamed	LH1	478188	6228862	Winter-Spring-Fall-Summer 2005/Summer 2006
Unnamed	LH2	473870	6227359	Summer-Spring 2005
Soho (Owl) Lake	LH3	470619	6225356	Fall-Spring-Summer 2005
Unnamed	LL1	476587	6180510	Summer-Spring 2005
Unnamed	LL2	481855	6183602	Fall-Summer2005
Unnamed	LL3	444725	6193800	Spring 2005/Summer 2006
Unnamed	LL4	452729	6196552	Winter-Spring-Summer 2005/Summer 2006
Unnamed	LL5	476598	6162118	Winter-Spring-Summer-Fall 2005

* Lake depth was spot measured two to four times over the period of record by Matrix Solutions Inc.

6.4.2 Analyses

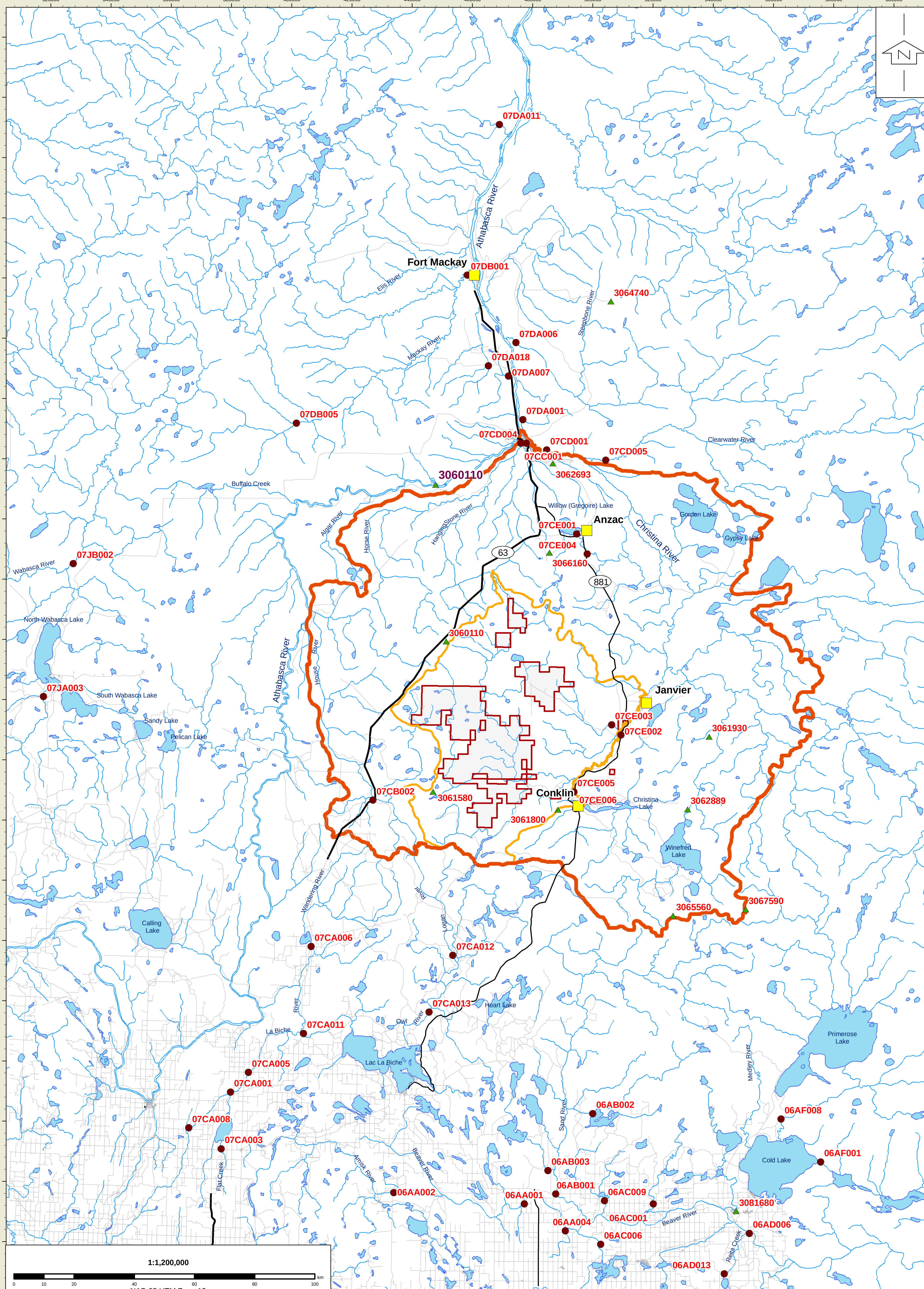
Statistical analyses, summaries and comparisons were conducted to describe and predict the variability of climatic and hydrologic conditions relevant to the study areas. Climatic and hydrological variables analyzed include: temperature, precipitation, evaporation rates, lake water levels, local and regional stream flows, sediment loading, surface water withdrawal licenses, channel section, and geomorphic data.

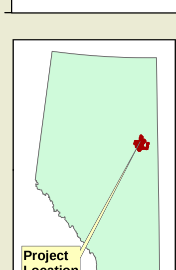
6.4.3 Existing and Planned Developments

Oil sands developments, either existing or approved, within the Project study areas were assumed as part of the existing or baseline case. These projects include:

- Nexen/OPTI Long Lake SAGD Project – located north of the LSA.
- Petrobank Whitesands Project – located east and south of the Leismer lease within the LSA.
- EnCana Christina Lake Pilot Project – situated east of the Leismer lease within the RSA.
- ConocoPhillips Canada Resources Corporation Surmont Project – located near the Engstrom Lake area. This project commenced development in 2004 and is located northwest of the Corner lease area.
- Petro-Canada Meadow Creek Project – is an approved development stationed north and northwest adjacent to the Hangingstone lease area within the RSA.
- JACOS Hangingstone Project – located approximately 25 km west of Anzac and is northwest of the Hangingstone lease within the RSA.
- Connacher Great Divide Pilot Project – located west of the Hangingstone lease area, and straddles the LSA border.
- Devon Jackfish SAGD Project – situated east of the LSA.
- MEG Energy Christina Lake Regional Project (pilot and first phase commercial) – located east of the LSA.

Other existing developments in the study areas include forest harvesting, La Loche Road realignment, municipalities, non-industrial sources, trapping and hunting, recreation, electric transmission linear corridors, and various oil and gas industry facilities including wells, buried pipelines and associated access roads. The other principal linear facilities in the RSA include Secondary Highways 881 and 63 and the Alberta Northern Railway traversing north to south within the RSA.





Legend

- North American Lease Boundary
- Regional Study Area (19,474 km²)
- Local Study Area (4,341 km²)
- Lake
- Stream
- Metereological Service of Canada Station
- Water Survey of Canada Station
- Town
- Hwy. 63
- Hwy. 881
- Other Roads

Title:

REGIONAL CLIMATE AND STREAMFLOW MONITORING LOCATIONS

NORTH AMERICAN OIL SANDS CORPORATION

Approved: GH	Revision Date: Apr. 10, 2007

File: Fig 6.4-1 Local Study Area Stream and Lake Monitoring Locations_Tabloid_P_20070221.mxd

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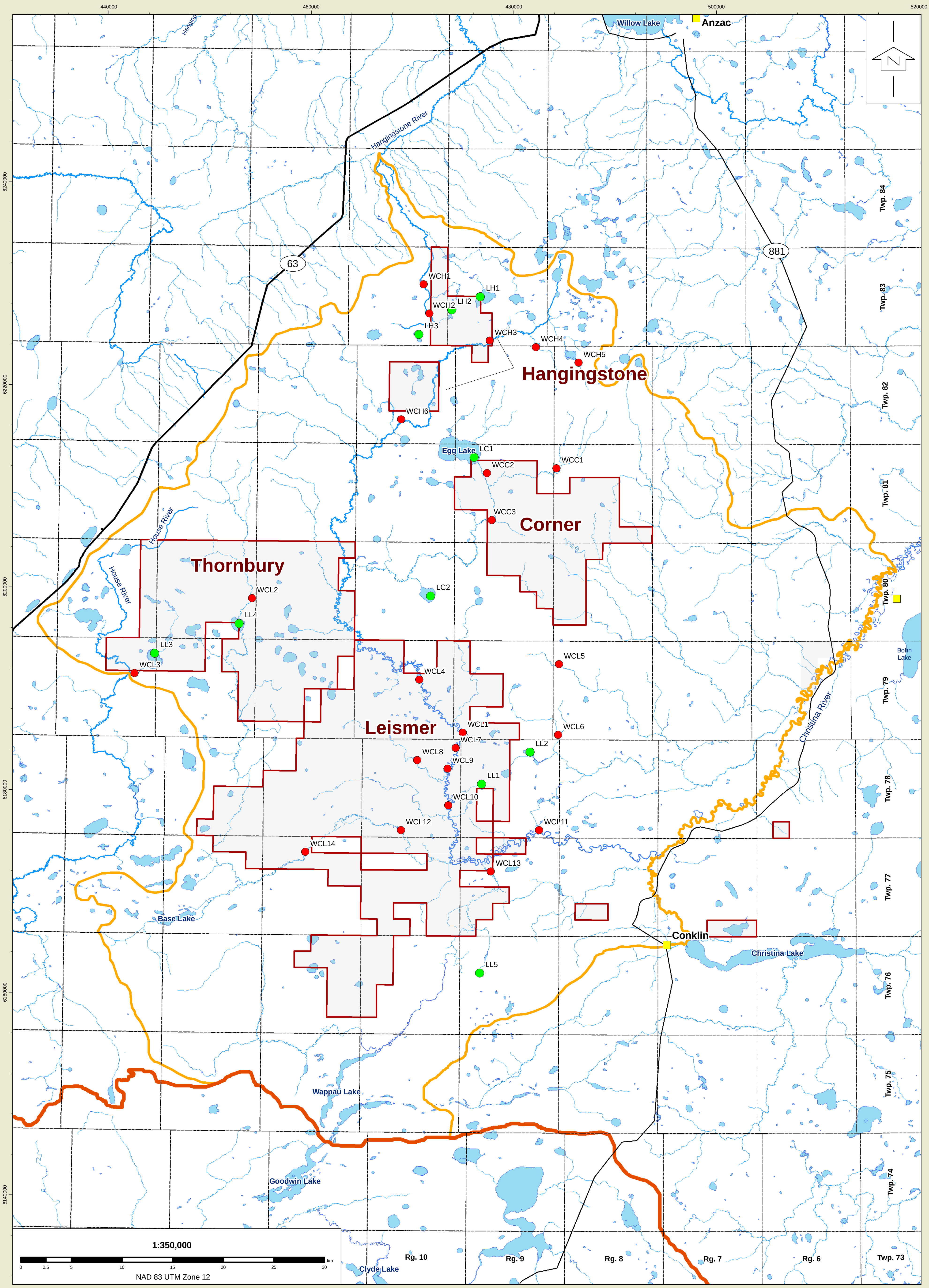
LZ/JC	GH/LZ	6.4-1

14455-514_NAOSC\NAOSC_Maps\Maps_Surface_Hydrology\FINAL\Fig 6.4-1 Local Study Area Stream and Lake Monitoring Locations_Tabloid_P_20070221.mxd



Project Location

Legend

- North American Lease Boundary
- Regional Study Area
- Local Study Area
- Lake
- Stream
- Hydrometric Station (Discharge)
- Hydrometric Station (Lake Level)

Title:

LOCAL STUDY AREA SHORT-TERM STREAM FLOW AND LAKE LEVEL MONITORING LOCATIONS

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:
GH/LZ	May 15, 2007

File: Fig 6.4-2 LSA_Stream_and_Lake_Monitoring Locations_350k_Tabloid_P_20070515.mxd

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6.5 Climatic Conditions

Climatic factors are important for characterizing the surface water hydrologic conditions of the Project site because variability in precipitation, temperature and evaporation greatly affects basin runoff characteristics and streamflows. The climate in the study area is characterized as continental with four distinct seasons; however, the most prevalent seasons are summer and winter. The summers are typically warm and moist as a result of air masses advancing from the south. The winter months are frequently under the influence of cold, arctic air from the north.

6.5.1 Regional Temperature

Air temperature is an important factor in determining snowmelt rate, timing of peak flows and ice break-up. Both the Cold Lake and Fort McMurray climate stations collect year-round climate data that are applicable to the study area. Monthly temperature trends and historical mean annual temperatures at Cold Lake Airport and Fort McMurray Airport climate stations are shown in Figure 6.5-1. The long-term mean annual temperature for Cold Lake is 1.6°C (1953 – 2005) and for Fort McMurray it is 0.2°C (1944 – 2005). Mean monthly temperatures are warmest in July averaging 16.6°C at Fort McMurray and 17.1°C at Cold Lake and the coolest mean monthly temperatures are in January averaging -19.8°C at Fort McMurray and -17.3°C at Cold Lake.

Extensive regional data exist from forestry lookout stations for the summer period (May to August inclusive). These data in conjunction with year-round Cold Lake and Fort McMurray climate data, and temperature relationships between latitude and elevation can be used to derive temperature characteristics of the local area within the RSA. Mean, maximum and minimum monthly temperatures for the climate stations used in the study are presented in Table 6.5-1. Mean summer (May-August) temperature variations with station elevation and latitude are shown in Figure 6.5-2. The figure illustrates that temperature decreases slightly with increasing latitude and elevation.

6.5.2 Local Temperature

The two nearest year-round climate stations to the LSA are Fort McMurray and Cold Lake, located north and south of the RSA, respectively. Mean, maximum and minimum summer monthly temperatures for the LSA were initially estimated from regressions derived between monthly temperature and elevation and a median LSA elevation of 671 m. The R^2 values up to 0.5 and 0.6 were obtained for several of the metrics; however, generally very weak relationships resulted, with R^2 values often less than 0.1. Overall, it was concluded that LSA summer temperature trends were too variable to estimate from the regressions and were better reflected by averaging May to August data combining the two year round stations with the LSA seasonal stations. This resulted in summer temperatures about 0.8°C cooler in the LSA than the average of Fort McMurray and Cold Lake. For the winter months, monthly temperatures were assumed to be equivalent to the average of Fort McMurray and Cold Lake monthly winter temperatures. Table 6.5-2 presents estimated monthly temperatures for the LSA based on the above.

6.5.3 Regional Precipitation

The amount of precipitation an area receives determines the potential amount of runoff generation. The two nearest continuous year-round climate stations, Fort McMurray and Cold Lake, indicate that the average annual precipitation is approximately 440 mm. Over half of the yearly precipitation falls in the four-month summer period from May to August (Figure 6.5-3). The wettest month is July and the driest months are February and March.

Seasonal precipitation data for the summer month period (May to August inclusive) at nine climate stations in and around the study areas are presented in Table 6.5-3 and Figure 6.5-3. Generally, mean summer precipitation increases with increasing elevation at lookout stations. By comparison, summer precipitation at the lower elevation Fort McMurray and Cold Lake stations is less than the lookout stations except for Gordon Lake.

Table 6.5-1 Mean Monthly and Mean Annual Temperatures for Climate Stations

Station	Period of Record		Location			Monthly Temperature (°C)												Mean Annual	Mean Summer[1]
	Start	End	Latitude	Longitude	Elevation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
Mean																			
ALGAR LO[2]	1959	2006	56.12	-111.8	780.3	-	-	-	-	10.22	13.50	14.00	13.17	-	-	-	-	-	12.72
CHRISTINA LO	1967	2002	55.58	-111.9	823	-	-	-	-	9.46	13.25	15.31	15.17	-	-	-	-	-	13.30
COLD LAKE A[3]	1953	2006	54.42	-110.3	541	-17.32	-12.63	-6.30	3.45	10.38	14.67	17.07	15.82	10.03	4.06	-6.32	-13.94	1.58	14.49
CONKLIN LO	1954	2006	55.62	-111.2	670.6	-	-	-	-	9.57	13.76	15.84	14.55	-	-	-	-	-	13.43
COWPAR LO	1957	2006	55.83	-110.4	563.3	-	-	-	-	9.95	13.94	16.18	14.92	-	-	-	-	-	13.74
FORT MCMURRAY A	1944	2006	56.65	-111.2	369.1	-19.82	-14.96	-7.90	2.37	9.62	14.12	16.59	14.98	9.21	2.84	-8.33	-16.44	0.19	13.83
GORDON LAKE LO	1964	2006	55.62	-110.5	487.7	-	-	-	-	10.87	14.78	15.78	13.54	-	-	-	-	-	13.74
MUSKEG LO	1959	2005	57.13	-110.9	652.3	-	-	-	-	8.46	13.42	15.61	14.36	-	-	-	-	-	12.96
ROUND HILL LO	1952	2006	55.3	-112	749.8	-	-	-	-	9.66	13.45	15.60	14.36	-	-	-	-	-	13.27
STONEY MOUNTAIN LO	1954	2006	56.38	-111.2	762	-	-	-	-	8.35	13.02	15.18	13.91	-	-	-	-	-	12.61
WINEFRED LO	1962	2006	55.2	-112.5	563.9	-	-	-	-	9.21	13.41	15.53	14.42	-	-	-	-	-	13.14
Maximum																			
ALGAR LO	1959	2006	56.12	-111.8	780.3	-	-	-	-	15.94	18.92	19.32	18.53	-	-	-	-	-	18.17
CHRISTINA LO	1967	2002	55.58	-111.9	823	-	-	-	-	15.78	19.02	20.96	21.01	-	-	-	-	-	19.19
COLD LAKE A	1953	2006	54.42	-110.3	541	-12.25	-6.92	-0.52	9.32	16.87	20.79	23.01	21.87	15.80	9.31	-2.13	-9.38	7.15	20.63
CONKLIN LO	1954	2006	55.62	-111.2	670.6	-	-	-	-	15.68	19.43	21.21	20.12	-	-	-	-	-	19.11
COWPAR LO	1957	2006	55.83	-110.4	563.3	-	-	-	-	16.29	19.68	21.79	20.64	-	-	-	-	-	19.60
FORT MCMURRAY A	1944	2006	56.65	-111.2	369.1	-14.45	-8.64	-0.96	8.98	16.75	21.15	23.40	21.81	15.29	8.08	-3.83	-11.55	6.33	20.78
GORDON LAKE LO	1964	2006	55.62	-110.5	487.7	-	-	-	-	17.39	20.90	21.71	19.60	-	-	-	-	-	19.90
MUSKEG LO	1959	2005	57.13	-110.9	652.3	-	-	-	-	14.48	19.07	21.00	19.73	-	-	-	-	-	18.57
ROUND HILL LO	1952	2006	55.3	-112	749.8	-	-	-	-	16.24	19.68	21.58	20.45	-	-	-	-	-	19.49
STONEY MOUNTAIN LO	1954	2006	56.38	-111.2	762	-	-	-	-	13.66	18.01	20.03	18.65	-	-	-	-	-	17.59
WINEFRED LO	1962	2006	55.2	-112.5	563.9	-	-	-	-	15.64	19.41	21.43	20.46	-	-	-	-	-	19.23
Minimum																			
ALGAR LO	1959	2006	56.12	-111.8	780.3	-	-	-	-	4.44	8.01	8.75	7.80	-	-	-	-	-	7.25
CHRISTINA LO	1967	2002	55.58	-111.9	823	-	-	-	-	3.13	7.44	9.63	9.23	-	-	-	-	-	7.36
COLD LAKE A	1953	2006	54.42	-110.3	541	-17.49	-18.62	-16.58	-9.52	-2.81	3.60	7.66	9.25	7.40	3.93	-3.65	-10.91	-3.98	4.43
CONKLIN LO	1954	2006	55.62	-111.2	670.6	-	-	-	-	3.43	8.04	10.42	8.94	-	-	-	-	-	7.71
COWPAR LO	1957	2006	55.83	-110.4	563.3	-	-	-	-	3.56	8.16	10.51	9.17	-	-	-	-	-	7.85
FORT MCMURRAY A	1944	2006	56.65	-111.2	369.1	-24.97	-21.21	-14.72	-4.21	2.46	7.05	9.74	8.10	3.08	-2.43	-12.77	-21.27	-5.93	6.83
GORDON LAKE LO	1964	2006	55.62	-110.5	487.7	-	-	-	-	4.29	8.61	9.84	7.48	-	-	-	-	-	7.56
MUSKEG LO	1959	2005	57.13	-110.9	652.3	-	-	-	-	2.47	7.74	10.18	8.90	-	-	-	-	-	7.32
ROUND HILL LO	1952	2006	55.3	-112	749.8	-	-	-	-	3.02	7.18	9.57	8.22	-	-	-	-	-	7.00
STONEY MOUNTAIN LO	1954	2006	56.38	-111.2	762	-	-	-	-	3.03	8.01	10.36	9.11	-	-	-	-	-	7.63
WINEFRED LO	1962	2006	55.2	-112.5	563.9	-	-	-	-	2.86	7.40	9.60	8.29	-	-	-	-	-	7.04

[1] Mean Summer = May to August
[2] LO = Forestry Lookout Station
[3] A = Airport

Table 6.5-2 Derived Monthly Air Temperatures for the Local Study Area

Month	Monthly Temperature (°C)		
	Maximum	Mean	Minimum
January	-13.4	-18.6	-23.7
February	-7.8	-13.8	-19.8
March	-0.7	-7.1	-13.4
April	9.1	2.9	-3.4
May	15.7	9.5	2.9
June	19.5	13.6	7.5
July	20.1	14.4	8.6
August	21.1	15.5	9.7
September	15.5	9.6	3.7
October	8.7	3.5	-1.8
November	-3.0	-7.3	-11.6
December	-10.5	-15.2	-19.9

Table 6.5-3 Mean Monthly Precipitation at Climate Stations

Station	Period of Record		Location			Mean Monthly Precipitation (mm)												Mean Annual	Mean Summer[1]
	Start	End	Latitude	Longitude	Elevation (masl)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
ALGAR LO	1959	2006	56°2'12"	-111°46'48"	780	-	-	-	-	62.7	84.6	92.0	73.0	-	-	-	-	-	312.3
CHRISTINA LO	1967	2002	55°34'48"	-111°51'0"	823	-	-	-	-	47.7	91.5	101.8	52.8	-	-	-	-	-	293.9
COLD LAKE A	1953	2006	54°25'12"	-110°16'48"	541	19.0	13.4	17.9	26.2	39.5	71.6	81.4	68.0	42.3	18.9	19.3	21.1	438.4	260.4
CONKLIN LO	1954	2006	55°37'12"	-111°10'48"	671	-	-	-	-	47.8	91.1	98.5	74.8	-	-	-	-	-	312.2
COWPAR LO	1957	2006	55°49'48"	-110°22'48"	563	-	-	-	-	43.0	76.3	88.5	67.5	-	-	-	-	-	275.3
FORT MCMURRAY A	1944	2006	56°39'0"	-111°13'12"	369	19.9	16.0	17.2	20.7	35.5	67.3	78.5	66.8	49.4	26.9	22.5	20.9	441.4	248.1
GORDON LAKE LO	1964	2006	55°37'12"	-110°3'0"	488	-	-	-	-	49.4	75.5	77.7	56.4	-	-	-	-	-	259.0
MUSKEG LO	1959	2005	57°7'48"	-110°5'24"	652	-	-	-	-	36.7	74.9	88.2	65.7	-	-	-	-	-	265.6
ROUND HILL LO	1952	2006	55°1'48"	-111°58'48"	750	-	-	-	-	43.6	85.4	98.5	68.1	-	-	-	-	-	295.5
STONEY MOUNTAIN LO	1954	2006	56°22'48"	-111°13'48"	762	-	-	-	-	59.0	101.2	114.2	92.6	-	-	-	-	-	367.0
WINEFRED LO	1962	2006	55°19'48"	-110°1'12"	564	-	-	-	-	53.7	86.5	90.9	62.0	-	-	-	-	-	293.2

[1] Mean Summer = May to August
[2] LO = Forestry Lookout Station
[3] A = Airport

6.5.4 Local Precipitation

Precipitation data for the LSA were assembled using the linear relationship between average year-round data for the Fort McMurray and Cold Lake stations and average summer precipitation between three LSA lookout stations: Conklin, Christina, and Algar.

To derive the dataset for the summer months, a linear relationship was developed between precipitation and elevation for the year-round and seasonal stations for the mean, minimum and maximum average summer precipitation totals. However, the relationship was found to be generally weak, with R^2 values typically less than 0.5 and sometimes less than 0.2. Three exceptions were determined where there was a strong relationship (R^2 = 0.64 to 0.78), for mean and minimum May precipitation and mean July precipitation. For these exceptions, the LSA temperature was estimated using the derived regression equations and a median elevation of 671 masl. Otherwise, LSA summer precipitation was estimated by averaging precipitation from all stations, that is, the three lookout and the two year-round stations. For the remaining months of the year, fall, winter and spring precipitation was assumed equal to the average of the Fort McMurray and Cold Lake stations.

The derived mean, minimum and maximum monthly precipitation estimates for the LSA are presented in Table 6.5-4. The average of the Fort McMurray and Cold Lake rainfall data were used to represent rainfall Intensity-Duration-Frequency (IDF) curves for the LSA (Table 6.5-5; Figure 6.5-4).

Recent precipitation observed during the field monitoring program is useful for comparing the hydrologic data collected. At Fort McMurray the total precipitation recorded in 2005 was 85% of average while at Cold Lake it was higher than normal, at 122% of average. In 2006, data are available only from January to June, inclusive. However, total precipitation over the first six months of 2006 is equal to the long-term average for the same time period at the Fort McMurray station and slightly below, or 92% of average, for Cold Lake.

Table 6.5-4 Estimated Monthly Precipitation for the Local Study Area

Month	Monthly Precipitation (mm)		
	Minimum	Mean	Maximum
January	3.8	19.4	44.1
February	2.6	14.7	40.9
March	1.5	17.5	55.0
April	0.9	23.4	86.5
May[1]	5.2	48.2	124.1
June[1]	29.9	89.1	212.7
July[1]	26.7	92.1	197.6
August[1]	5.4	66.9	210.0
September	10.4	45.8	117.5
October	1.8	22.9	77.7
November	1.4	20.9	53.4
December	4.0	21.0	56.6
Annual	**-**	**481.9**	**-**

[1] Based on: average of data at Fort McMurray A, Cold Lake A, Conklin LO, Christina LO and Algar LO, or regression equation between elevation and precipitation. The average of the Fort McMurray A and Cold Lake A station's data was used for all other months.

Table 6.5-5 Rainfall Intensity Duration Frequency Values for Local Study Area

	Rainfall Intensity (mm/h)			
Duration	**2 Year**	**10 Year**	**25 Year**	**100 Year**
30 min	24.4	44.1	54.0	68.6
1 hour	14.6	25.7	31.2	39.5
2 hour	9.0	15.2	18.3	23.0
6 hour	4.2	6.8	8.1	10.0
12 hour	2.7	4.4	5.5	6.5
24 hour	1.6	2.7	3.2	4.0
2 day	1.0	1.5	1.9	2.5
5 day	0.4	0.7	0.8	1.1
10 day	0.3	0.4	0.5	0.7

Based upon average of Cold Lake A and Fort McMurray A IDF values.

6.5.5 Evaporation and Evapotranspiration

Evaporation and evapotranspiration account for the largest loss of water from Alberta's watersheds. Evaporation is the direct transformation of liquid water to water vapour while transpiration is the release of water vapour to the air through the stoma of plants. Evapotranspiration (ET) is the combination of evaporation and transpiration from an area (usually terrestrial) and is used to assess losses when compiling a water balance. Evapotranspiration processes are important hydrologically as they have a direct effect on the amount of runoff from a watershed. Potential evaporation is the evaporation that occurs from a small water surface, and lake evaporation is the evaporation that occurs from the surface of a large waterbody. Potential evapotranspiration (PET) is the evapotranspiration that occurs in a moist environment from a small area. Areal evapotranspiration is the evapotranspiration that occurs from a large area.

Monthly mean evaporation and evapotranspiration data are available for Fort McMurray from 1971 to 1992 and for Cold Lake from 1973 to 1992 (Bothe and Abraham, 1987 and 1993). The data have been extended at Fort McMurray to 2003 based upon climatic records at the station and using the Morton evaporation model (Abraham, 1999). Averaging the data at Cold Lake and Fort McMurray provides the evaporation and evapotranspiration values for the Project area as listed in Table 6.5-6.

The actual evaporation from shallow lake surfaces averages 602 mm annually which is 72% of the potential of 835 mm annually. Approximately 77% (464 mm) of actual lake evaporation occurs in the May-August period peaking at 133 mm in July. The timing of peak lake evaporation rates is a function of lake depth. The greater heat capacity of a deep lake delays seasonal warming and cooling, typically resulting in higher evaporation rates later in the summer season.

The mean annual potential evapotranspiration of 817 mm is comparable to the annual potential evaporation at 835 mm. Actual areal evapotranspiration averages only 322 mm per year or 39% of the potential because of limited water available for evaporation at times in a basin and the cooling effect of moving air, especially in the winter months. Most (82%) of areal evapotranspiration occurs in the May-August period, peaking in July.

Table 6.5-6 Evaporation and Evapotranspiration in the LSA

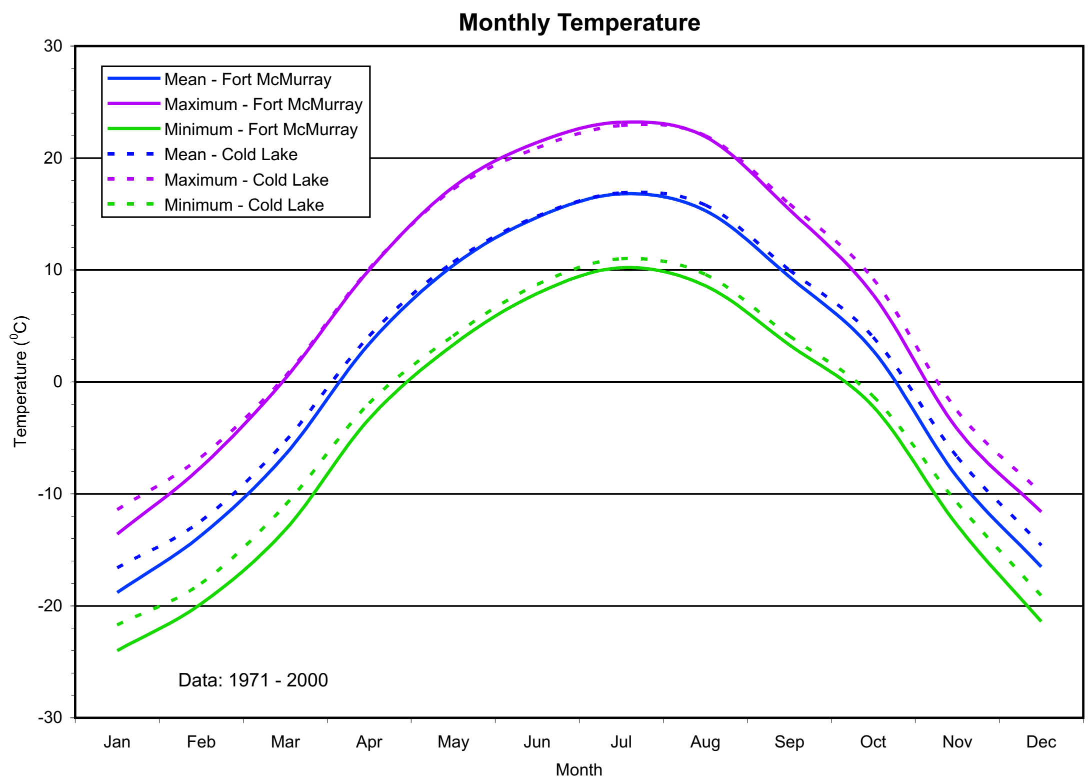
Month	Evaporation (mm)		Evapotranspiration (mm)	
	Potential	Lake	Potential	Area
January	-3	-3	-2	-2
February	0	0	1	1
March	24	19	21	14
April	99	64	98	21
May	153	104	152	44
June	166	124	163	73
July	170	133	165	87
August	137	103	134	60
September	71	45	66	17
October	21	17	21	11
November	-1	-1	-1	-1
December	-3	-3	-3	-3
Annual Total	*835*	*602*	*817*	*322*

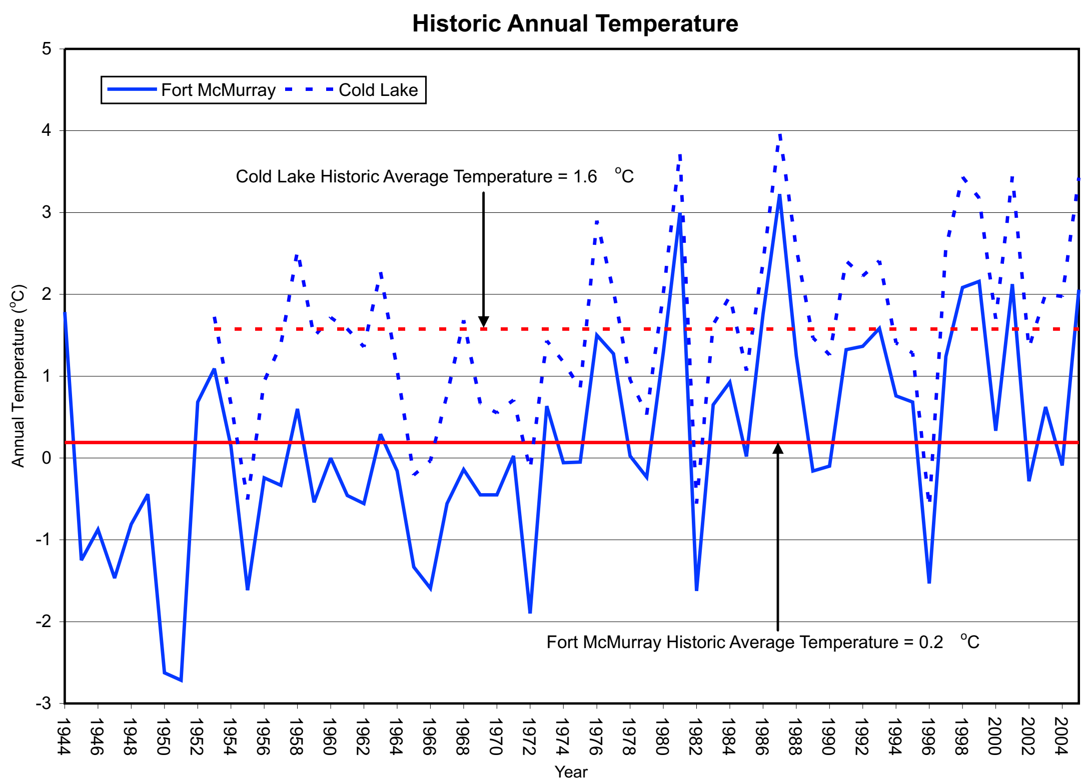
Notes: Negative values denote condensation.

Potential evaporation is the amount of water that would evaporate from a very small area with an unlimited supply of water.

Potential evapotranspiration relates to the amount of water that could pass from the soil-water interface under ideal conditions and an unlimited supply of water.

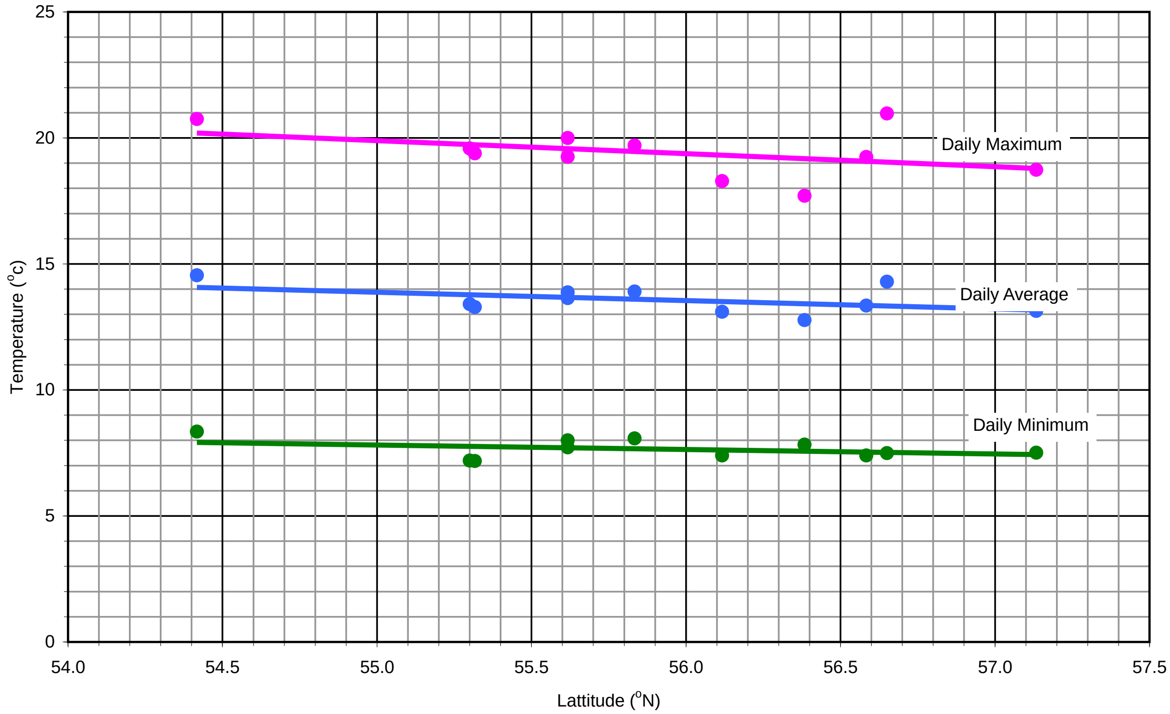
Based on 1953 - 2003 temperature and relative humidity data from Fort McMurray Airport climate station and 1953 - 2000 solar radiation data.



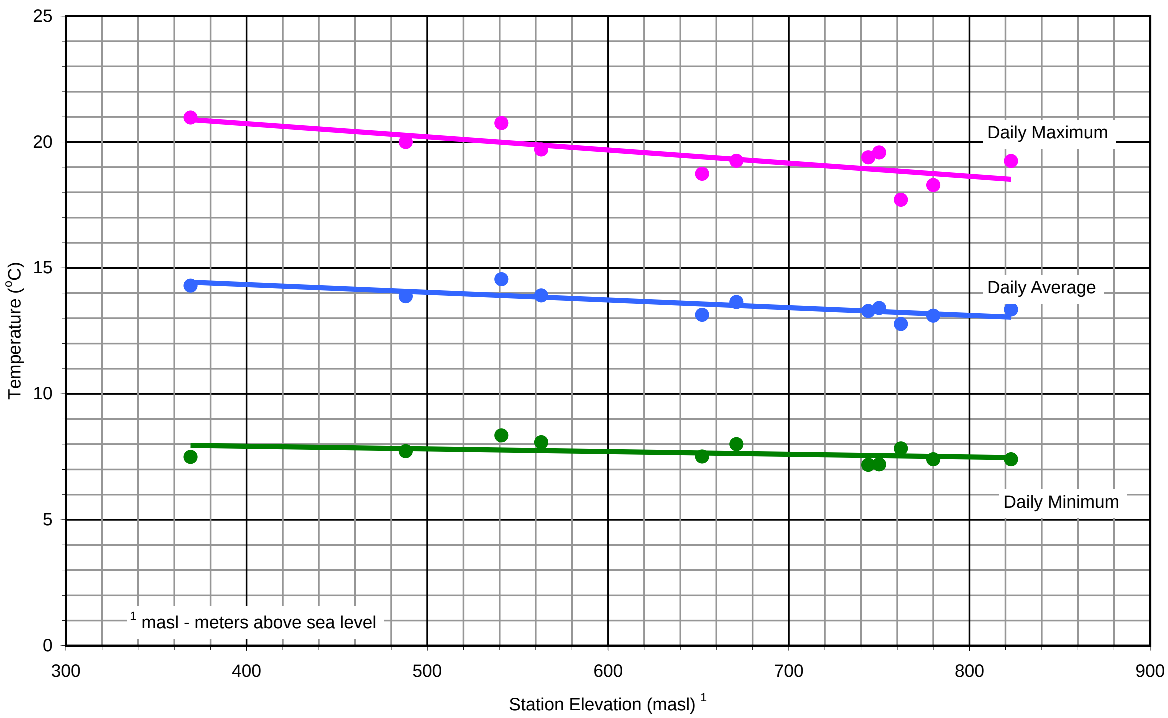


Title:	
MONTHLY AND HISTORIC MEAN ANNUAL TEMPERATURES AT FORT McMURRAY AND COLD LAKE	NORTH AMERICAN OIL SANDS CORPORATION
Approved: LP	Revision Date: 07/05/15
File: 4455-HydCharts-06.cdr	
Drawn by: GDE	Checked: GH	Fig. No.: **6.5-1**

Mean Summer Temperature versus Latitude

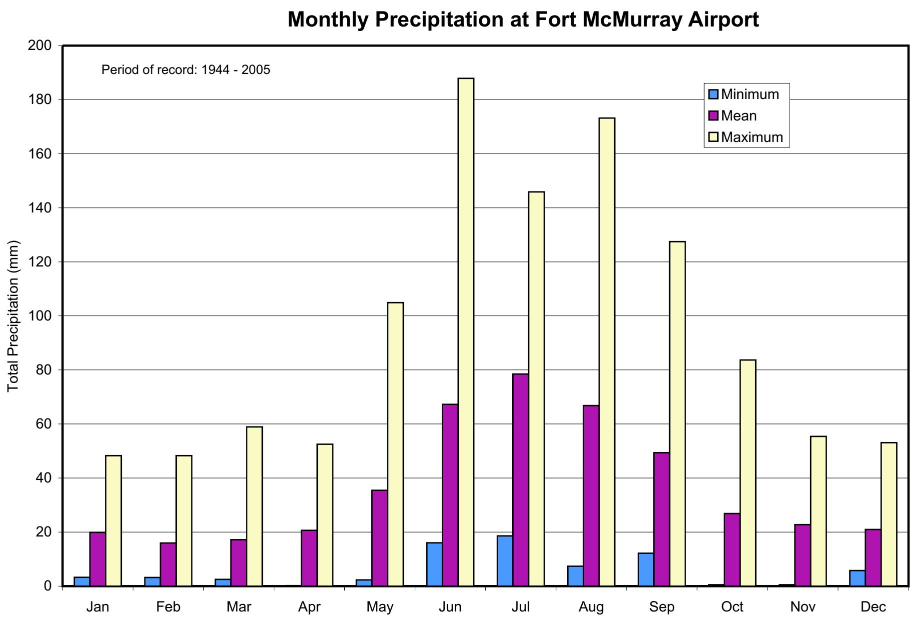


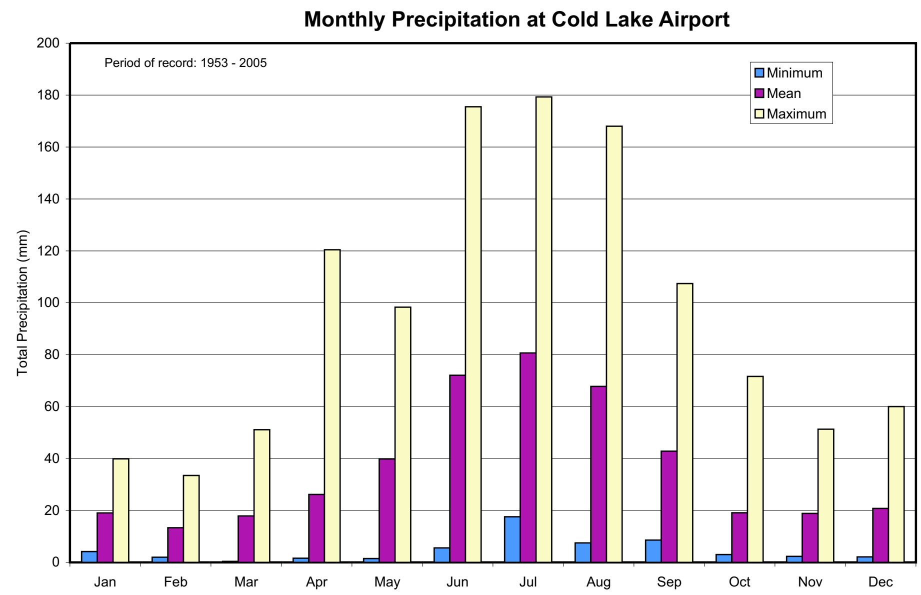
Mean Summer Temperature versus Elevation

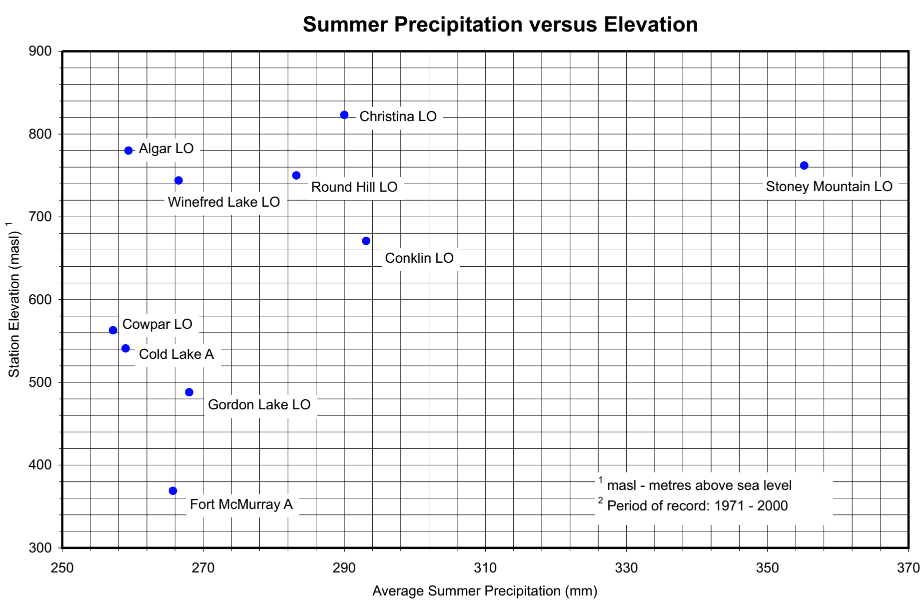


Summer = May to August

Title: TEMPERATURE VERSUS LATITUDE AND ELEVATION	North American Oil Sands Corporation		
	Approved: LP	Revision Date: 07/05/15	
	File: 4455-HydCharts-06.cdr		
	Drawn by: GDE	Checked: GH	Fig. No.: **6.5-2**







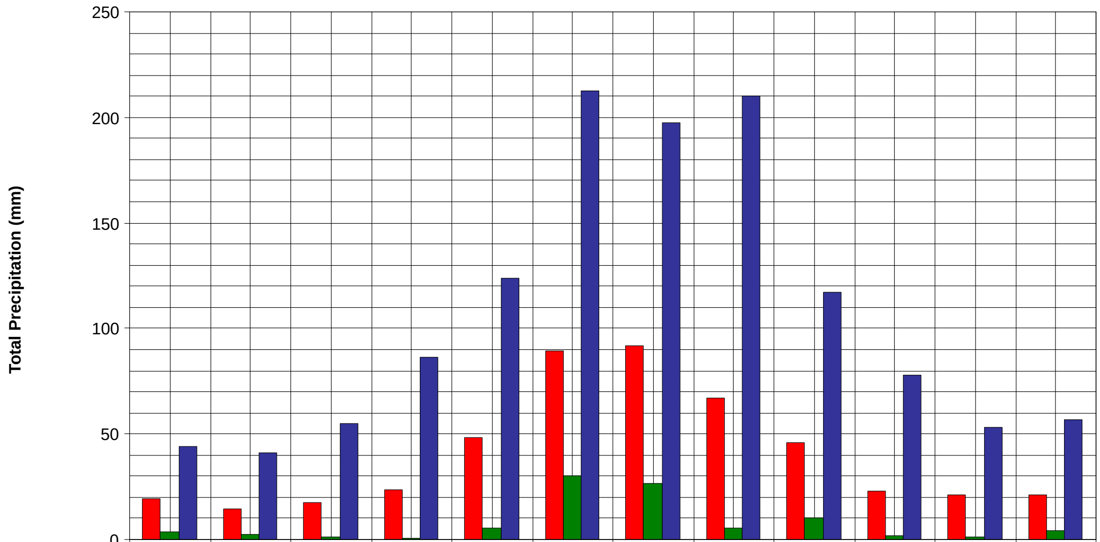
Title:

REGIONAL PRECIPITATION STATISTICS

Approved: LP	Revision Date: 07/03/28
File: 4455-HydCharts2-06.cdr	

Drawn by: GDE	Checked: GH	Fig. No.: **6.5-3**

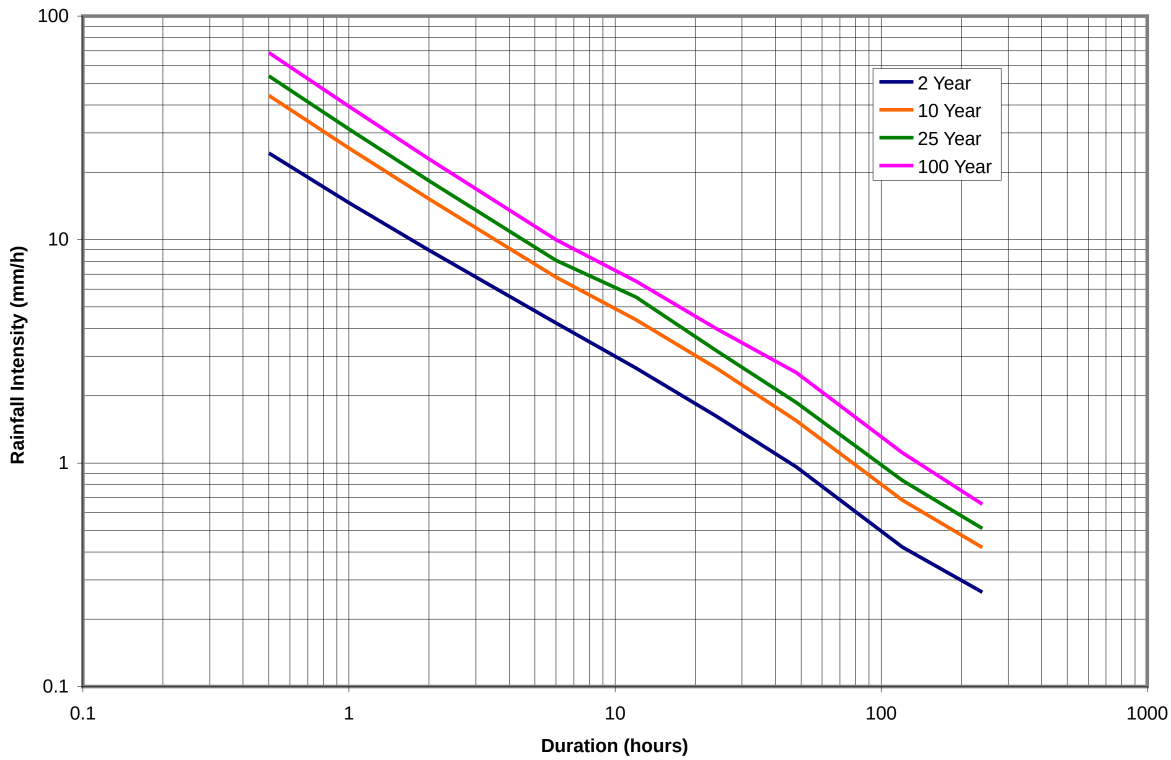
Monthly Precipitation at the Local Study Area



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	19.4	14.7	17.5	23.4	48.2	89.1	92.1	66.9	45.8	22.9	20.9	21.0
Minimum	3.8	2.6	1.5	0.9	5.2	29.9	26.7	5.4	10.4	1.8	1.4	4.0
Maximum	44.1	40.9	55.0	86.5	124.1	212.7	197.6	210.0	117.5	77.7	53.4	56.6

Month

Rainfall Intensity Duration Frequency Curves for the Local Study Area



Title:

LOCAL STUDY AREA ESTIMATED PRECIPITATION

NORTH AMERICAN OIL SANDS CORPORATION

Approved: LP	Revision Date: 07/05/15	
File: 4455-HydCharts-06.cdr		
Drawn by: GDE	Checked: GH	Fig. No.: **6.5-4**

6.6 Water Withdrawal Licenses

Registered surface water licenses within the RSA are summarized in Table 6.6-1. These license data are based upon AENV database records and indicate the maximum annual diversion volumes from surface water sources. Estimates of actual use and return flows, if any, are not readily available. The licensed annual surface withdrawals in the RSA total 821,920 m³, which is less than 0.04 mm of runoff per year over the RSA.

Table 6.6-1 Surface Water Licenses* in the Regional Study Area

Applicant	Source	Quantity (m^3/year)	Specific Purpose
FORT MCMURRAY ADVISORY COUNCIL	Christina Lake	20,960	COOPERATIVE**
REGIONAL MUNICIPALITY OF WOOD BUFFALO	Christina River	125,000	URBAN
FORT MCMURRAY ADVISORY COUNCIL	Christina River	66,610	URBAN
VISTA RIDGE REC ASSOC	Clearwater River	35,770	OTHR**
VISTA RIDGE REC ASSOC	Clearwater River	35,786	SNOW/ICE**
MISKANAW GOLF & COUNTRY CLUB	Clearwater River	140,610	PARKS
KIDD, RON	Gregoire Lake	1,361	REGISTRY**
FORT MCMURRAY INDIAN BAND	Gregoire Lake	29,600	URBAN
REGIONAL MUNICIPALITY OF WOOD BUFFALO	Gregoire Lake	100,000	URBAN
FORT MCMURRAY ADVISORY COUNCIL	Gregoire Lake	43,170	URBAN
ALBERTA ENVIRONMENT	Gregoire Lake	37,000	PARKS
BURNCO ROCK PRODUCTS LTD.	Gregoire Lake	25,227	OTHR
V S P NORTH HOLDINGS LTD	Grist Lake	1,230	RECREATION
ALBERTA-PACIFIC FOREST INDUSTRIES INC.	Kettle Creek	14,000	OIL/GAS
ESSO RESOURCES CANADA LTD.	Saline Creek	22,200	INJECTION
LYNTON SULPHUR PROCESSING LTD	Saprae Creek	6,170	OTHR
LYNTON SULPHUR PROCESSING LTD	Saprae Creek	8,630	OTHR
KIDD, RON	Surmont Creek	1,362	REGISTRY
NEXEN INC.	Unnamed Lake - Noncontributing	8,000	OIL/GAS
ENBRIDGE PIPELINES (ATHABASCA) INC.	Unnamed Lake - Noncontributing	24,000	OIL/GAS
NEXEN INC.	Unnamed Lake - Noncontributing	8,000	OIL/GAS
WHITEFISH LAKE BAND #459	Utikuma River	37,000	URBAN
G & E MAUNDER ENTERPRISES LTD	Winefred Lake	1,230	OTHR
PINE-WEST MAINTENANCE LTD.	Gregoire Lake	20	OTHR
PINE-WEST MAINTENANCE LTD.	Kettle Creek	15	OTHR
PINE-WEST MAINTENANCE LTD.	Christina River	20	OTHR
PINE-WEST MAINTENANCE LTD.	Jackfish River	20	OTHR
NEXEN INC.	Kinosis Lake	10,000	OIL/GAS
NEXEN INC.	Gregoire River	18,000	CONSTRUCTION
UNIVERSITY OF GUELPH	Gregoire Lake	25	FISHERY
UNIVERSITY OF GUELPH	Gregoire Lake	4	FISHERY
REGIONAL MUNICIPALITY OF WOOD BUFFALO	Clearwater River	900	OTHR
	Total	**821,920**	

Note: * Data from AENV, March 2007

**COOPERATIVE means farmsteads, homes, colonies, institution, senior/correctional centres, nursing/children's homes, hospitals

OTHR means other uses such as abbatoirs, dust control, bridge washing, and hydroseeding.

SNOW/ICE means snow/ice making

REGISTRY means traditional agriculture user registration program

6.7 Watershed Description and Hydrology

6.7.1 Regional Drainage Basins

The RSA (area = 19,474 km^2) is bordered by the Clearwater River to the north, the Christina River Watershed to the east and south, and the House River and Horse River watersheds to the west (Figure 6.2-1). A listing of the major watersheds within the RSA and their respective gross drainage areas and major sub-watersheds is presented in Table 6.7-1.

6.7.2 Local Drainage Basins

The LSA (area = 4,341 km^2) lies almost entirely on a plateau of the upper Christina River Watershed, and includes the following sub-watersheds: May River, the East and West tributaries, and three adjacent sub-watersheds: Waddell Creek, Pony Creek, and Kettle River.

A portion of the House River and Hangingstone River watersheds complete the LSA.

Approximately 30% of the LSA is occupied by the Christina River Residual (i.e., Mainstem) sub-watershed, which is comprised of numerous small (low order) streams, or hill slopes without streams, that drain direct to the Christina River mainstem. The LSA consists largely of low-relief topography with considerable wetlands and small lakes that regulate runoff.

The LSA sub-watersheds are shown in Figure 6.7-1 along with 23 watercourse and 10 lake monitoring stations for the Project. Corresponding drainage areas are presented in Tables 6.7-2 and 6.7-3 for streams and lakes, respectively.

LSA watersheds and field observations of LSA streams and their riparian areas are discussed further in Section 6.7-4. However, the drainage area of the streams in the LSA is strongly associated with bankfull width (R^2= 0.8); further, bankfull width accounted for about 60% of the variation of maximum recorded flow at stream monitoring stations, even though flow was recorded at different times in 2005 and 2006.

In contrast to streams, there is no obvious relationship between lake surface area and drainage area (Table 6.7-3). Lake depth ranged from 1.0 m to 6.5 m and several lakes had no discernible inlet or outlet (e.g., Soho Lake and Unnamed LL1).

Table 6.7-1 Watersheds within the RSA

Primary Watershed	RSA Watershed	Major Sub-Watersheds of the RSA Watershed	Drainage Area of Major Sub-Watersheds (km^2)
Clearwater River	Christina River (DA = 13,174 km^2)	Kettle River	300
		May River	657
		Cottonwood Creek	249
		Pony Creek	269
		Waddell Creek	364
		Gordon River	747
		Gregoire River	1,001
		Winefred River	4,296
		Jackfish River	1,470
	Saprae Creek (DA = 156 km^2)	N/A	N/A
Athabasca River	Horse River (DA = 3,481 km^2)	Hangingstone River	1,095
	House River (DA = 2,663 km^2)	N/A	N/A
Total RSA	19,474 km^2		

Note: DA = Drainage area

Table 6.7-2 LSA Watersheds and Monitored Watercourses

Primary RSA Watershed	LSA Sub-Watershed	Watercourse ID	Bankfull Width (m)	Drainage Area at Monitoring Station (km^2)
Christina River (DA = 4,029 km^2 within the LSA)	Christina River Residual (Mainstem) (DA = 1,293 km^2)	WCH3	6.2	123
		WCH4	3.2	16
		WCH5	1.5	6
		WCH6	6.9	181
		WCL1	30	1,062
		WCL4	22.8	996
		WCL7	25	1,082
		WCL8	7.7	85
		WCL9	22	1,151
		WCL10	33	1,265
		WCL11	37.5	2,725
	East Tributary (DA = 368 km^2)	WCC1	7	68
		WCC2	8.5	68
		WCC3	8	156
	West Tributary (DA = 711 km^2)	WCL2	7.5	669
		WCL12	12.5	45
		WCL14	15	547
	May River (DA = 657 km^2)	WCL13	15	657
	Pony Creek (DA = 269 km^2)	None	N/A	N/A
	Waddell Creek (DA = 364 km^2)	WCL5	2.7	269
		WCL6	5	364
	Christina Face Unit (DA = 67 km^2)	None	N/A	N/A
	Kettle River (DA = 300 km^2)	None	N/A	N/A
Hangingstone River (DA = 144 km^2 within the LSA)	Unnamed Tributary (DA = 144 km^2)	WCH1	7.4	65
		WCH2	5.3	45
House River (DA = 168 within the LSA)	Unnamed Tributary (DA = 168 km^2)	WCL3	2.2	168
Total in LSA= 4,341 km^2				

Notes: DA = Drainage area

Figure 6.7-1 provides a map of the sub-watersheds, and section 6.7.4 provides watershed descriptions.

Table 6.7-3 Monitored Lakes in the LSA

Name	Lake ID	Location		Surface Area (SA)	Drainage Area (DA)	Range of Water Depth	Ratio	Elevation
		Northing (m)	Easting (m)	(km^2)	(km^2)	(m)	DA:SA	(m)
Egg	LC1	474318	6213929	8.3	78.3	1.5-2.0	9.4	702
Unnamed	LC2	471488	6199513	1.6	14.9	1.5	9.3	689
Unnamed	LH1	478188	6228862	1.9	12.7	1.5 - 3	6.7	721
Unnamed	LH2	473870	6227359	2.2	1.8	1.25 - 1.6	0.8	719
Soho (Owl)	LH3	470619	6225356	0.2	5.2	2.0-2.5	26.0	719
Unnamed	LL1	476587	6180510	0.2	3.2	1.0 - 1.4	16.0	628
Unnamed	LL2	481855	6183602	0.3	14.6	3.7-6.5	48.7	641
Unnamed	LL3	444725	6193800	1.5	14.4	0.75 - 1.25	9.6	682
Unnamed	LL4	452729	6196552	1.2	157	1 - 1.5	130.8	681
Unnamed	LL5	476598	6162118	0.03	1.4	4.5 - 5.5	46.7	652

6.7.3 Regional Stream Flow Characteristics

6.7.3.1 Review of Data

There are three WSC streamflow monitoring stations located within the LSA, Pony Creek at Chard (07CE003), Christina River near Chard (07CE002) and Jackfish River below Christina Lake (07CE005). Four additional WSC stations are within the RSA: Birch Creek near Conklin (07CE006), which is immediately south and outside of the LSA, House River at Highway 63 (07CB002), Robert Creek North near Anzac (07CE004), and Gregoire River near Fort McMurray (07CE001). All stations collect seasonal flow data with various periods of record that span 5 years to 50 years (Table 6.4-2 provides details). There are no stations with continuous data.

Additional streamflow monitoring stations outside the RSA were included to conduct a more thorough regional streamflow analysis. A total of 40 stations were located as shown in Figure 6.4-1. This list was reduced to 29 representative stations listed in Table 6.4-4. They were selected based on their location and similarity in precipitation and regional physiographic characteristics to streams in the RSA.

The hydrometric stations were divided into two hydrologic groups for regional analysis purposes, as follows:

- 17 basins with minor lakes, marsh and swamp areas, and
- 12 basins with lakes, marsh and swamps having a moderating affect on runoff characteristics (generally taken as covering greater than 4% of their watershed area).

Using these 29 stations, considerable regional data exists to characterize and compute peak flows and open water flows in the region. Available winter flows are limited to only 12 of the selected stations as they are the only ones which are, or have been continuously operated throughout all four seasons. There are no long-term data available to define regional hydrologic characteristics for basins with drainage areas less than 50 km^2.

As part of the hydrological assessment, additional field data were collected to further establish the existing, local hydrological conditions in the LSA. An additional 23 streams and 10 lakes were monitored during the 2005 and 2006 field seasons to characterize flows and lake depths.

Table 6.7-4 Hydrometric Station Groups

Station ID	Name	Basin Characteristics				
		Gross Drainage Area (km²)	Effective Drainage Area (km²)	Lake Area (km²)	% Lake Area	Comment
Basins with Minor Lakes and Wetlands						
07CE004	Robert Creek Near Anzac	54	54	0.00	0.00	
07CA003	Flat Creek Near Boyle	184	88	0.00	0.00	
07DA007	Poplar Creek Near Fort McMurray	151	151	0.00	0.00	
07DA018	Beaver River Above Syncrude	165	165	0.00	0.00	
06AA004[1]	Columbine Creek Near the Mouth	241	229	1.28	0.53	Used for peak flow analysis only
07CE006	Birch Creek Near Conklin	232	232	2.85	1.23	
07DA011	Unnamed Creek Near Fort Mackay	274	274	1.70	0.62	
07CE003	Pony Creek Near Chard	278	278	0.00	0.00	
07CA012	Logan River Near the Mouth	425	425	8.69	2.04	Not on main channel, regulates runoff from 8% of watershed area
07CB002	House River at Highway No. 63	764	764	13.04	1.71	Not in main channel
07CD004	Hangingstone River at Fort McMurray	959	959	0.00	0.00	
07JA003	Willow River Near Wabasca	1,030	1,030	6.35	0.62	
07CA006	Wandering River Near Wandering River	1,110	1,110	17.20	1.55	
07DA006	Steepbank River Near Fort McMurray	1,320	1,320	0.00	0.00	
06AB001	Sand River Near the Mouth	4,910	4,730	179.00	3.65	
07CE002	Christina River Near Chard	4,860	4,830	55.50	1.14	
07DB001	Mackay River Near Fort Mackay	5,570	5,570	0.00	0.00	
Basins with Lakes and/or Wetlands (having impact on runoff characteristics)						
06AF001	Cold River at Outlet of Cold Lake	6,520	6,260	896.00	13.70	Outlet of Cold Lake
06AB002	Wolf River at Outlet of Wolf Lake	725	564	34.32	4.73	Outlet of Wolf Lake (0.3 km)
06AC001	Jackfish Creek Near La Corey	489	333	21.35	4.37	Outlet of Tucker Lake (14 km)
07CA005	Pine Creek Near Grassland	1,450	933	34.82	2.40	Flat Lake in Sub Channel (16 km)
07CE005	Jackfish River Below Christina Lake	1,290	1,270	21.54	1.67	Outlet of Christina Lake (5.5 km)
06AA002	Amisk River at Highway 36	2,510	1,890	142.27	5.67	
07CA013	Owl River Below Piche River	3,080	3,040	134.94	4.38	
07CA008	Babette Creek near Colinton	222	68	5.00	2.25	70% wetlands
07CA011	La Biche River at Highway 63	4,860	4,740	363.94	7.49	Outlet of La Biche Lake (23 km)
06AA001	Beaver River Near Goodridge	4,710	3,780	339.99	7.22	Many lakes and swamps
06AF008	Martineau River Above Cold Lake	5,350	5,340	535.00	10.00	Outlet to Primrose Lake
06AD013	Reita Creek Near Outlet of Angling Lake	161	161	10.60	6.58	Limited data, used for annual/monthly flow only

6.7.3.2 Mean Annual Flow

Mean annual and seasonal (March – October) flows for the selected regional hydrometric stations are presented in Table 6.7-5. Since there are few stations with year-round data, regional relationships were developed for mean seasonal (March – October) flows. Flow was strongly associated with effective drainage area (R^2= 0.75), and the relationship improved (R^2 >0.91) when stations were stratified into basins regulated by lakes and wetlands and those not considerably regulated by lakes and wetlands (Figure 6.7-2). Regressions were statistically significant (P<0.01) for both curves.

It should be noted that the relationships in Figures 6.7-2 are based on all available station data and each with different periods of record. The period of record for these stations ranges from 8 years to 37 years averaging 23 years.

Seasonal flow was converted to water yield by dividing by the effective drainage area. The spread of the resulting water yields for the gauged streams is presented in Figure 6.7-2. The figure shows that water yields for watersheds with lakes and wetlands are statistically significantly lower (38 mm) than those not regulated by lakes (93 mm) (P<0.001). The maximum water yield is 192 mm on Poplar Creek near Fort McMurray (a modified basin due to mine diversions) and the lowest water yield is 16 mm on Reita Creek near the outlet of Angling Lake.

6.7.3.3 Mean Monthly Flows

Mean monthly regional streamflows on a unit area basis are presented in Table 6.7-5. Mean monthly runoff from all the stations varies from 0.33 L/s/km^2 to 5.22 L/s/km^2 and typically peaks in May due to snowmelt. The minimum monthly flows typically occur in February. Relationships between mean monthly flows and effective drainage area for June and for November are shown in Figure 6.7-3. The graphs illustrate a distinction in seasonal monthly runoff rates between watersheds with and without lakes and/or wetlands in June, but not November. This observation is valid for the other winter months. Therefore, a single regional relationship was developed for the low flow months (November – April). For the higher flow months (May – October), separate monthly relationships were developed for watersheds with and without lakes and/or wetlands.

Monthly flows were estimated using the following equation:

$$Q_m = \alpha\, DA^{\beta}$$

where: Q_m = monthly flows in m^3/s

DA = effective drainage area in km^2

α, β = coefficients determined from regression analysis

The derived coefficients α and β for each month are presented in Table 6.7-6. Monthly unit runoff for various drainage areas are presented in Figure 6.7-4 for basins not regulated by lakes and for basins regulated by lakes. Analysis of the figure with respect to the two basin types shows the much greater runoff response from the unregulated basins.

Table 6.7-5 Regional Mean Annual and Monthly Unit Area Flows

Station ID	Name	Gross Drainage Area (km²)	Effective Drainage Area (km²)	Elevation (masl)	Mean flow Mar-Oct (m³/s)	Yield Mar-Oct (mm)	Mean Monthly Unit Area Flows (L/s/km²)												Annual Flows (L/s/km²)	
							Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mar - Oct	Jan - Dec
07CE004	Robert Creek Near Anzac	54.1	54.1	465	0.26	102	-	-	0.34	4.14	10.25	7.71	7.26	2.74	1.54	1.86	-	-	4.81	-
07CA003	Flat Creek Near Boyle	184	88.1	570	0.2	48	-	-	0.46	3.04	1.90	3.35	2.63	0.81	0.44	0.43	-	-	1.09	-
07DA007	Poplar Creek Near Fort McMurray	151	151	235	1.37	192	0.08	0.03	0.55	7.75	18.44	11.51	6.57	8.33	11.92	7.57	3.09	0.42	9.07	6.38
07DA018	Beaver River Above Syncrude	165	165	318	0.75	96	0.23	0.16	0.39	3.87	8.71	7.62	4.86	3.49	4.29	2.87	1.03	0.37	4.55	2.99
07CE006	Birch Creek Near Conklin	232	232	565	0.73	67	-	-	0.63	2.17	6.15	4.41	3.48	2.51	1.90	1.85	-	-	3.15	-
07DA011	Unnamed Creek Near Fort Mackay	274	274	250	0.59	46	0.24	0.24	0.25	2.11	5.27	3.40	1.76	1.14	1.68	1.43	0.81	0.29	2.15	1.54
07CE003	Pony Creek Near Chard	278	278	495	1.19	91	-	-	0.15	3.03	5.82	6.84	6.63	4.48	3.19	2.92	-	-	4.28	-
07CA012	Logan River Near The Mouth	425	425	585	1.95	97	-	-	1.10	4.67	6.25	6.42	6.97	4.69	3.52	3.13	-	-	4.59	-
07CB002	House River At Highway No. 63	764	764	665	4.04	112	-	-	0.76	4.57	7.41	8.65	8.50	5.65	3.45	2.83	-	-	5.29	-
07CD004	Hangingstone River At Fort McMurray	959	959	250	5.13	113	0.34	0.25	0.30	4.39	8.39	8.09	7.43	5.30	5.12	3.61	1.54	0.58	5.35	4.15
07JA003	Willow River Near Wabasca	1,030	1,030	470	5.56	114	-	-	0.36	4.46	8.12	10.65	9.68	4.56	3.24	2.09	-	-	5.40	-
07CA006	Wandering River Near Wandering River	1,110	1,110	575	4.42	84	0.20	0.14	0.13	3.19	6.01	6.09	6.81	4.33	3.24	2.07	0.99	0.38	3.98	2.90
07DA006	Steepbank River Near Fort McMurray	1,320	1,320	260	6.89	110	0.33	0.26	0.32	3.50	9.86	7.65	7.06	4.65	5.71	4.39	1.60	0.54	5.22	3.64
06AB001	Sand River Near The Mouth	4,910	4,730	550	14.32	64	-	-	0.42	2.71	4.25	4.09	4.74	2.65	2.31	1.86	-	-	2.92	-
07CE002	Christina River Near Chard	4,860	4,830	475	18.32	80	-	-	0.64	2.64	5.33	5.92	5.96	4.10	2.75	2.48	-	-	3.77	-
07DB001	Mackay River Near Fort Mackay	5,570	5,570	250	20.58	78	0.10	0.07	0.10	3.84	7.28	5.99	4.52	2.82	2.53	2.18	0.59	0.17	3.69	2.40
06AD013	Reita Creek Near Angling Lake	161	161		0.12	16	0.25	0.31	0.25	1.76	1.41	0.81	0.51	0.53	0.41	0.16	0.25	0.34	0.75	0.59
06AF001	Cold River At Outlet Of Cold Lake	6,520	6,260	550	16.66	56	1.20	1.18	1.16	1.34	2.13	3.03	3.71	3.43	3.06	2.36	1.80	1.47	2.56	2.19
06AB002	Wolf River At Outlet Of Wolf Lake	725	564	600	1.37	51	0.47	0.47	0.43	1.09	3.02	3.06	3.35	1.72	1.16	0.89	0.61	0.56	1.89	1.42
07CA008	Babette Creek Near Colinton	222	67.5	570	0.17	53	-	-	0.07	2.43	1.03	0.80	1.05	0.61	0.76	0.23	-	-	0.77	-
06AC001	Jackfish Creek Near La Corey	489	333	550	0.43	27	-	-	0.24	1.62	2.02	1.27	0.98	0.43	0.24	0.23	-	-	0.88	-
07CA005	Pine Creek Near Grassland	1,450	933	550	1.83	42	-	-	0.24	3.36	2.00	1.30	1.50	0.88	0.81	0.56	-	-	1.26	-
07CE005	Jackfish River Below Christina Lake	1,290	1,270	550	3.12	52	-	-	0.72	1.57	4.08	3.43	3.27	2.43	1.21	1.12	-	-	2.42	-
06AA002	Amisk River At Highway No. 36	2,510	1,890	560	2.75	31	-	-	0.19	1.98	2.00	1.58	1.38	0.62	0.61	0.40	-	-	1.10	-
07CA013	Owl River Below Piche River	3,080	3,040	565	6.97	49	-	-	0.46	1.81	2.96	3.40	3.38	2.57	1.93	1.77	-	-	2.26	-
07CA011	La Biche River At Highway No. 63	4,860	4,740	540	3.87	17	0.35	0.31	0.51	1.48	1.46	0.56	0.61	0.39	0.46	0.63	0.54	0.39	0.80	0.67
06AF008	Martineau River Above Cold Lake	5,350	5,340	555	9.34	37	0.61	0.53	0.69	1.66	2.82	2.42	2.12	1.75	1.61	1.10	0.85	0.65	1.75	1.37
06AA001	Beaver River Near Goodridge	4,710	3,780	560	4.8	27	-	-	0.19	2.31	1.69	1.24	1.20	0.57	0.51	0.40	-	-	1.02	-
				Min (L/s/km²)	0.12	16	0.08	0.03	0.07	1.09	1.03	0.56	0.51	0.39	0.24	0.16	0.25	0.17	0.75	0.59
				Mean (L/s/km²)	4.92	70	0.37	0.33	0.43	2.95	5.22	4.69	4.21	2.79	2.49	1.91	1.14	0.51	3.10	2.52
				Max (L/s/km²)	20.58	192	1.20	1.18	1.16	7.75	18.44	11.51	9.68	8.33	11.92	7.57	3.09	1.47	9.07	6.38

Table 6.7-6 Relationships Between Mean Monthly Flows and Effective Drainage Area

$$Q_m = \alpha DA^\beta$$

Month	Description	α	β	R^2
January	-	5.00E-05	1.271	0.880
February	-	4.00E-05	1.275	0.814
March	-	3.00E-04	1.024	0.856
April	-	9.20E-03	0.833	0.884
May	No Lakes[1]	1.07E-02	0.935	0.932
	Lakes[2]	3.60E-03	0.958	0.945
June	No Lakes	9.00E-03	0.954	0.949
	Lakes	1.90E-03	1.009	0.864
July	No Lakes	4.90E-03	1.026	0.929
	Lakes	1.60E-03	1.030	0.826
August	No Lakes	2.40E-03	1.062	0.908
	Lakes	9.00E-04	1.057	0.824
September	No Lakes	1.90E-03	1.071	0.873
	Lakes	6.00E-04	1.076	0.830
October	No Lakes	2.00E-03	1.036	0.910
	Lakes	1.00E-04	1.266	0.896
November	-	1.00E-03	0.995	0.833
December	-	2.00E-04	1.098	0.906

[1] i.e., watersheds without lakes and/or wetlands affecting runoff

[2] i.e., watersheds with lakes and/or wetlands affecting runoff

6.7.3.4 Peak Flows

A regional flood frequency analysis was carried out for two characteristic basin conditions:

- Basins not substantially covered by lakes and/or wetlands, with drainage areas between 54 km^2 and 10,000 km^2
- Basins with 2% to 10% of drainage area with lakes and/or wetlands, with drainage areas between 54 km^2 and 10,000 km^2

Table 6.7-7 summarizes the estimated 2-year to 100-year peak flows based on a frequency analyses. The estimated 2-year, 10-year, 50-year and 100-year flood discharge versus drainage area (gross areas) presented in Figure 6.7-5 shows the effect of peak flow attenuation by lakes, marsh and swamps. Plots of peak discharge versus effective drainage areas yields similar results. Gross drainage areas are therefore applied to simplify application to the LSA watersheds. The relationships established in Figure 6.7-5 can be used to estimate the maximum instantaneous discharge for various return periods at the un-gauged streams in the study area.

A long-term historic flow series was simulated for various sizes of small drainage basins representative of the LSA using the Hydrologic Simulation Program Fortran (HSPF) model (OPTI, 2000). Peak discharges for various return periods were derived based on a simulated annual peak discharge series for three representative basins with drainage areas of 2.7 km^2, 11.8 km^2 and 17.3 km^2. The peak flood discharge for these small basins is also shown in Figure 6.7-5 as a red triangle (2 year return period) and green triangle (100 year return period). Considering these results and the regional data for larger basins, regional relationships were developed for small basins on the basis of a linear relationship between peak flow and drainage area for areas less than 25 km². The predicted peak flows from these regional equations for small basins (dashed lines in Figure 6.7-5) are slightly higher than those predicted by the HSPF model simulations for watersheds without major lakes or wetlands and slightly lower than the model simulations for watersheds with wetlands and lakes.

Table 6.7-7 Maximum Instantaneous Discharge for Various Return Periods

Station ID	Name	Location		Drainage Area (km^2)		Discharge (m^3/s)				
		Lat	Long	Gross	Effective	Q_2	Q_{10}	Q_{25}	Q_{50}	Q_{100}
07CE004	Robert Creek near Anzac	56.38	-111.03	54	54	2.23	4.04	4.72	5.13	5.48
07CA003	Flat Creek near Boyle	54.59	-112.91	184	88	2.82	12.8	21.2	29.0	38.2
07DA007	Poplar Creek near Fort McMurray	56.91	-111.46	151	151	8.33	19.4	26.5	32.4	39.0
07DA018	Beaver River above Syncrude	56.94	-111.57	165	165	7.64	21.9	29.7	35.4	40.9
06AA004	Columbine Creek near The Mouth	54.36	-111.14	241	229	4.55	12.5	17.5	21.6	26.0
07CE006	Birch Creek near Conklin	55.62	-111.09	232	232	3.77	12.1	18.2	23.6	29.8
07DA011	Unnamed Creek near Fort Mackay	57.66	-111.52	274	274	4.13	11.9	19.0	26.1	35.0
07CE003	Pony Creek near Chard	55.87	-110.90	278	278	6.99	14.7	19.8	24.0	28.8
07CA012	Logan River near the Mouth	55.18	-111.73	425	425	6.88	38.7	60.6	78.5	97.4
07CB002	House River at Highway No. 63	55.64	-112.16	764	764	17.2	29.9	35.3	39.0	42.5
07CD004	Hangingstone River at Fort McMurray	56.71	-111.36	959	959	38.7	92.1	120	141	162
07JA003	Willow River near Wabasca	55.92	-113.92	1,030	1,030	46.8	120	156	182	206
07CA006	Wandering River near Wandering River	55.20	-112.47	1,110	1,110	24.3	56.5	69.1	76.7	82.9
07DA006	Steepbank River near Fort McMurray	57.01	-111.42	1,320	1,320	34.1	66.7	81.2	90.9	99.9
06AB001	Sand River near the Mouth	54.47	-111.19	4,910	4,730	48.6	119	172	222	282
07CE002	Christina River near Chard	55.84	-110.85	4,860	4,830	69.6	142	177	203	229
07DB001	Mackay River near Fort Mackay	57.21	-111.69	5,570	5,570	102	248	323	377	428
06AF001	Cold River at Outlet of Cold Lake	54.56	-109.83	6,520	6,260	27.0	70.9	98.0	120	144
06AB002	Wolf River at Outlet of Wolf Lake	54.71	-111.00	725	564	3.50	11.9	16.9	20.7	24.6
06AC001	Jackfish Creek near La Corey	54.44	-110.69	489	333	1.66	4.88	7.58	10.3	13.8
07CA005	Pine Creek near Grassland	54.82	-112.78	1,450	933	10.2	46.4	68.6	84.7	100.0
07CE005	Jackfish River below Christina Lake	55.67	-111.10	1,290	1,270	10.0	33.9	48.4	59.7	71.3
06AA002	Amisk River at Highway No. 36	54.47	-112.02	2,510	1,890	10.8	36.8	52.1	63.9	76.0
07CA013	Owl River below Piche River	55.01	-111.85	3,080	3,040	15.0	41.2	66.2	92.9	129
07CA008	Babette Creek near Colinton	54.65	-113.08	222	68	1.72	5.28	7.30	8.85	10.4
07CA011	La Biche River at Highway No. 63	54.94	-112.50	4,860	4,740	11.8	33.1	53.9	76.6	108
06AA001	Beaver River near Goodridge	54.44	-111.35	4,710	3,780	18.9	77.0	112	138	163
06AF008	Martineau River above Cold Lake	54.69	-110.03	5,350	5,340	30.0	64.3	81.5	94.1	106

6.7.3.5 Low Flows

The regional low flow data indicate that several stations, with drainage areas from 165 km² to 4680 km², frequently experience no flow. A low flow frequency analysis was performed for one-day and seven-day low flows for the open water period (March-October). Table 6.7-8 lists 1Q10 (one day, one-in-ten year low flow) and 7Q10 (seven day, one-in-ten year low flow) flows for the stations used in the hydrologic analysis. Regional relationships versus drainage area show a trend but poor correlation (R^2 <0.5: trend plots not shown).

Table 6.7-8 Low Flow at Regional Hydrometric Stations (March-October)

Station ID	Name	Gross Drainage Area (km^2)	Effective Drainage Area (km^2)	Lake Area (km^2)	Discharge (L/s)	
					7Q10	1Q10
Watersheds without Lakes and/or Wetlands						
07CE004	Robert Creek near Anzac	54.1	54.1	0	0	0
07CA003	Flat Creek near Boyle	184	88.1	0	0	0
07DA007	Poplar Creek near Fort McMurray	151	151	0	0	0
07DA018	Beaver River above Syncrude	165	165	0	0	0
06AA004	Columbine Creek near the Mouth	241	229	1.3	0	0
07CE006	Birch Creek near Conklin	232	232	2.8	10	1
07DA011	Unnamed Creek near Fort Mackay	274	274	1.7	10	6
07CE003	Pony Creek near Chard	278	278	0	0	0
07CA012	Logan River near the Mouth	425	425	10.7	279	261
07CB002	House River at Highway No. 63	764	764	13	226	164
07CD004	Hangingstone River at Fort McMurray	959	959	0	13	12
07JA003	Willow River near Wabasca	1,030	1,030	6.4	0	0
07CA006	Wandering River near Wandering River	1,110	1,110	17.2	6	4
07DA006	Steepbank River near Fort McMurray	1,320	1,320	0	162	132
06AB001	Sand River near the Mouth	4,910	4,730	179	492	475
07CE002	Christina River near Chard	4,860	4,830	55.5	1,217	1,114
07DB001	Mackay River near Fort Mackay	5,570	5,570	0	105	94
Watersheds with Lakes and/or Wetlands						
06AF001	Cold River at Outlet of Cold Lake	6,520	6,260	896	355	333
06AB002	Wolf River at Outlet of Wolf Lake	725	564	34.3	0	0
06AC001	Jackfish Creek near La Corey	489	333	21.4	0	0
07CA005	Pine Creek near Grassland	1,450	933	34.8	0	0
07CE005	Jackfish River below Christina Lake	1,290	1,270	21.5	176	153
06AA002	Amisk River at Highway No. 36	2,510	1,890	142.3	0	0
07CA013	Owl River below Piche River	3,080	3,040	134.9	516	481
07CA008	Babette Creek near Colinton	222	67.5	5	0	0
07CA011	La Biche River at Highway No. 63	4,860	4,740	363.9	0	0
06AA001	Beaver River near Goodridge	4,710	3,780	340	0	0
06AF008	Martineau River above Cold Lake	5,350	5,340	535	233	205

6.7.3.6 Summary of Flow Characteristics and Regional Relationships

Regional relationships for maximum instantaneous flows ranging from 2-year to 100-year return periods, mean annual flows and mean monthly flows were developed for basins with and without lakes and/or wetlands. The relationships demonstrate that lakes and wetlands substantially reduce the magnitude of peak flows and annual water yields but have negligible effects on winter flows. Reasonable estimates of flow conditions in the study areas can be made, for assessment purposes, by applying these regional relationships.

6.7.4 Regional and Local Watercourses

Major regional rivers are described below along with the 23 local watercourses (WC) and 10 lakes (L) that have been monitored for flow and/or lake depth within the LSA. The local streams and lakes are shown in Figure 6.4-2. Figure 6.7-1 also shows local sub-basins in the LSA. For monitoring stations, the letters H, C or L refer to the Hangingstone, Corner or Leismer leases, respectively. The number that follows refers to the station number within the lease area. Sampled streams and lakes are described in the sections below and are organized by regional watershed.

6.7.4.1 Clearwater River

The Clearwater River originates in the northern coniferous forest region of the Precambrian Shield in northwestern Saskatchewan. It flows southeast for approximately half of its 187 km course through Saskatchewan before turning sharply southwest and continues beyond the Alberta border draining into the Athabasca River at Fort McMurray. The Clearwater River drops about 150 m from its headwaters in Brach Lake at elevation 460 m to the Athabasca River confluence. The upper portion of the Clearwater River flows over the Precambrian Shield. The lower portion of the Clearwater River forms a deeper valley as it enters the Interior Plains with a meandering channel pattern forming sandbars and islands. High valley walls of Devonian limestone are exposed in this reach.

There are two streamflow monitoring stations along the Clearwater River, one above the Christina River confluence (Water Survey of Canada (WSC) Station 07CD005) where the drainage area is 17,000 km^2 and the other near its mouth at Draper (07CD001) where the drainage area is 30,800 km^2. Streamflows in the Clearwater River above Christina River have been monitored by WSC since 1966 and at Draper since 1957. The station above Christina River has year-round data from 1976 to 1995. Based on the WSC record from 1976 to 1995, mean annual water yields are 136 mm above Christina River and 120 mm at Draper. Annual water yields range from 58.0 mm to 220 mm at Draper and 103 mm to 182 mm above Christina River.

Table 6.7-9 summarizes mean monthly Clearwater River flows. Mean monthly flow in the Clearwater River ranges from 43 m^3/s to 124 m^3/s above the confluence of the Christina River and from 51 m^3/s to 221 m^3/s below the Christina River at Draper. Clearwater River historical seasonal discharge statistics above Christina River and at Draper are shown in Figure 6.7-6. Freeze-up starts in late October and break up occurs in mid to late April. The low flow hydrographs show distinct drops in flow in the late October period reflecting a temporary reduction in flow during ice growth periods. The estimated historical mean annual flood discharge for the Clearwater River ranges from 85 m^3/s above the Christina River to 146 m^3/s at Draper (Figure 6.7-7). The estimated 100-year peak discharge ranges from 350 m^3/s to 830 m^3/s at the two stations respectively. Historical mean annual flows (Figure 6.7-7) at the two stations show a general dry period from 1980 to present except for three above average flows in 1996, 1997 and 2005.

Historic trends in Figure 6.7-7 reveal that Clearwater River flow increases by over 50% in the 25 km distance between the upstream (07CD005) and downstream (07CD001) stations, which is largely attributed to inflow from the Christina River. At the station upstream of the Christina River, Clearwater River levels typically increase between March 27 and April 20 due to snowmelt and ice break-up, and peak flows usually occur around the first of May (Figure 6.7-6). Downstream of the Christina River at Draper, however, flow rises in early June and peaks in early July, a delay of over month when compared to the upstream site. This delayed flow response at the downstream site coincides with the late June peak in the Christina River, shown in Figure 6.7-8.

Table 6.7-9 Clearwater River Monthly Flows

Month	Flow (m^3/s)[a] at Draper			Flow (m^3/s)[b] Above Christina River		
	Minimum	Mean	Maximum	Minimum	Mean	Maximum
January	32.1	55.9	89.9	33.5	45.9	60.9
February	29.3	50.8	78.3	26.6	42.8	56.6
March	29.7	50.8	74.9	25.9	43.1	58.2
April	44	132	318	41	87.2	171
May	75	221	488	67	124	218
June	78.5	187	478	62.8	101	166
July	60.3	171	467	51.2	91.1	170
August	48.1	143	348	43.4	83.7	166
September	44.1	136	430	40.8	82.5	154
October	47.6	125	282	42	83	151
November	40.1	88.2	175	43	62.3	91.9
December	38.5	66.3	120	35.6	50.9	69.1
Annual	**56.9**	**119**	**215**	**55.5**	**73.4**	**98**

[a] Based on data 1930 - 2005

[b] Based on data from 1976 - 2005

6.7.4.2 Christina River

The Christina River originates about 60 km south of Fort McMurray in the Stoney Mountain Wildland Provincial Park at the northern extent of the LSA. The river flows south for about 60 km before heading east and then north to discharge into the Clearwater River about 30 km upstream and east of Fort McMurray. The single WSC streamflow monitoring station on the Christina River is the seasonally operated station near Chard (07CE002) where the gross drainage area is 4,860 km^2. Other hydrometric stations within the Christina River watershed are Robert Creek North (discontinued), Pony Creek, Jackfish River below Christina Lake and Birch Creek. Lake levels are monitored on Christina and Gregoire lakes. Above Chard, the Christina River's discharges are regulated by Christina Lake and other small lakes in the watershed. The Christina Lake/Jackfish River drainage basin represents 30% of the total drainage area contributing to flows at Chard. Seasonal (March-October) stream flow data at the gauge site are available from 1982 to 2004. For this period of record the mean seasonal water yield is 80 mm. Figure 6.7-8 shows the Christina River historical daily flow statistics near Chard for the open water season, accompanied by a plot of mean seasonal flow over the period of record. Increases in flow typically occur between March 27 and April 26 due to snowmelt and ice break-up. Historical median flows show an initial peak around May 1 with high flows maintained throughout May, June and July, and then dropping gradually to the end of October. The historical mean seasonal flow, shown in Figure 6.7-8 ranges from a high of 52.4 m^3/s (228 mm runoff) in 1996 to a low of 4.59 m^3/s (20 mm runoff) in 1999. Estimated mean monthly flows for the Christina River near Chard are summarized in Table 6.7-10. Estimated 2-year and 100-year flood discharges are 70 m^3/s and 230 m^3/s, respectively.

Figure 6.7-9 depicts the longitudinal profile of the Christina River for its nearly 300 km length through the LSA. The profile represents the channel gradient of the river as it changes in the upstream direction; flattest near the confluence with the Kettle River and in the headwaters (0.05%) and with steeper (concave) sections up to 0.6% immediately upstream of both Waddell

Creek and the West Tributary. The gradient over the entire length is 0.1%, characteristic of meandering riffle-pool morphology streams. Several major LSA tributaries to the Christina River are shown entering the River in Figure 6.7-9. These are also low gradient streams (less than 0.7%) but steeper than the Christina River, except for the East Tributary which is 0.07%. Figure 6.7-9 also shows the short-term watercourse monitoring stations, the Christina River near Chard WSC station (07CEE002) and illustrates the approximate extent of lease borders on the Christina River mainstem.

Major sub-watersheds of the Christina River watershed in the LSA are described below along with a summary of data collected at the watercourse and lake sites that were established and monitored in 2005 and 2006.

Table 6.7-10 Christina River Near Chard - Monthly Flows

Month	Flow (m^3/s)[a]		
	Minimum	Mean	Maximum
January	-	2.21 [b]	-
February	-	1.55 [b]	-
March	1.74	3.12	5.08
April	3.78	14.8	47.3
May	6.22	28	95.6
June	4.58	29.9	76.2
July	3.85	29.8	76.2
August	2.23	21.5	78.8
September	2.79	14	61.2
October	2.68	12.5	50
November	-	4.17 [b]	-
December	-	2.28 [b]	-
Annual	**-**	**19.2**	**-**

[a] Based on data 1982 – 2006

[b] Estimated from regional equations for monthly flows.

East Tributary

The East Tributary sub-watershed drains an area of 368 km^2 and flows northeast to southwest to join the Christina River at 690 m elevation. The length of the mainstem channel is 58 km with an overall channel gradient of 0.07%. The maximum basin elevation is 750 masl and at the mouth the elevation is 672 masl. There are a number of lakes including Egg Lake (area = 8.4 km^2) and wetland areas that likely function to moderate stream flow. Although there are no gauged streams within the watershed; there are three short-term streamflow monitoring stations established at WCC1, WCC2 and WCC3, located either within or close to the Corner lease area. These streams meander in an irregular pattern through a mature coniferous forest with riparian vegetation consisting of shrubs and grasses. Bankfull widths at these three sites range from approximately 7 m to 8 m.

Spot discharges, measured seasonally at the watercourses, are summarized in Table 6.7-11. A maximum flow of 1.6 m^3/s was recorded in August 2005 at both WCC1 and WCC3. Flows at WCC2 are generally lower than flows at WCC1 despite almost equal drainage areas; this is attributed to the regulating effect of Egg Lake. Winter flow drops to near zero, based on the February 2005 measurement of 0.09 m^3/s at WCC3.

Water depth was 1.5 m at Unnamed Lake LC2, and 1 m to 1.5 m at Egg Lake (LC1) over the 2005 and 2006 sampling seasons (Table 6.7-3). Egg Lake is the largest of the sampled lakes, with a surface area of 8.4 km^2 and LC2 is 1.6 km^2. Photos and descriptions of this lake and other waterbodies are provided in Volume 3, Section 8 (Fish and Fish Habitat).

West Tributary

The West Tributary originates in the northwest portion of the LSA at an elevation of 720 masl and drops 140 m flowing first north-south then west-east to the confluence with the Christina River at 580 masl. Overall gradient is 0.1% and the mainstem is 126 km in length. The tributary drains an area of 711 km^2, which is about 18% of the total Christina River watershed area within the LSA. A portion of the Hangingstone lease area sits in this sub-watershed. There are numerous small unnamed lakes and one named lake (Base Lake), often situated at the headwaters of streams, along with wetland areas scattered throughout.

There is one short-term flow monitoring site in the upper (WCL2) watershed area and two sites (WCL14 and WCL12) in the lower reaches. All sites are within the lease area. At the upper site, spot flows ranged from zero in winter up to 1.5 m^3/s in May 2006 in a 6 m wide meandering channel. The riparian area was well vegetated by grasses and shrubs. Beaver activity was observed during the field surveys immediately upstream of WCL2. The highest flow was recorded downstream at WCL12, and was 15.5 m^3/s in August 2005, where the channel width was 25 m (Table 6.7-11). This watercourse also showed evidence of beaver activity and meandered through a mixedwood forest.

At monitored Unnamed Lake LL4, depth ranged from 1.0 m to 1.5 m over the sampling period. The unnamed lake LL4 is located on the west border of the Leismer lease and covers a surface area of approximately 1.2 km^2. Tamarack, black spruce and aspen lined the lake edge. The lake drains south to the mainstem of the West Tributary.

May River

The May River watershed (area = 657 km^2) is located at the southern extent of the LSA and drains north to the Christina River. Channel gradient is about 2% over its 87 km length. Elevation ranges from 731 masl at the Christina Basin Airfield at the headwaters, to about 564 masl at the mouth. Wappau Lake is a prominent lake (area = 4.7 km^2) near the south border, and there are several smaller unnamed lakes scattered throughout the watershed. Part of the Leismer lease area lies within this sub-watershed.

No streams are gauged by the WSC in the May River watershed. However, one short-term flow station is established near the mouth of May River, located at WCL13. Discharge measured at that site in May 2006 was 9.2 m^3/s and channel width was 15 m. Zero flow was recorded in February 2005. The stream is bordered by grass and willows.

Lake depth ranged from 4.5 m to 5.5 m in 2005 at Unnamed Lake LL5, which is the single monitored lake in this sub-watershed. Unnamed Lake LL5 covers a surface area of 0.03 km^2 and drains an area of 1.4 km^2. Beaver activity has impounded outflow from this lake.

Table 6.7-11 Data at Short-term Watercourse Sites in the LSA

Watershed	Sub-Watershed	Station ID	Effective Drainage Area (km²)	Survey Dates	Max. Water Depth (m)	Discharge (m³/s)	Wetted Width (m)	Avg. Bankfull Width (m)
Christina	Residual	WCH3	91	7-Aug-05	1.8	5.6	1.83	6.2
				30-Sep-05	1.2	0.79	4.9	
				8-Feb-06	0.85	0	6.5	
				4-May-05	1.2	0.81	6.5	
		WCH4	9	6-Aug-05	0.95	0.74	n/a	3.2
				3-Oct-05	0.5	0.07	5	
				4-May-06	1.1	0.19	3.25	
		WCH5	5	6-Aug-05	0.55	0.11	1.5	1.5
				3-Oct-05	0.3	0.05	1.2	
				5-May-06	0.45	0.05	1.3	
		WCH6	147	6-Aug-05	1.57	6.13	6.8	6.9
				29-Sep-05	1	1.05	7.75	
				8-Feb-06	n/a	0	n/a	
				5-May-06	1.38	1.74	5.5	
		WCL1	988	5-Aug-05	1	12	n/a	30
				30-Sep-05	1.2	10.48	19.5	
				10-May-06	0.5	0.02	8.1	
				28-Sep-05	n/a	0.23	n/a	
		WCL4	923	5-Aug-05	1.2	5.58	19.3	22.8
				29-Sep-05	0.5	4.36	22	
				9-Feb-06	0.3	0.023	n/a	
				6-May-06	0.3	8.96	19.3	
		WCL7	1007	29-Sep--05	0.6	6.37	n/a	25
				7-May-06	0.8	11.18	22	
		WCL8	78	5-Aug-05	1.04	2.35	9	7.7
				28-Sep-05	0.65	0.28	5.4	
				6-May-06	1	0.56	6.95	
		WCL9	1077	4-Aug-05	n/a	n/a	22	22
				28-Sep-05	0.7	5.13	n/a	
				10-Feb-06	0.8	0	n/a	
				7-May-06	0.8	11.82	23	
		WCL10	1183	4-Aug-05	1	22.5	32	33
				28-Sep-05	0.6	2.34	32.78	
				8-May-05	1	2.46	22	
		WCL11	2619	27-Sep-05	0.24	10.369	34	37.5
				7-Feb-06	0.5	5.06	36	
	East Tributary	WCC1	60	6-Aug-05	1.6	0.46	8	7
				29-Sep-05	1.4	0.35	6.2	
				5-May-06	0.6	1.03	4.25	
		WCC2	55	5-Aug-05	0.98	n/a	n/a	8.5
				29-Sep-05	1	0.93	8.5	
				5-May-06	0.65	0.21	5	
		WCC3	132	9-Feb-05	0.94	0.09	n/a	8
				5-Aug-05	1.6	n/a	7.8	
				29-Sep-05	0.5	1.62	8.55	
				5-May-06	0.98	3.14	8.5	
	West Tributary	WCL2	96	28-Sep-05	1.4	0.23	5.4	7.5
				18-Feb-06	1.2	0	6.5	
				6-May-06	1.75	1.47	6	
				8-Aug-06	1.65	n/a	6	
		WCL12	570	4-Aug-05	2.2	15.51	11.8	12.5
				29-Sep-05	0.4	2.02	9.7	
				11-Feb-06	1	0.1	11.9	
				7-May-06	0.65	12.12	19	
		WCL14	524	8-Aug-05	1	5.6	n/a	15
				7-May-06	1	0.76	12	
	May River	WCL13	657	7-Feb-06	0.5	0	n/a	15
				3-May-06	1.05	9.15	13	
	Waddell Creek	WCL5	35	6-Aug-05	0.59	0.38	2.8	2.7
				28-Sep-05	0.4	0.1	2.5	
				8-Feb-06	0.12	0.02	n/a	
				6-May-06	0.49	0.68	3.2	
		WCL6	35	6-Aug-05	1.1	0.53	8	5
				8-Feb-06	0.3	0	3.8	
				6-May-06	0.5	0.48	3.5	
Hangingstone	Unnamed	WCH1	62	7-Aug-05	0.85	1.76	6.8	7.4
				1-Oct-05	0.75	0.02	6.8	
				4-May-05	1.25	0.2	10	
	Unnamed	WCH2	43	7-Aug-05	0.82	0.46	4.1	5.3
				30-Sep-05	0.5	0.08	5.8	
				7-Feb-06	0.16	0	4.1	
				4-May-06	0.8	0.93	5	
House	Unnamed	WCL3	30.2	10-May-06	0.32	0.12	2	2.2

Waddell Creek

Waddell River flows west to east to the Christina River, and drains an area of 364 km^2. At the headwaters, elevation is 725 masl and at the confluence with the Christina River, elevation is 461 masl. Channel gradient is approximately 0.4% over the 57 km mainstem length. A small portion of the Leismer lease lies within the headwaters of this watershed.

Two short-term monitoring stations are located at unnamed tributaries in the upper elevations, at WCL5 and WCL6. Substantial upstream beaver activity has created localized channel changes such as braiding at WCL5 and pools at WCL6. Both streams meander through a coniferous forest, and are bordered by grasses and willows. Winter low flows dropped close to zero during the sampling season, and maximum flows were 0.7 m^3/s and 0.5 m^3/s at WCL5 and WCL6, respectively.

Unnamed Lake LL1 is a headwater lake that covers an area of 0.2 km^2. No outlet or inlet was observed in the field surveys. Water depth ranged from 1.0 m to 1.4 m over the 2005 sampling season. Unnamed Lake LL2 also has a surface area of 0.3 km^3, but is deeper than LL1, with a measured depth of 3.7 m to 6.5 m. The lake drains southeast to another unnamed lake and then into Waddell Creek.

Pony Creek

This watershed is 269 km^2 with a 52 km mainstem channel that drains northeast to southwest into the Christina River. Overall channel gradient is 0.5% and elevations range from 762 masl at its headwaters to 455 masl at the mouth. Part of the Corner lease area is within the headwaters of the Pony Creek watershed.

Pony Creek is gauged (WSC station 07CE003) with a partial record of seasonal (March to October) flows from 1982-2005. The historical average flow for Pony Creek is 1.2 m^3/s over the period of record (Figure 6.7-10). High seasonal average flows of 3.5 m^3/s occurred in both 1996 and 2005; 1997 was also higher than average. The plot of historical daily discharge tracks a similar profile to the Christina River near Chard Station. Flow rises sharply in mid March, about two weeks earlier than the Christina River. High flows are sustained from the end of April to early July, dropping gradually by mid-July.

Kettle River

This watershed is 300 km^2 and drains west to east into the Christina River. Elevations range from 760 masl, at the height of land, to 437 masl at the mouth. The mainstem channel is 46 km long with an overall gradient of 0.6%. A very small portion of the Corner lease area straddles the northwest border of the Kettle River watershed.

Christina River Residual

This is a large (1,293 km^2) area that consists of many small unnamed tributaries to the Christina River as well as hill slopes (face units) that contribute direct (surface and sub-surface) runoff to the Christina River mainstem. As such, the Christina River Residual is not a discrete sub-watershed on its own because of the numerous watersheds contained within; rather it is a collection of small watersheds.

The Residual area begins in the upper north portion of the LSA at an elevation of 760 masl at the Algar Lookout Station and drains to the junction with Waddell Creek at 460 masl. The Christina River flows through the Hangingstone lease and much of the Leismer lease (Figure 6.7-9).

The monitoring program established ten short-term streamflow sites distributed along the length of the Residual from the headwaters to the lower elevations, with seven of the ten sites located on the Christina River mainstem. Channel characteristics and flow at these seven mainstem sites are discussed below, followed by the three tributary sites.

Christina Mainstem

In general, there are systematic increases in both channel width and discharge in the downstream direction, as expected with increasing drainage areas. Starting at site WCH3, in the north headwater area of the watershed, channel width is about 6 m and measured flows ranged from zero in the winter months up to 5.6 m^3/s in August 2005.

Located about 12 km downstream of headwater site WCH3 is WCH6, which has a channel width of 7 m, and a maximum flow measured in August 2005 of 6.1 m^3/s. There was no flow in February 2006 due to ice. Tall grasses and willows form the riparian vegetation along this meandering section of the Christina River.

Sites WCL4, WCL1, WCL7, WCL9, and WCL10 are clustered along the Christina River mainstem between the East and West Tributary watersheds. The Christina River meanders with wide floodplains at the upstream sites, and the channel becomes more incised and partially confined at the downstream site WCL10. Forest is mature conifers or mixed forest, and stream banks are vegetated by an assemblage of grasses, willow and trees. WCL4 was located on an oxbow of the river. Beaver activity was observed during the field surveys at all sites except WCL4. Channel widths ranged from 23 m at upstream site WCL4 to 33m at downstream site WCL10. Maximum flow recorded ranged from 9 m^3/s at WCL4 to 22.5 m^3/s at WCL10. Low flows dropped to zero in February 2006 at WCL9.

Site WCL11 is the most downstream site on the Christina River, below the confluence of the May River. At WCL11, the Christina River is about 38 m wide, slightly incised, meandering with banks vegetated by cottonwood, willow, spruce and jack pine.

Other Tributaries

Channel widths are 1.5 m at WCH5 and 3.2 m at WCH4 in the north headwater tributaries of the Christina River. Maximum flow at WCH4 and WCH5 was 0.1 m^3/s and 0.2 m^3/s, respectively. These headwater streams meander through a conifer forest and are bordered by grasses, forbes and sedges in wide (e.g., 32 m to 200 m) floodplains. Beaver activity was noted at both sites.

Site WCL8 is located on an unnamed tributary which enters the Christina River mainstem immediately below site WCL9. The tributary is about 8 m wide and measured flow ranged from 0.3 m^3/s to 2.4 m^3/s. The channel exhibited a meandering pattern with willows, grasses and shrubs on its banks.

Lakes

Unnamed Lake LL1 is the single monitored lake within the Residual area, located on a small tributary east of the Christina River mainstem between stream flow sites WCL9 and WCL10. The lake's surface area is 0.3 km^2 and depth measured in 2005 was between 1.0 m and 1.4 m. There was no inlet or outlet observed during the field surveys for this lake.

Christina Face Unit

This is a small (67 km^2) area between the Pony Creek and Kettle River watersheds with several small streams that drain direct to the Christina River (essentially a small residual area). There is no development proposed in this face unit.

6.7.4.3 House River

The House River watershed is 2,779 km^2 in area and flows initially south for about 90 km then north for an additional 60 km to the Athabasca River. Elevations span 433 m, from 853 masl at May Hill at the southwest height of land to 420 masl at the mouth. The west portion of the Leismer lease drains into this watershed.

Topography is generally gentle throughout the watershed, with lakes and wetlands in the upper and lower elevations and a trellis drainage network at Dropoff Creek in the mid elevations. Steep headwalls flank both sides of the House River mainstem starting at about 610 m elevation to its mouth.

The long-term historical average flow at House River at Highway 63 is 4 m^3/s (Figure 6.7-11). Flows have been below average for most of the period of record except for three wet years in 1996, 1997 and 2005. River levels typically rise sharply starting mid-March and peak by end April. Streamflow historically starts to drop by about July 19 through the fall months.

There is one sampled creek and lake located in a 168 km^2 unnamed tributary sub-watershed at the east border of the House River watershed. The sub-watershed has gentle terrain with several unnamed lakes and scattered wetlands that occupy about 9% of the upslope area. Elevations range from 730 masl at the headwaters to 433 masl at sampling station WCL3, where channel width is 2.2 m. The watercourse flowed through a conifer forest ecosystem with grasses and forbes growing on the banks and floodplain. Unnamed Lake LL3 is immediately upstream of WCL3, has a surface area of 1.5 km^2 and is 0.75 m to 1.5 m in depth. This lake has inlets entering both north and south, and an outlet that drains southwest to the House River.

6.7.4.4 Horse River

The Horse River flows south to north and drains an area of 3,275 km^2. Elevation spans 480 m from 760 masl in the headwaters to 280 masl at the mouth. Terrain is gentle, with extensive wetland areas in the watershed and few lakes. The stream network is trellis at the east divide - consisting of a system of sub-parallel streams- suggesting a strong geologic control at its headwaters. At lower elevations, the drainage pattern is more dendritic, with streams evenly distributed. The north portion of the Hangingstone lease drains into the Horse River watershed.

The river has a discontinuous discharge record at WSC station 07CC001 (at Abasands Park). The flow record is short: three months in 1931, continuous data from 1976 to 1978 and seven months in 1979. Over this period of record, average annual flow is 12.3 m^3/s. Major tributaries to the Horse River are Cameron Creek and Hangingstone River, the latter being the largest and is discussed in further detail below.

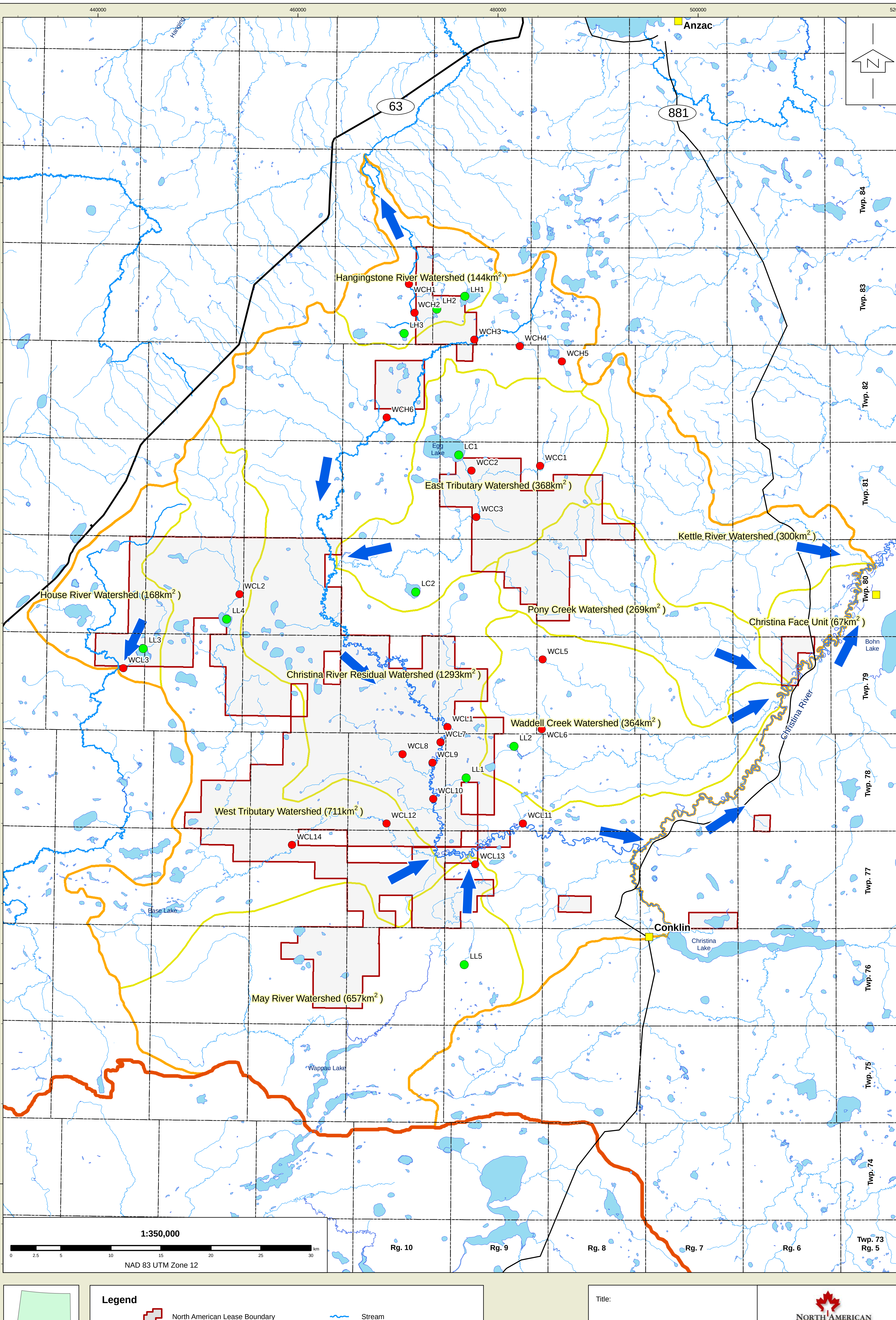
Hangingstone River

The Hangingstone River watershed (956 km^2 at the WSC Station) flows south to north to join the Horse River near Fort McMurray. As discussed above for the Horse River watershed, the drainage pattern of the Hangingstone River is distinctly trellis, especially at the headwaters near the northwest corner of the Hangingstone lease area. Elevation ranges from 760 masl at the headwaters to 280 masl at the mouth. Within the LSA the unnamed tributary of the Hangingstone is 144 km^2 in area and the elevation change is 180 m from the top of divide (720 masl) to the confluence (580 masl) with the Hangingstone River mainstem.

According to 1965-2004 monthly discharge records for Hangingstone River at WSC station 07CD004, the historical average is 5.2 m^3/s (Figure 6.7-12). Recorded maximum instantaneous discharge ranges from 11.2 m^3/s to 149 m^3/s. High flow years were 1970 and from 1995-1997. Flows typically start to rise in mid-March, peak by late April and sustain high flows with a series of peaks and drops until mid-July. This is a similar pattern to other creeks in the RSA.

Two short-term monitoring stations (WCH1 and WCH2) are located on headwater tributaries of the Hangingstone River, and are within the LSA. The sites drain upslope areas of 43 km^2 and 62 km^2 for WCH2 and WCH1, respectively. The basins are partially covered by lakes and/or wetlands that likely moderate flows. Channel width was 5.3 m at WCH2 and 6.0 m at WCH1. Measured discharge varied from zero or near zero during fall and winter surveys up to 1.8 m^3/s in August 2005 at WCH1. Flow was less than 1 m^3/s at WCH2 in the 2005-2006 measurement season. Both streams exhibited an irregular meander pattern and were bordered by willows and grasses growing on banks and floodplains. Beaver activity was observed at both sites.

There are two unnamed lakes, LH1 and LH2, and one named lake at LH3 (Soho Lake) with short-term monitoring data in the Hangingstone River watershed. Surface areas are 1.9 km^2, 2.2 km^2 and 0.2 km^2 for LH1, LH2 and LH3, respectively. Water depth ranged from 1.25 m to 2.5 m in the three lakes (Table 6.7-3). LH1 drains into Hangingstone River via a northwest outlet. LH2 drains via another small waterbody into Hangingstone River, but the connecting channel between the two waterbodies is blocked by an old beaver dam (field survey in 2006), obstructing surface flow. No inlet or outlet was observed at Soho Lake during the field surveys.



Legend

- North American Lease Boundary
- Regional Study Area (19,474 km²)
- Local Study Area (4,341 km²)
- Sub Basin Boundary
- Lake
- Stream
- Drainage Direction
- Hydrometric Station (Discharge)
- Hydrometric Station (Lake Level)

Title:

DRAINAGE BASINS WITHIN THE LOCAL STUDY AREA

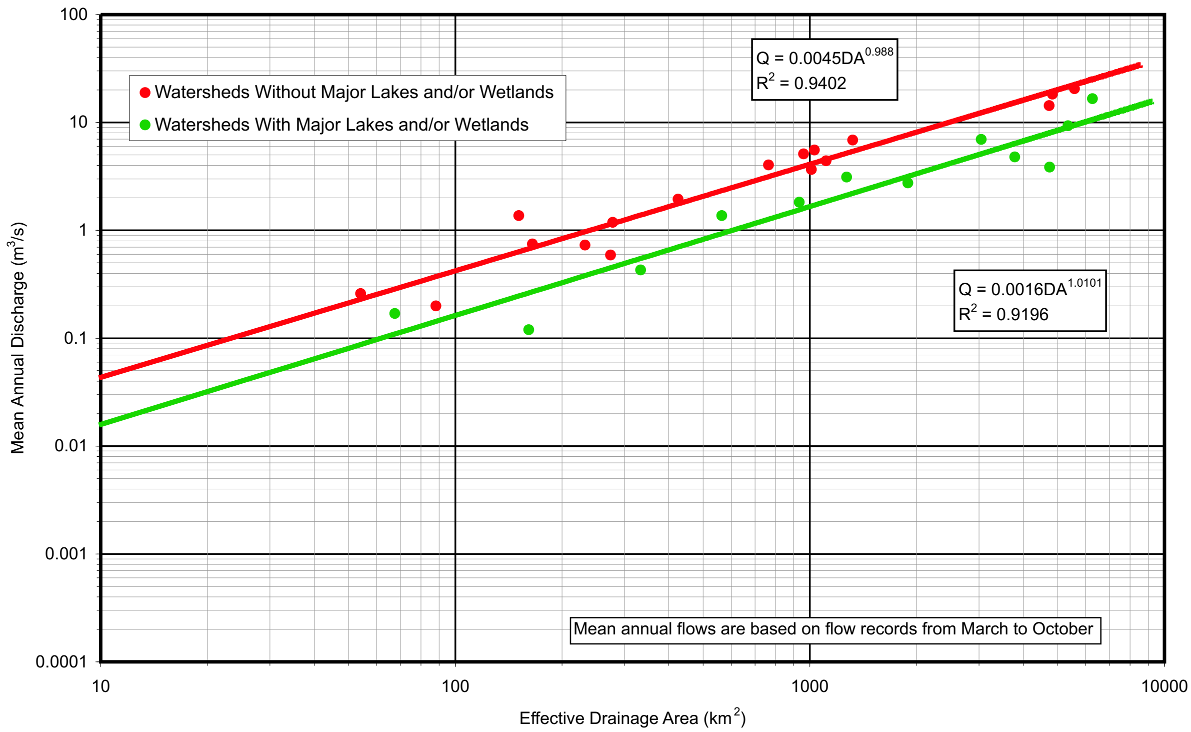
NORTH AMERICAN OIL SANDS CORPORATION

Approved: GH	Revision Date: Apr. 10, 2007
File: Fig 6.7-1 Drainage Basins Within the LSA_20070516.mxd	

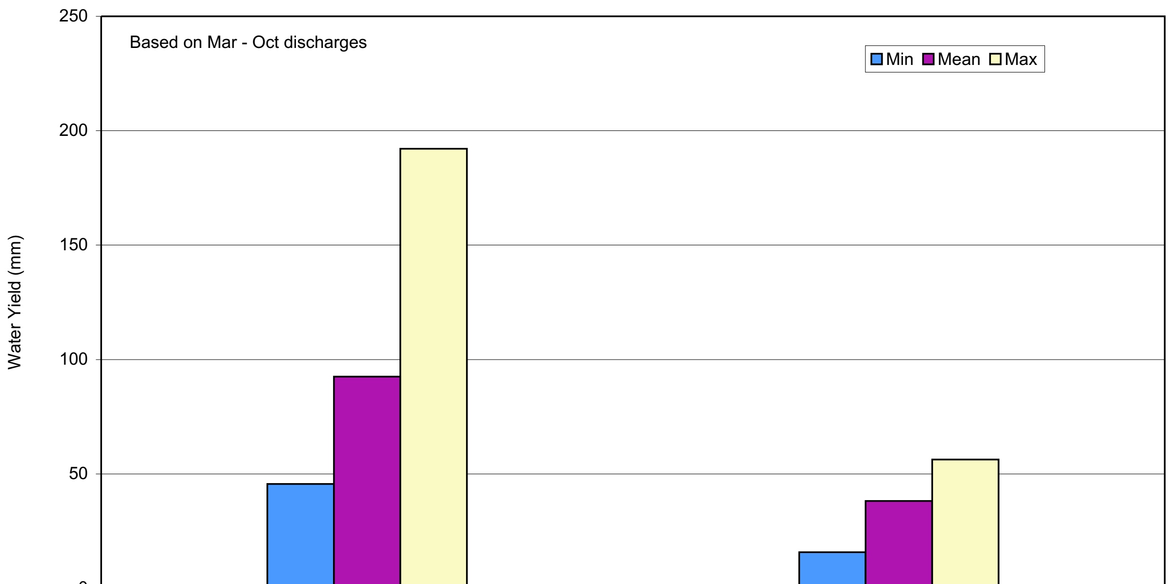
Drawn by:	Checked:	Fig. No.:
LZ/JC	GH/LZ	6.7-1

I:\4455-514_NAOSC\NAOSC_Maps\Maps_Surface_Hydrology\Baseline_Maps\FINAL\Fig 6.7-1 Drainage Basins Within the LSA_20070516.mxd

Mean Seasonal Flows versus Effective Drainage Area



Minimum, Mean and Maximum Seasonal Water Yields



	Watersheds Without Major Lakes and/or Wetlands	Watersheds With Major Lakes and/or Wetlands
Min	45.6	15.8
Mean	92.5	38.2
Max	192.1	56.3

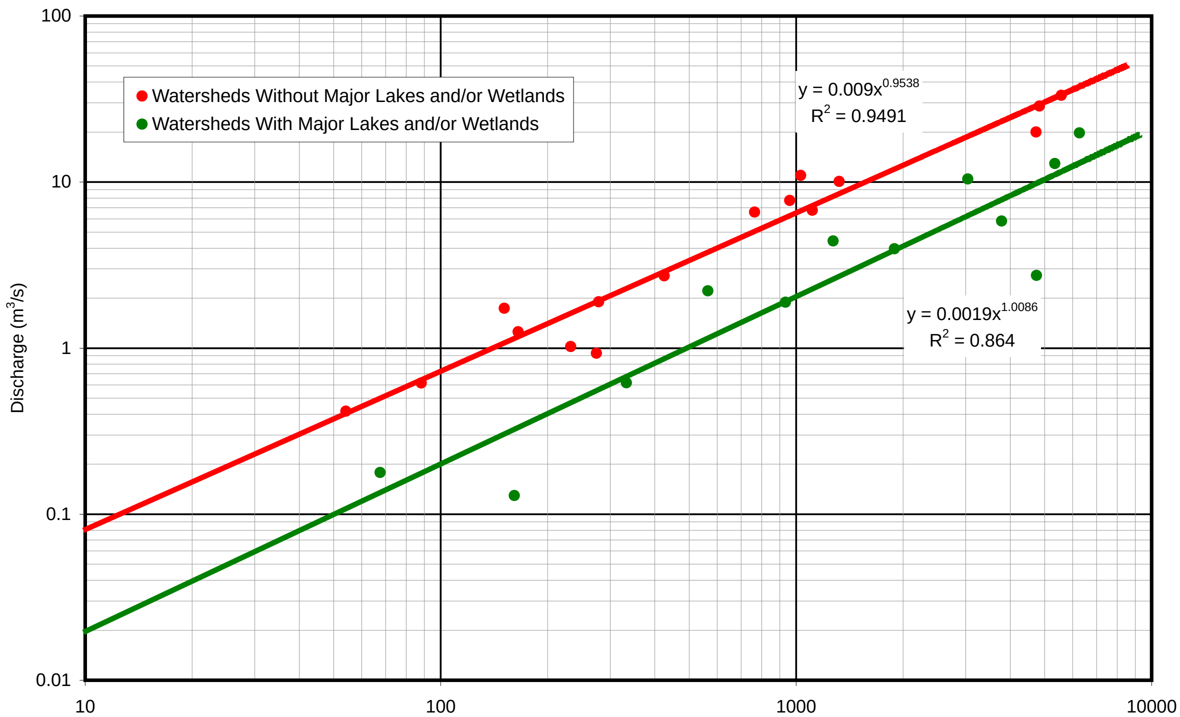
Title:

REGIONAL MEAN SEASONAL FLOWS

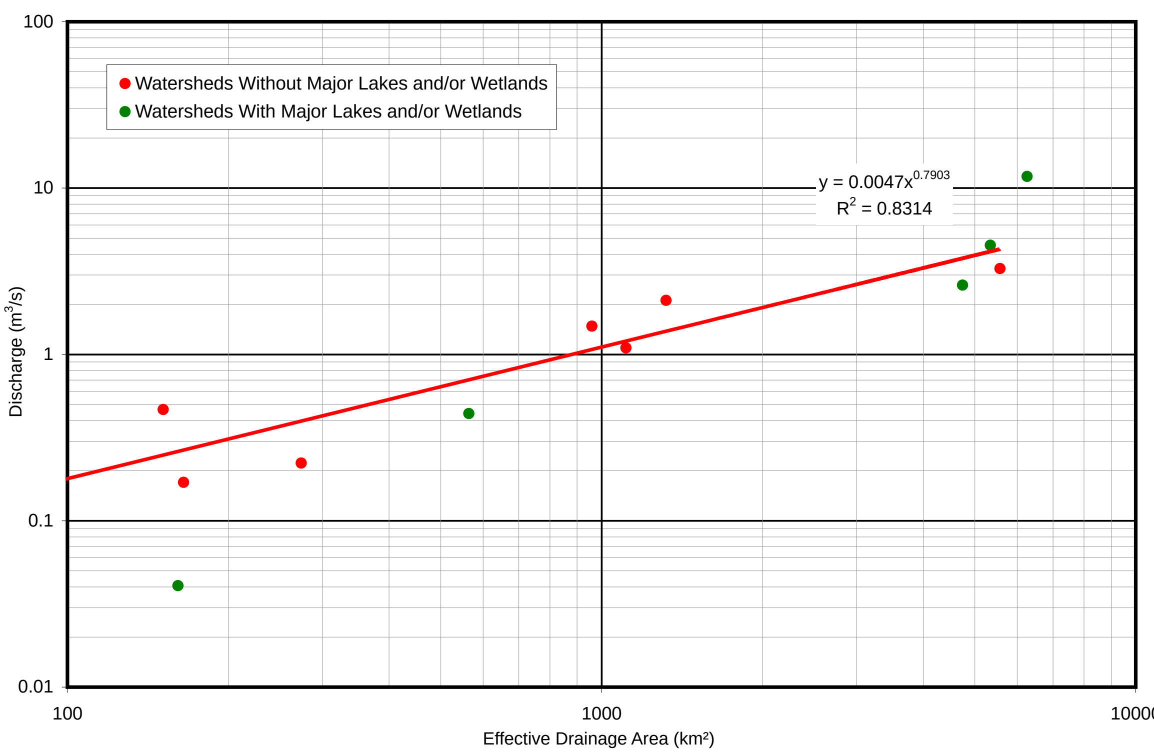
NORTH AMERICAN OIL SANDS CORPORATION

Approved: LP	Revision Date: 07/05/15	
File: 4455-HydCharts-06.cdr		
Drawn by: GDE	Checked: GH	Fig. No.: **6.7-2**

Mean Monthly Flow versus Effective Drainage Area - June



Mean Monthly Flow versus Drainage Area - November



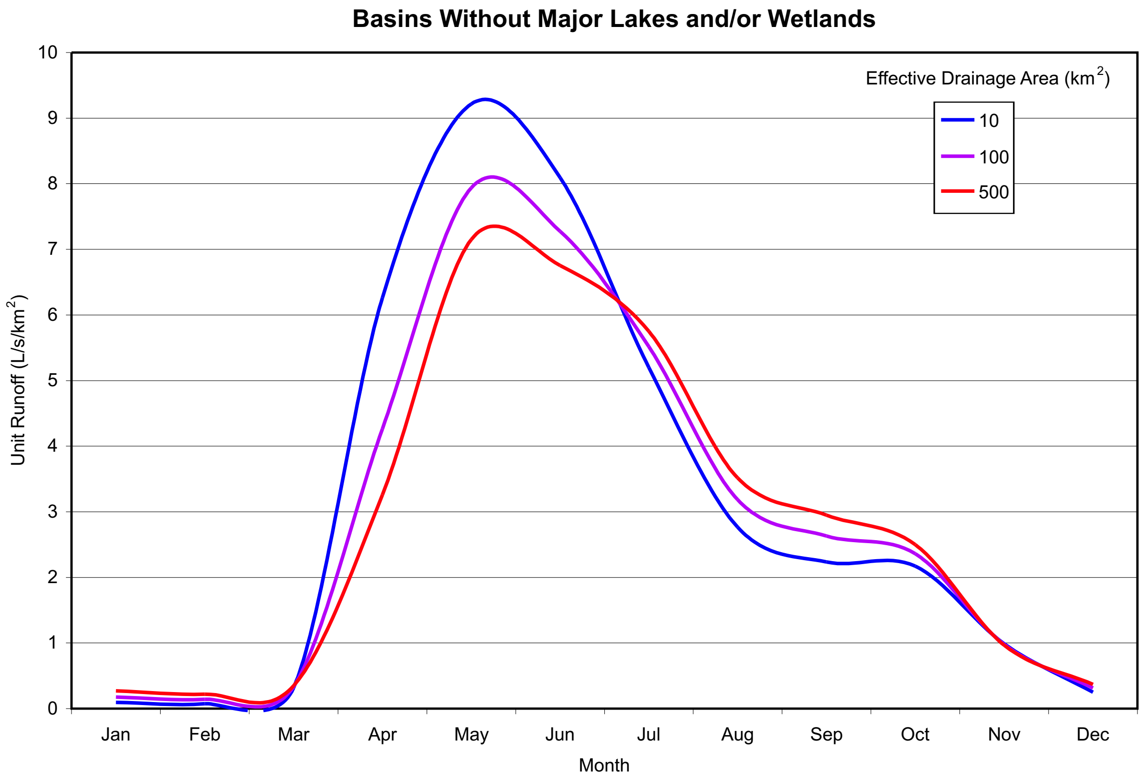
Title:

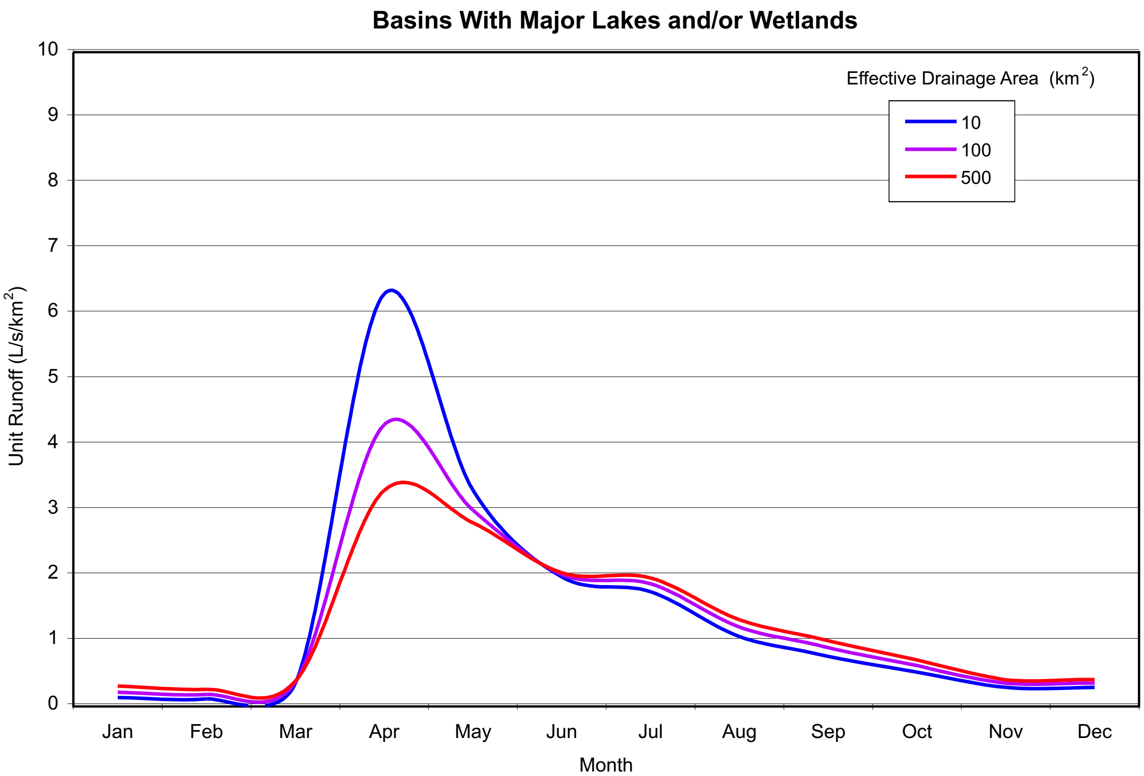
REGIONAL JUNE AND NOVEMBER FLOW VERSUS DRAINAGE AREA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: LP	Revision Date: 07/05/15
File: 4455-HydCharts-06.cdr	

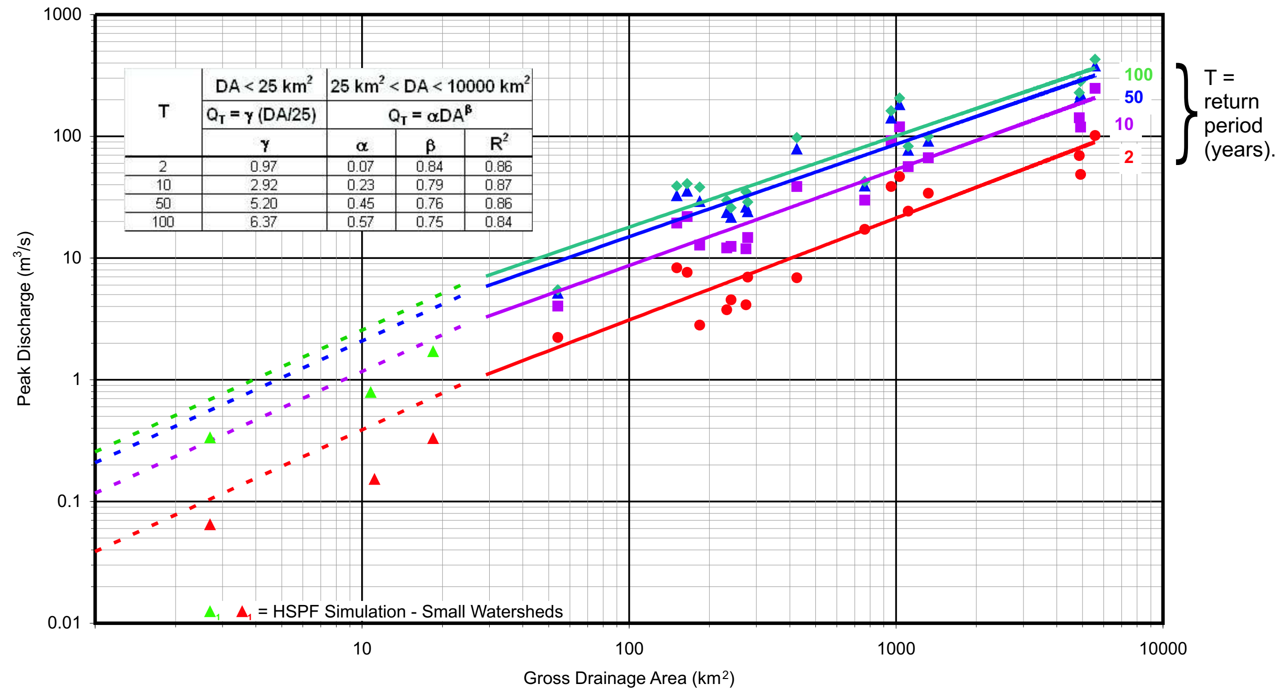
Drawn by:	Checked:	Fig. No.:
GDE	GH	**6.7-3**





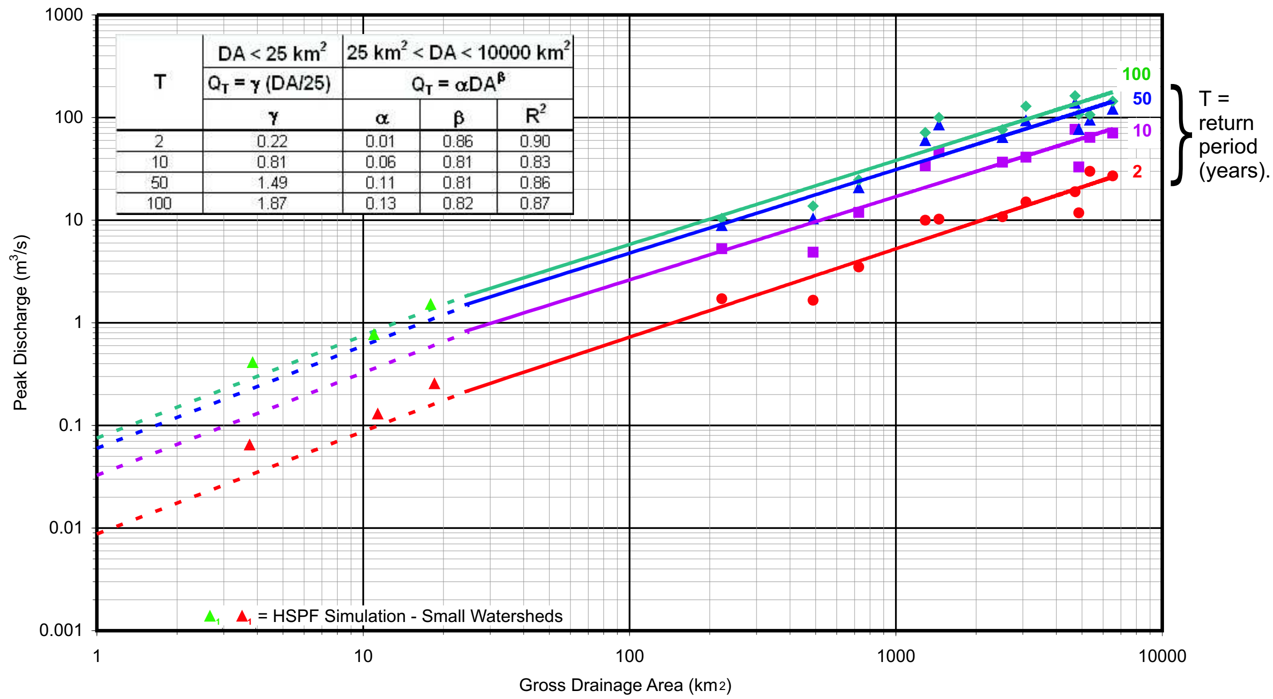
Title: UNIT RUNOFF IN STUDY AREA	NORTH AMERICAN OIL SANDS CORPORATION
Approved: LP	Revision Date: 07/05/15
File: 4455-HydCharts-06.cdr	
Drawn by: GDE	Checked: GH
Fig. No.: 6.7-4	

Maximum Instantaneous Discharge for Watersheds Without Major Lakes and/or Wetlands



T	DA < 25 km²	25 km² < DA < 10000 km²		
	$Q_T = \gamma (DA/25)$	$Q_T = \alpha DA^{\beta}$		
	γ	α	β	R^2
2	0.97	0.07	0.84	0.86
10	2.92	0.23	0.79	0.87
50	5.20	0.45	0.76	0.86
100	6.37	0.57	0.75	0.84

Maximum Instantaneous Discharge for Watersheds With Major Lakes and/or Wetlands



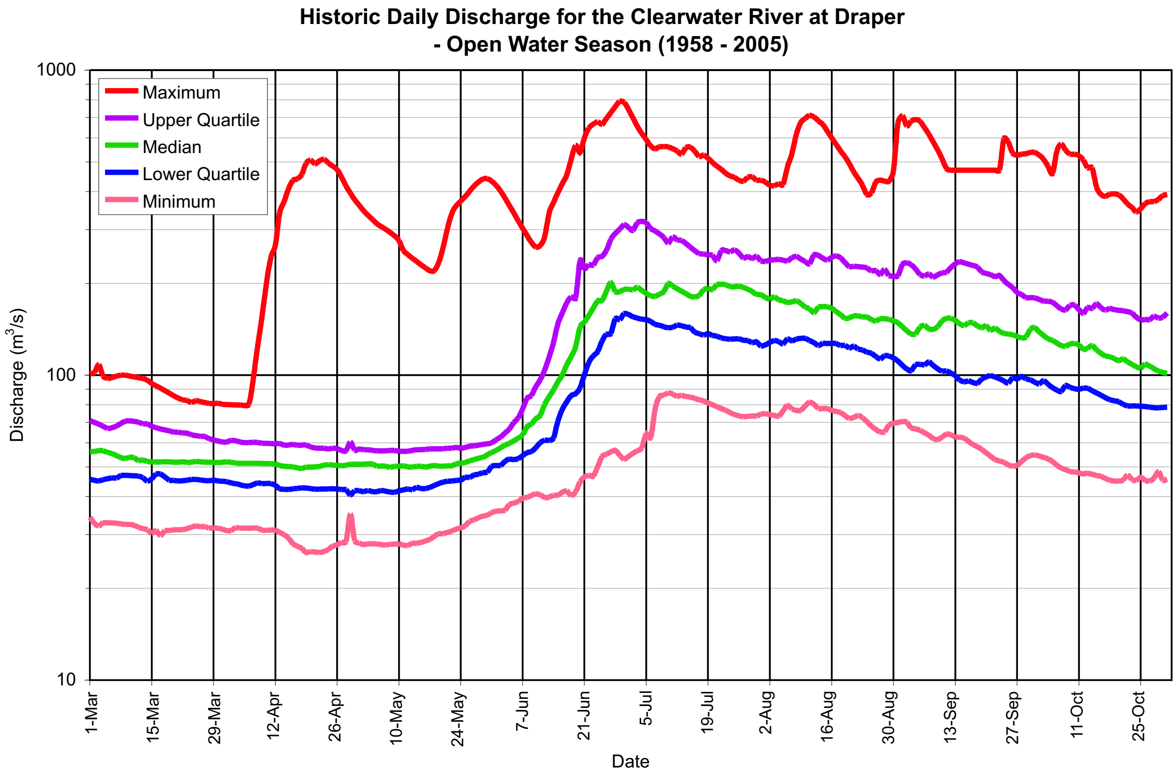
T	DA < 25 km²	25 km² < DA < 10000 km²		
	$Q_T = \gamma (DA/25)$	$Q_T = \alpha DA^{\beta}$		
	γ	α	β	R^2
2	0.22	0.01	0.86	0.90
10	0.81	0.06	0.81	0.83
50	1.49	0.11	0.81	0.86
100	1.87	0.13	0.82	0.87

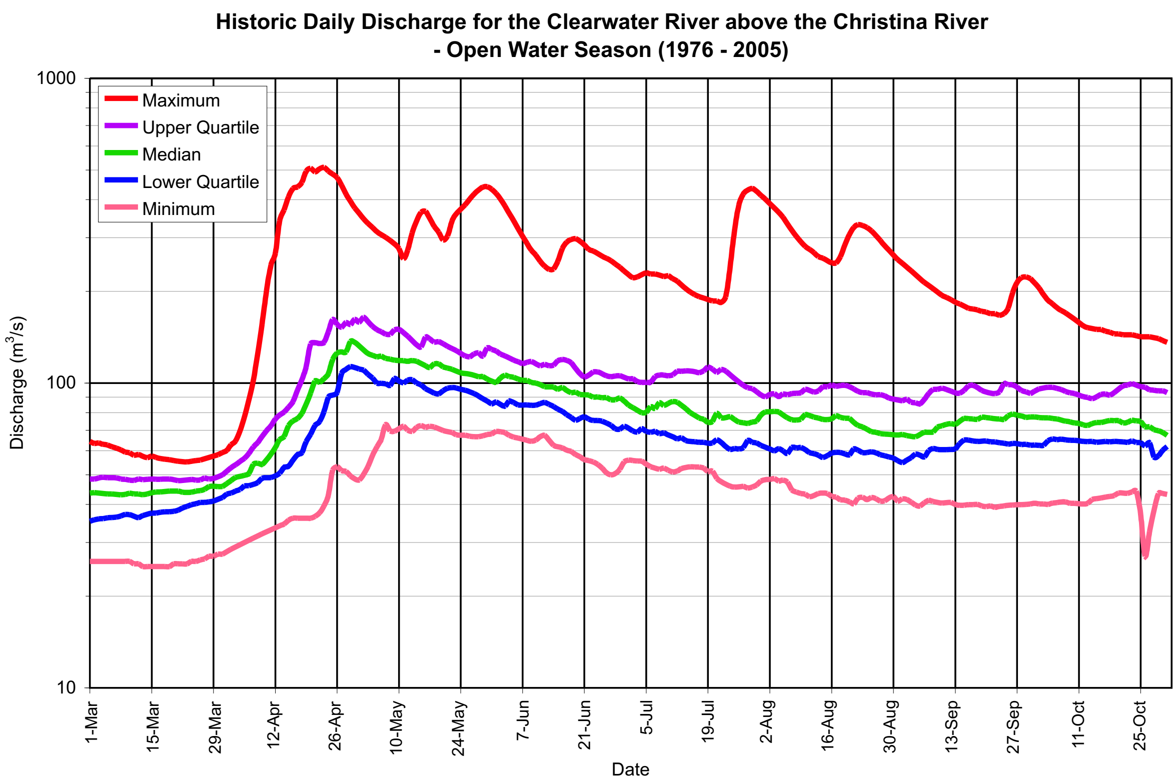
Title:

MAXIMUM INSTANTANEOUS DISCHARGE VERSUS DRAINAGE AREA

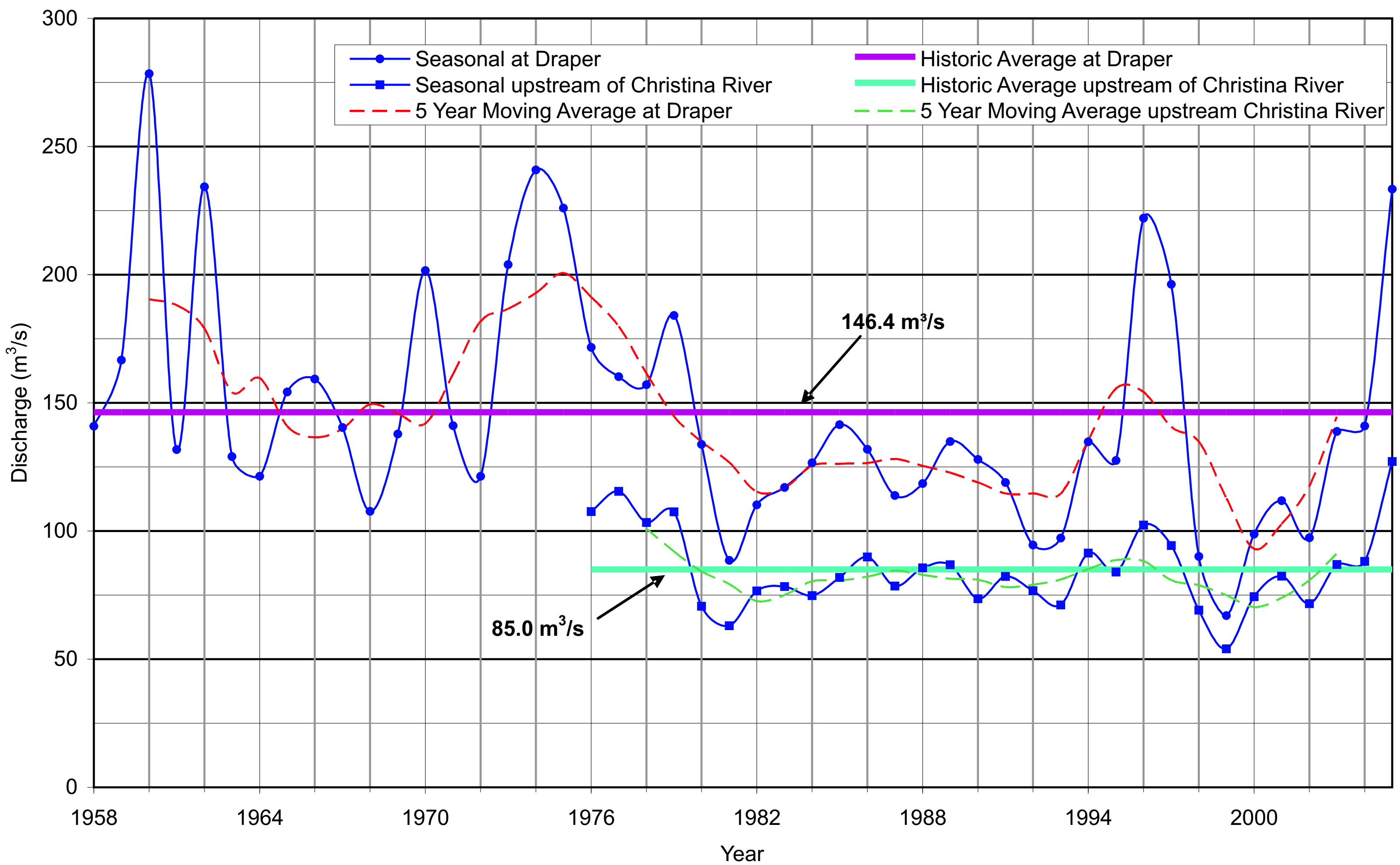
NORTH AMERICAN OIL SANDS CORPORATION

Approved: LP	Revision Date: 07/05/15
File: 4455-HydCharts-06.cdr	
Drawn by: GDE	Checked: GH
Fig. No.: **6.7-5**	





Title: HISTORIC DAILY DISCHARGE FOR THE CLEARWATER RIVER	NORTH AMERICAN OIL SANDS CORPORATION		
	Approved: LP	Revision Date: 07/03/28	
	File: 4455-HydCharts-07.cdr		
	Drawn by: GDE	Checked: GH	Fig. No.: **6.7-6**

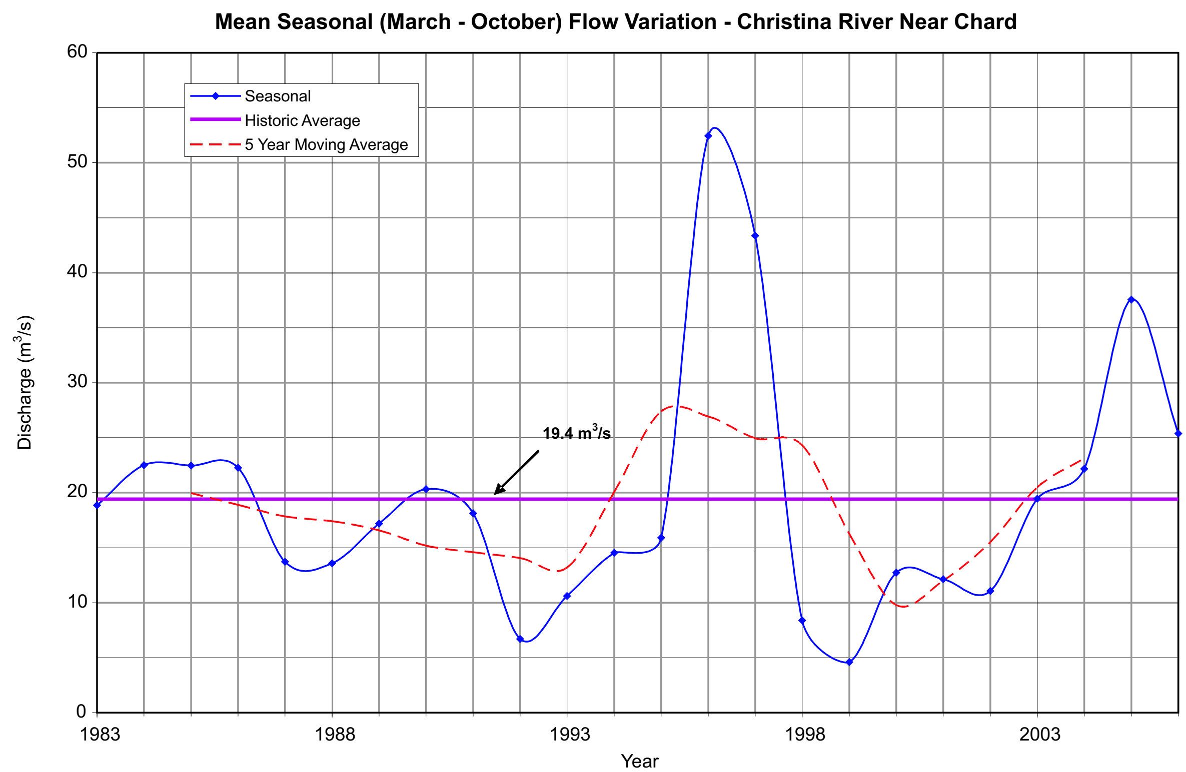


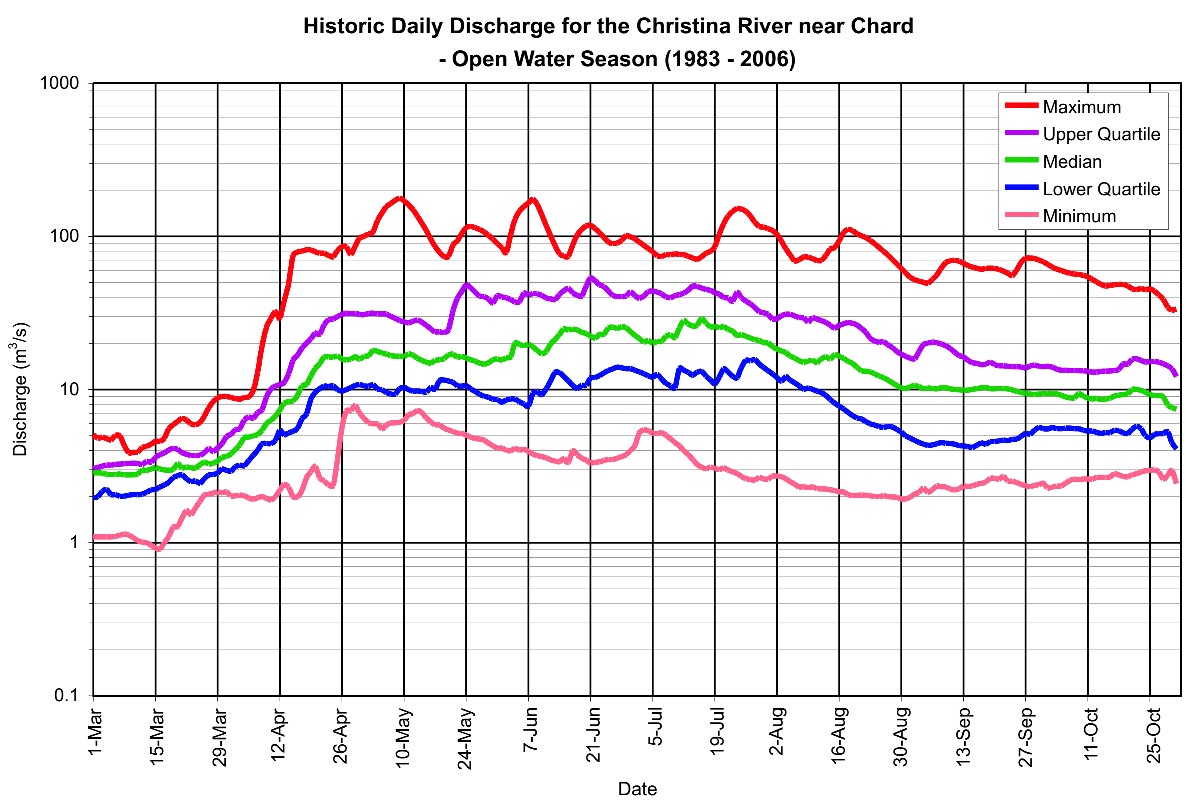
Title:

MEAN SEASONAL (MARCH-OCTOBER) FLOW VARIATION CLEARWATER RIVER

NORTH AMERICAN OIL SANDS CORPORATION

Approved: LP	Revision Date: 07/03/28	
File: 4455-HydCharts2-07.cdr		
Drawn by: GDE	Checked: GH	Fig. No.: **6.7-7**



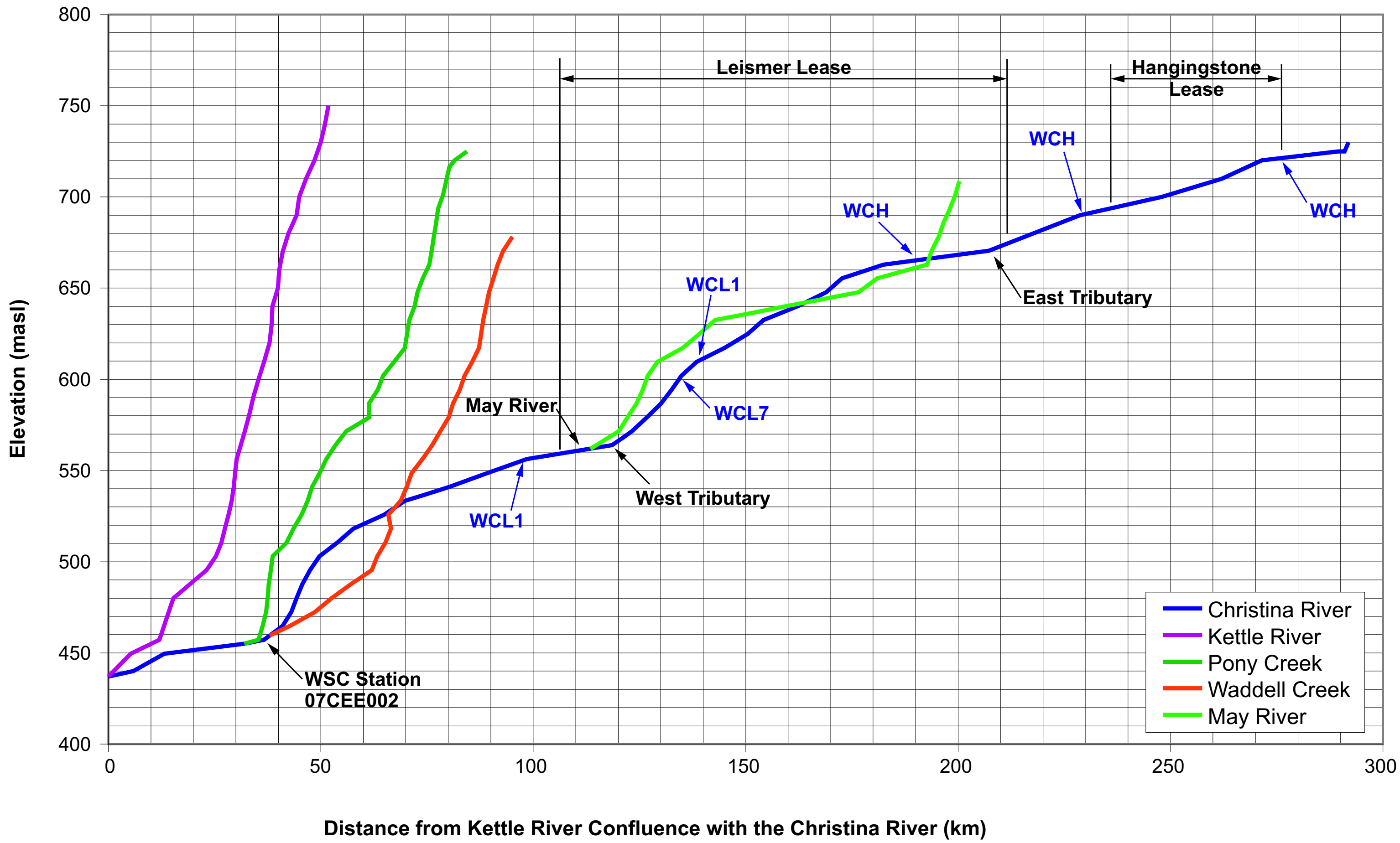


Title:

MEAN SEASONAL FLOW VARIATION AND HISTORIC DAILY DISCHARGE FOR THE CHRISTINA RIVER

NORTH AMERICAN OIL SANDS CORPORATION

Approved: LP	Revision Date: 07/03/28	
File: 4455-HydCharts-07.cdr		
Drawn by: GDE	Checked: GH	Fig. No.: **6.7-8**

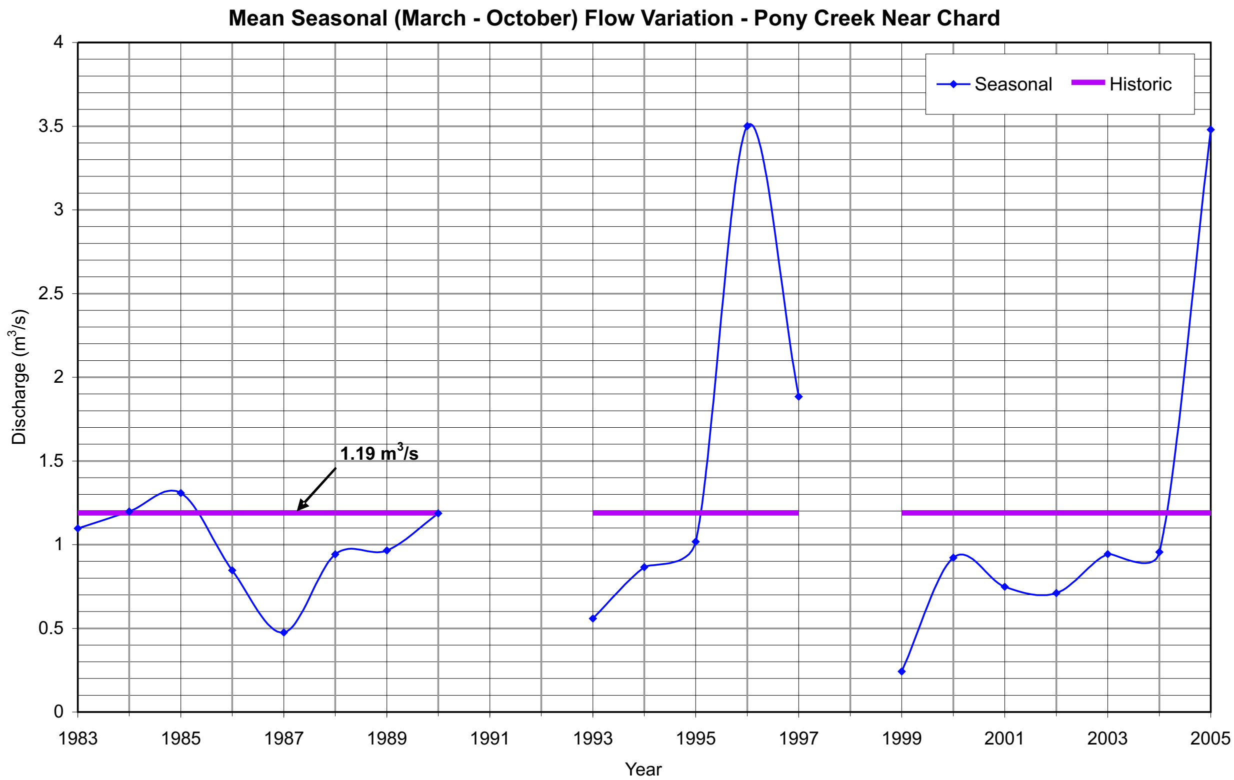


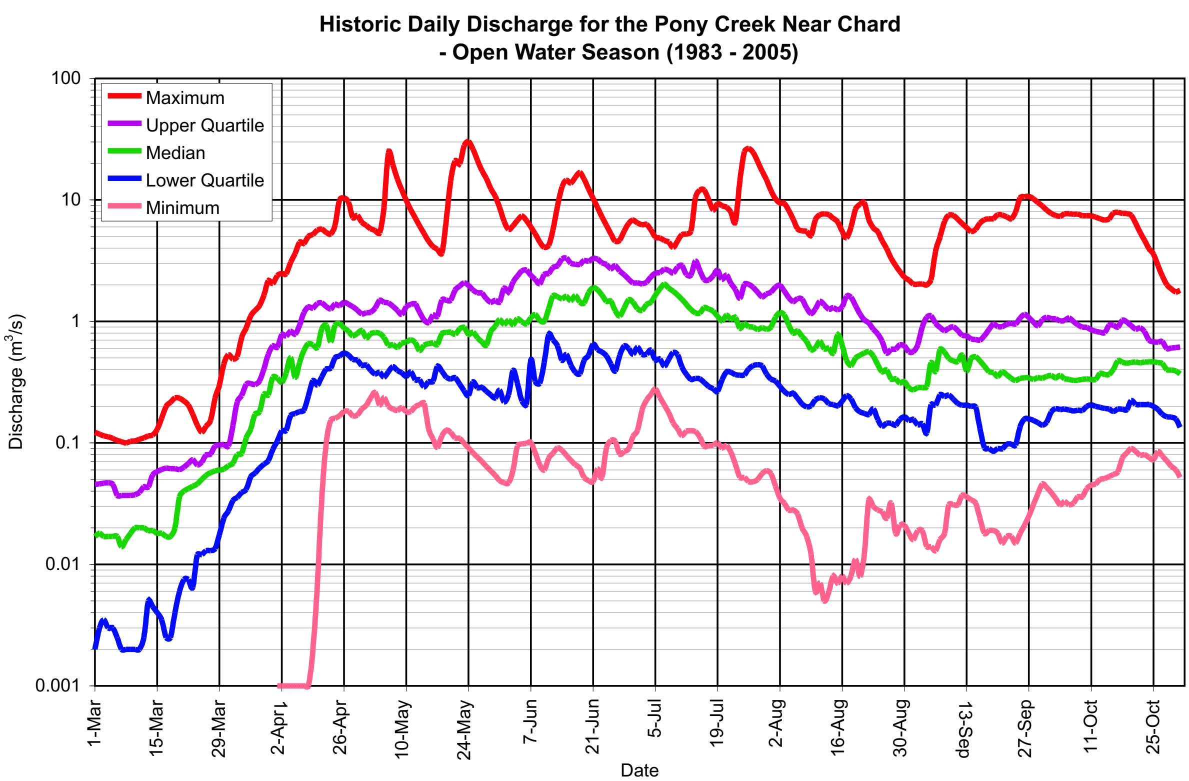
Title:

LONGITUDINAL PROFILE OF CHRISTINA RIVER AND TRIBUTARIES WITHIN THE LSA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: LP	Revision Date: 07/03/28	
File: 4455-HydCharts2-07.cdr		
Drawn by: GDE	Checked: GH	Fig. No.: **6.7-9**





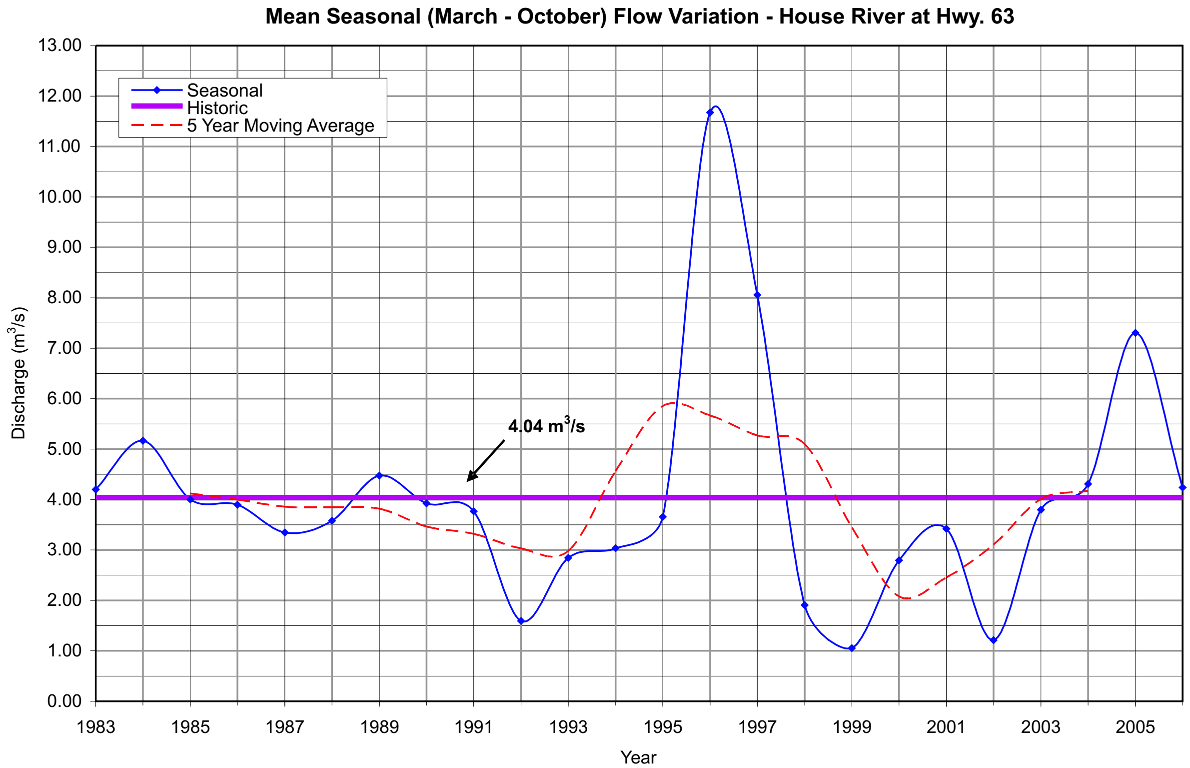
Title:

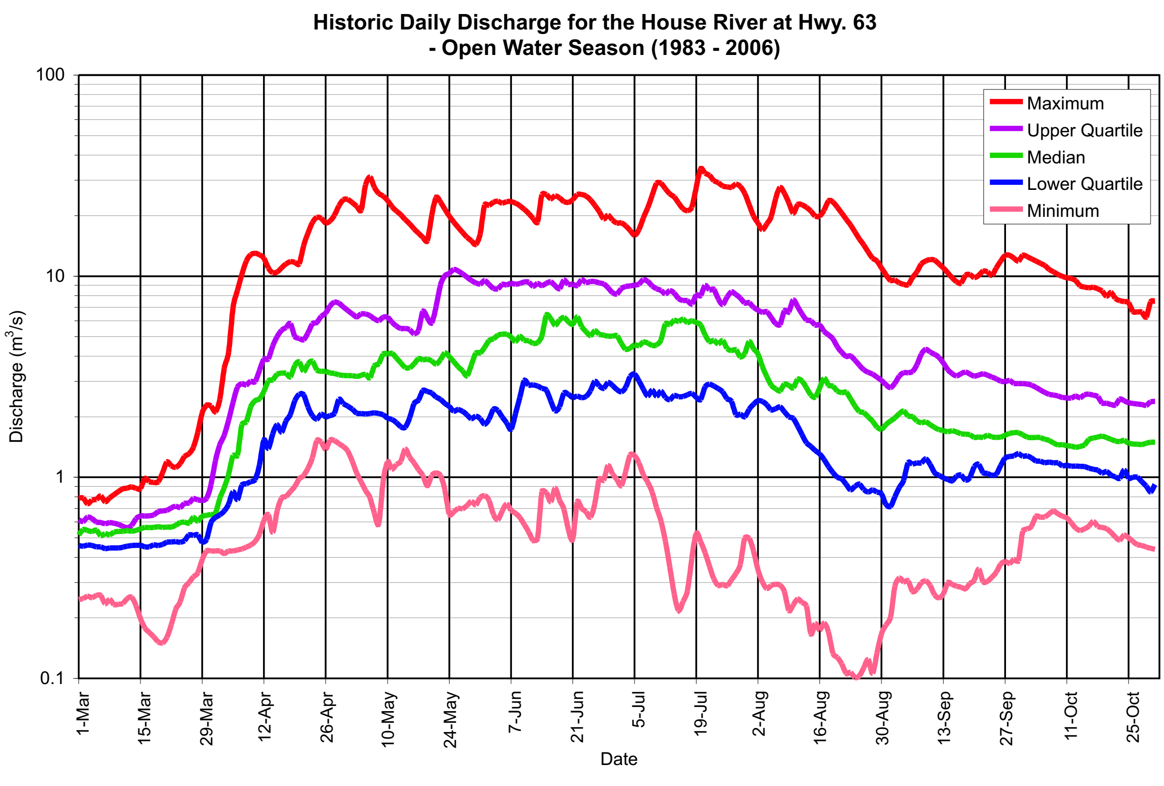
MEAN SEASONAL FLOW VARIATION AND HISTORIC DAILY DISCHARGE FOR THE PONY CREEK

NORTH AMERICAN OIL SANDS CORPORATION

Approved: LP	Revision Date: 07/03/28
File: 4455-HydCharts-07.cdr	

Drawn by:	Checked:	Fig. No.:
GDE	GH	**6.7-10**





Title: **MEAN SEASONAL FLOW VARIATION AND HISTORIC DAILY DISCHARGE FOR THE HOUSE RIVER**	NORTH AMERICAN OIL SANDS CORPORATION		
	Approved: LP	Revision Date: 07/03/28	
	File: 4455-HydCharts-07.cdr		
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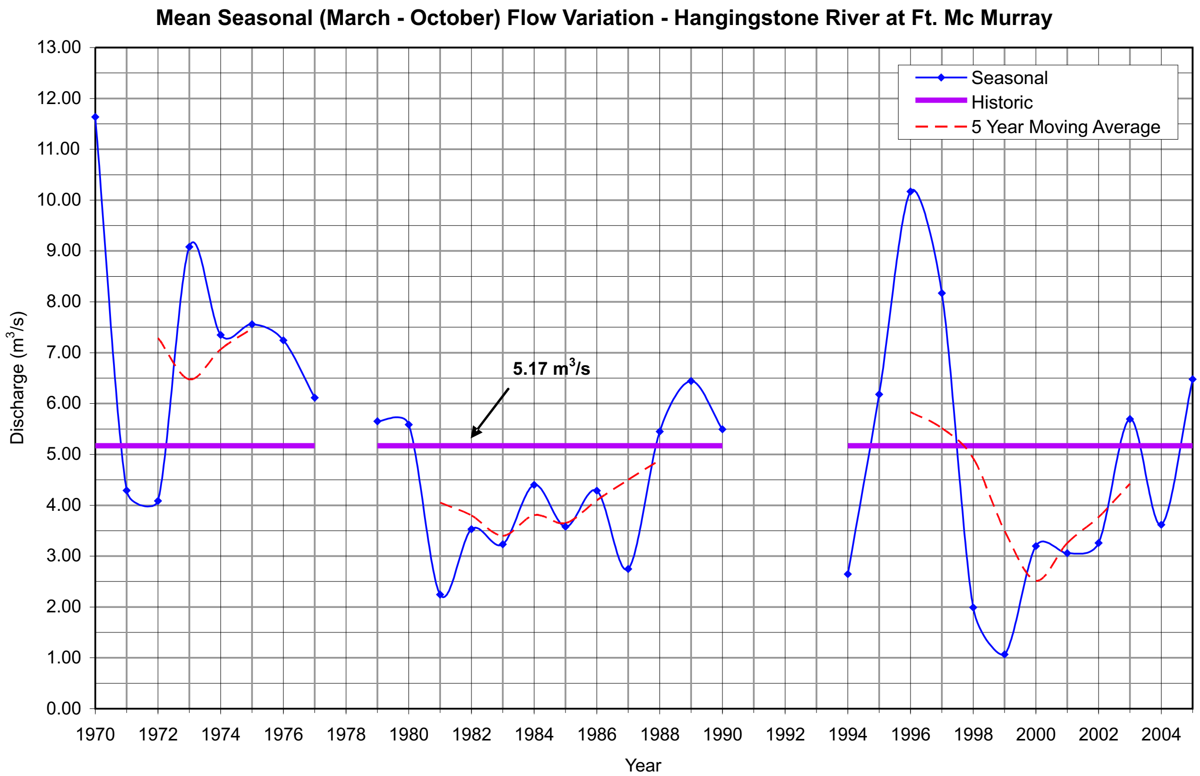
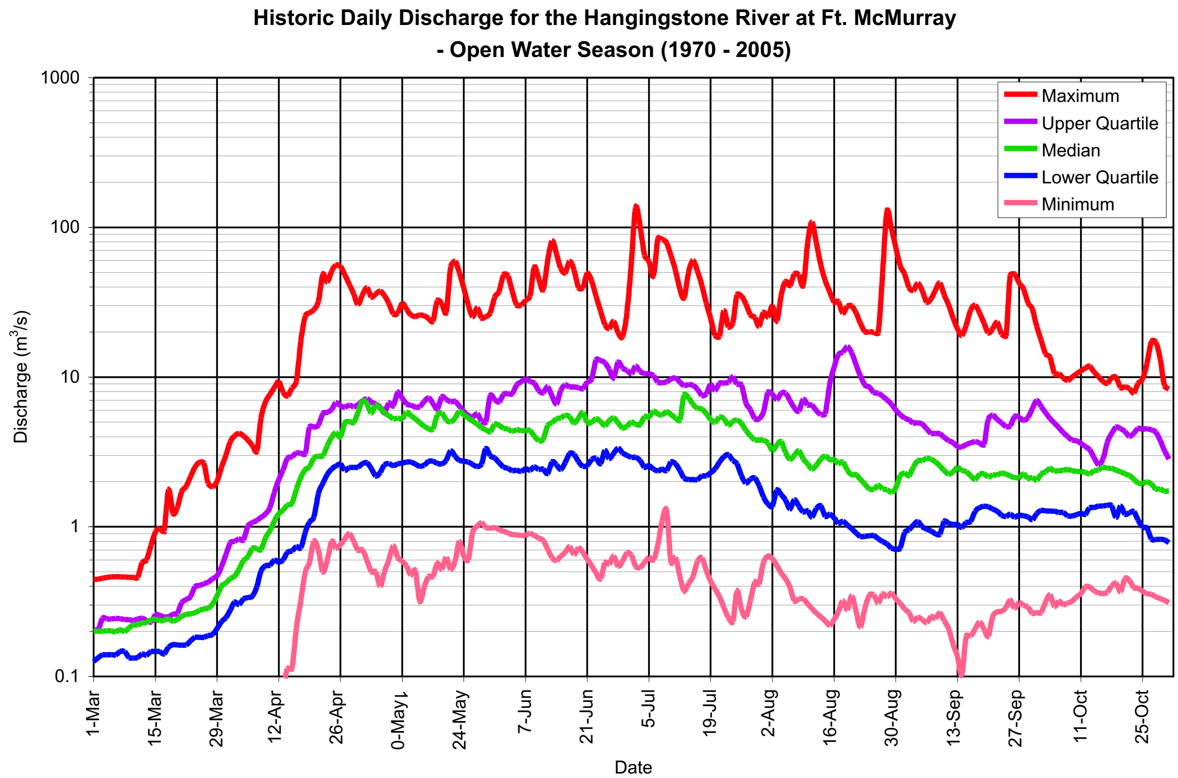




Title:

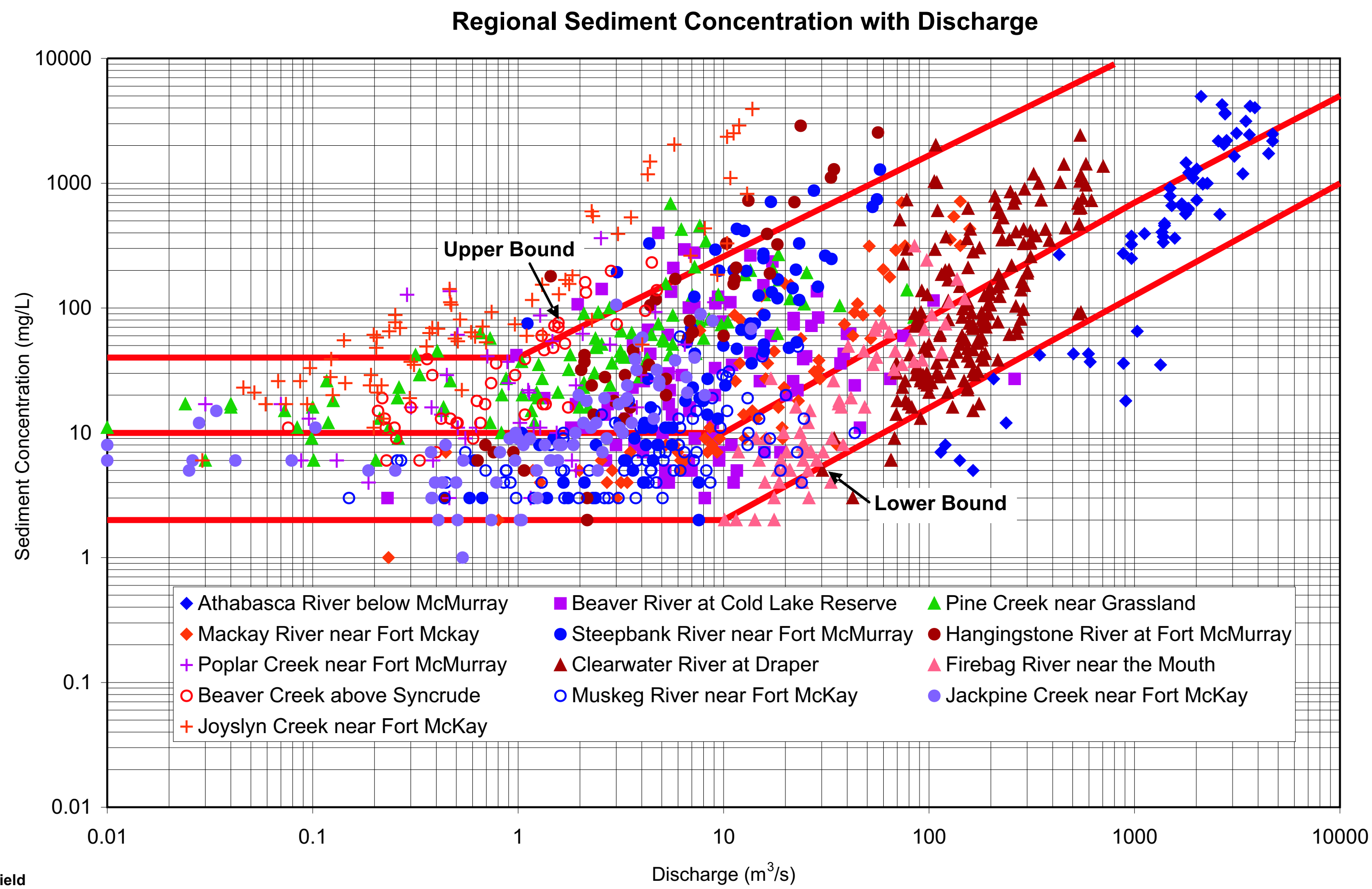
MEAN SEASONAL FLOW VARIATION AND HISTORIC DAILY DISCHARGE FOR THE HANGINGSTONE RIVER

NORTH AMERICAN OIL SANDS CORPORATION

Approved: LP	Revision Date: 07/03/28

File: 4455-HydCharts-07.cdr

Drawn by:	Checked:	Fig. No.:
GDE	GH	**6.7-12**



Mean Annual Sediment Yield

Station ID	Name	Drainage Area (km^2)	Period of Record	Years of Record	Annual Sediment Yield (mm) [2]
07DA007	Poplar Creek near Fort McMurray [1]	151	1974 -1986	9	0.0193
07DA018	Beaver River above Syncrude	165	1976 - 1980	4	0.0236
07DA016	Joslyn Creek near Fort McKay	257	1976 - 1992	15	0.0647
07DA009	Jackpine Creek near Fort McKay	358	1976 - 1990	15	0.0027
07CD004	Hangingstone River at Fort McMurray	959	1978 -2001	11	-
07DA006	Steepbank River near Fort McMurray	1,320	1975 - 2000	19	0.0246
07CA005	Pine Creek near Grassland	1,450	1974 - 1997	17	-
07DA008	Muskeg River near Fort McKay	1,460	1976 - 1990	15	0.0016
07DB001	Mackay River near Fort Mckay	5,570	1975 - 1989	14	0.0175
07DC001	Firebag River near the Mouth	5,990	1966 - 1990	21	0.0114
06AD006	Beaver River at Cold Lake Reserve	14,500	1975 - 1997	18	-
07CD001	Clearwater River at Draper	30,800	1966 - 1990	21	0.0219
07DA001	Athabasca River below McMurray	133,000	1967 - 1972	6	0.159

[1] Poplar Creek sediment data prior to diversion of flow from Beaver River
[2] Annual sediment yield values taken from Golder, 2002

Title:

REGIONAL SEDIMENT YIELD

NORTH AMERICAN OIL SANDS CORPORATION

Approved: LP | Revision Date: 07/03/28

File: 4455-HydCharts2-07.cdr

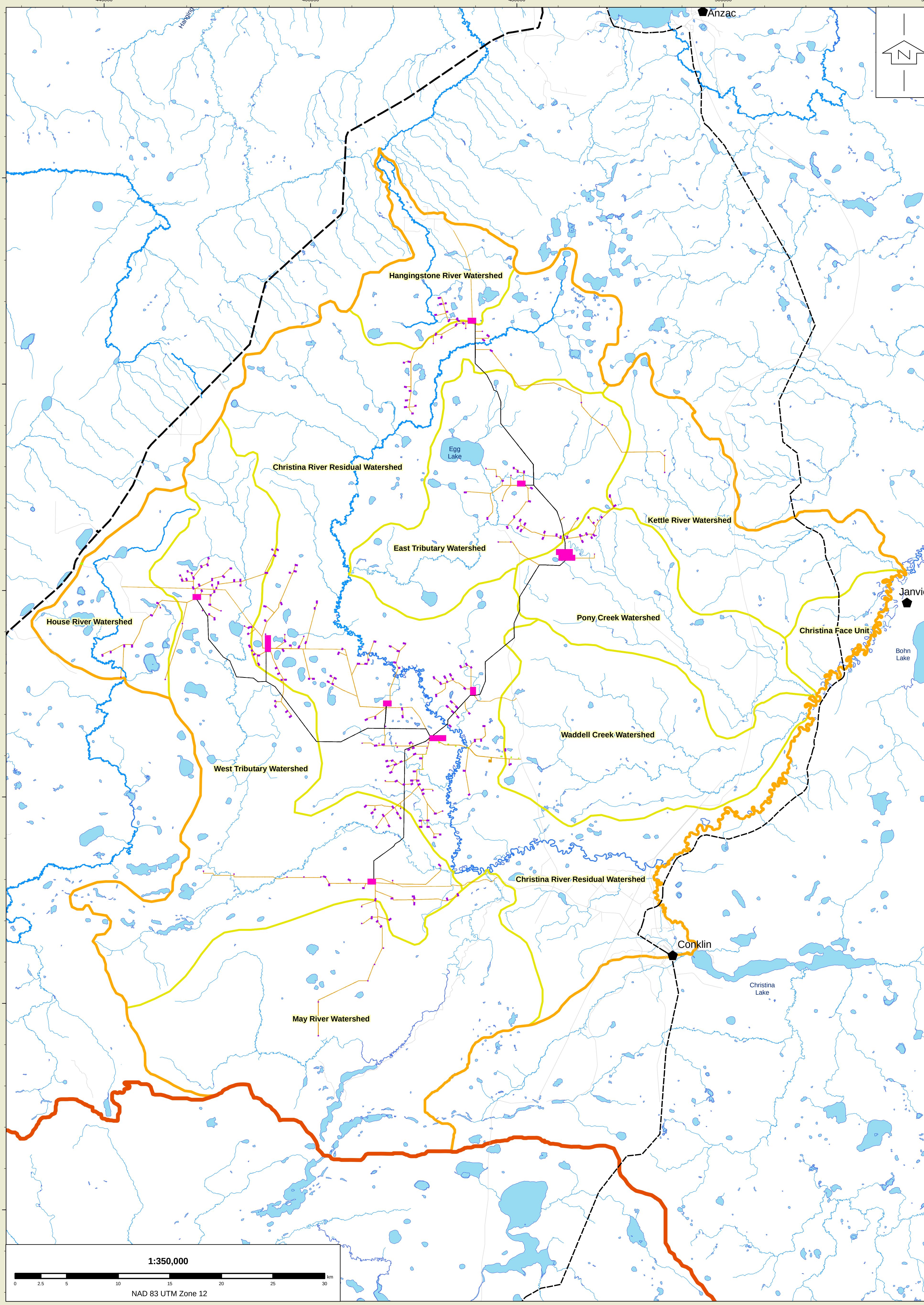
Drawn by: GDE | Checked: GH | Fig. No.: **6.7-13**

6.8 Summary of Local Flow Estimates

Table 6.8-1 provides a summary of estimated monthly, annual and peak flows of local watersheds in the LSA based upon the regional analyses and equations previously presented. Local adjustments based upon site-specific data and percentage of lakes and/or wetlands in the basin are applied where appropriate. Minimum flows, such as 7Q10, are all expected to be zero in these streams with no flow frequently occurring during winter on streams having drainage areas of less than 100 km^2.

Table 6.8-1 Modelled Discharge for Watersheds in the LSA

Location	Total Drainage Area	Lake Area	Wetland Area	Effective Drainage Area	Percentage Covered by Lakes and/or Wetlands	Mean Monthly Flow Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean Annual Flow	Water Yield	Peak Flows Q_2	Q_{10}	Q_{50}	Q_{100}
	(km²)	(km²)	(km²)	(km²)		(m³/s)	(m³/s)	(m³/s)	(m³/s)	(m³/s)	(m³/s)	(m³/s)	(m³/s)	(m³/s)	(m³/s)	(m³/s)	(m³/s)	(m³/s)	(mm)	(m³/s)	(m³/s)	(m³/s)	(m³/s)
Christina River																							
West Tributary																							
WCL2	99.3	0.8	2.1	96.4	3	0.02	0.01	0.03	0.41	0.77	0.70	0.53	0.31	0.25	0.23	0.09	0.03	0.28	92.4	0.51	2.43	4.45	5.51
WCL14	546.5	10.4	12.4	523.7	4	0.14	0.12	0.18	1.69	3.73	3.53	3.02	1.85	1.55	1.31	0.51	0.19	1.49	89.5	2.18	9.56	17.53	22.06
WCL12	593	10.4	12.4	570.2	4	0.16	0.13	0.20	1.82	1.57	1.14	1.10	0.74	0.55	0.31	0.55	0.21	0.71	39.1	2.35	10.25	18.78	23.65
Residual																							
WCH4	15.9	0	7.4	8.5	47	0.00	0.00	0.00	0.05	0.03	0.02	0.01	0.01	0.01	0.00	0.01	0.00	0.01	44.6	0.07	0.28	0.51	0.64
WCH5	5.7	0.2	0.2	5.3	7	0.00	0.00	0.00	0.04	0.02	0.01	0.01	0.01	0.00	0.00	0.01	0.00	0.01	45.8	0.05	0.17	0.32	0.40
WCL8	85	3.2	3.8	78	8	0.01	0.01	0.03	0.35	0.23	0.15	0.14	0.09	0.07	0.02	0.08	0.02	0.10	40.6	0.42	2.05	3.75	4.63
WCH3	122.9	5.8	25.3	91.8	25	0.02	0.01	0.03	0.40	0.27	0.18	0.17	0.11	0.08	0.03	0.09	0.03	0.12	40.4	0.49	2.33	4.28	5.29
WCH6	181.3	6.8	27.2	147.3	19	0.03	0.02	0.05	0.59	0.43	0.29	0.27	0.18	0.13	0.06	0.14	0.05	0.19	39.9	0.73	3.42	6.28	7.80
WCL1	1062.2	24.9	48.86	988.4	7	0.32	0.26	0.35	2.87	2.65	1.99	1.94	1.32	1.00	0.62	0.95	0.39	1.22	39.0	3.76	16.00	29.33	37.14
WCL4	996.2	24.8	48.86	922.5	7	0.29	0.24	0.33	2.71	2.48	1.86	1.81	1.23	0.93	0.57	0.89	0.36	1.14	39.0	3.55	15.13	27.74	35.09
WCL7	1081.9	25.5	48.86	1,007.5	7	0.33	0.27	0.36	2.92	2.70	2.03	1.98	1.35	1.02	0.64	0.97	0.40	1.25	39.0	3.83	16.25	29.79	37.72
WCL9	1151	25.5	48.86	1,076.6	6	0.36	0.29	0.38	3.09	2.88	2.17	2.12	1.45	1.10	0.69	1.04	0.43	1.33	39.0	4.05	17.14	31.43	39.83
WCL10	1265	28.7	53.06	1,183.2	6	0.40	0.33	0.42	3.34	3.15	2.39	2.33	1.60	1.21	0.78	1.14	0.47	1.46	39.0	4.39	18.51	33.93	43.04
WCL11	2724.5	39.3	65.86	2,619.3	4	1.11	0.91	0.95	6.47	6.75	5.33	5.29	3.70	2.85	2.13	2.51	1.14	3.26	39.3	8.70	35.23	64.58	82.58
East Tributary																							
WCC1	67.8	0.1	7.3	60.4	11	0.01	0.01	0.02	0.28	0.50	0.45	0.33	0.19	0.15	0.14	0.06	0.02	0.18	93.5	0.34	1.66	3.05	3.75
WCC2	67.6	8.9	3.9	54.8	19	0.01	0.01	0.02	0.26	0.17	0.11	0.10	0.06	0.04	0.02	0.05	0.02	0.07	41.1	0.31	1.54	2.82	3.47
WCC3	155.9	9.3	14.4	132.2	15	0.02	0.02	0.04	0.54	0.39	0.26	0.24	0.16	0.11	0.05	0.13	0.04	0.17	40.0	0.67	3.14	5.75	7.13
May Creek																							
WCL13	669.1	8.91	4.5	655.7	2	0.19	0.16	0.23	2.03	1.78	1.31	1.27	0.85	0.64	0.37	0.63	0.25	0.81	39.1	2.63	11.43	20.96	26.42
Waddell Creek																							
WCL5	34.7	0	0	34.7	0	0.00	0.00	0.01	0.18	0.11	0.07	0.06	0.04	0.03	0.01	0.03	0.01	0.05	41.8	0.21	1.06	1.95	2.38
WCL6	35.3	0.2	0	35.1	1	0.00	0.00	0.01	0.18	0.11	0.07	0.06	0.04	0.03	0.01	0.03	0.01	0.05	41.8	0.21	1.07	1.96	2.40
House River																							
WCL3	33.3	2.1	1	30.2	9	0.00	0.00	0.01	0.16	0.26	0.23	0.16	0.09	0.07	0.07	0.03	0.01	0.09	95.3	0.19	0.95	1.74	2.13
Hangingstone River																							
WCH1	64.4	1.5	0.9	62	4	0.01	0.01	0.02	0.29	0.51	0.46	0.34	0.19	0.16	0.14	0.06	0.02	0.18	93.4	0.35	1.70	3.11	3.83
WCH2	44.8	1.2	0.9	42.7	5	0.01	0.00	0.01	0.21	0.36	0.32	0.23	0.13	0.11	0.10	0.04	0.01	0.13	94.4	0.25	1.26	2.30	2.82



Legend

- Regional Study Area
- Local Study Area
- Sub-Basin Boundary
- Lake
- Stream
- Major Road (Hwy. 63)
- Road (881)
- Other Roads

NAOSC Footprint Features:

- Central Plant Facility (CPF)
- Well Pads (SAGD or Water)
- Road / Connector
- Pipeline
- Camps / Borrow Pits

Title:

PROPOSED PROJECT FOOTPRINT AND SUB-WATERSHEDS IN THE LOCAL STUDY AREA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: GH	Revision Date: Apr. 10, 2007	
File: Ftprnt_in_Sub-watersheds.mxd		
Drawn by: LZ/JC	Checked: GH/LZ	Fig. No.: 6.8-1

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6.9 Basin Water Balance

An average annual water balance can be expressed as follows:

Precipitation (P) = Runoff (R) + Evapotranspiration (ET) × (% Ground Area) + Lake and Wetland Evaporation (LE) × (% Lake and Wetland Area) + Groundwater Recharge (GW)

Regional values applied to the above water balance equation are: mean annual precipitation of 481 mm, runoff of 99 mm (average of Christina at Chard, Pony near Chard, House at Highway 63, and Hangingstone at Fort McMurray), evapotranspiration of 322 mm and lake and wetland evaporation at 602 mm (Section 6.5.5). Using areal estimates for lake and wetland of 15% and 85% for ground area, then substituting values into the above equation yields:

489 mm= 99 mm + (322 mm x 85%) + (602 mm x 15%) + groundwater recharge.

Solving the equation yields 18 mm as a value for groundwater recharge. Groundwater modelling utilizes an annual groundwater recharge range of 1 mm to 5 mm applied to the base of the overburden (Volume 3, Section 5 - Hydrogeology). Overburden layers are up to 100 m deep, and it is estimated that recharge to the water table nearer the surface could be an order of magnitude higher. Therefore, although groundwater recharge will vary locally, 18 mm appears reasonable.

6.10 Basin Sediment Yield

Basin sediment yield is a function of climatic, hydrologic, basin physiographic and channel geomorphic conditions. Available suspended sediment concentration data for the region are summarized in Table 6.10-1. Stream sediment or total suspended solids (TSS) concentrations in combination with stream discharge are used to determine watershed sediment yields and assess potential channel erosion rates. As the stations have intermittent suspended sediment concentration data, the estimated sediment yields shown in Figure 6.7-13 are based upon partial data sets from manual sampling primarily conducted over the 1974 – 1983 period. Subsequent data collection has been discontinued or is too sparse to provide further updates.

Excluding the Athabasca River, the mean annual sediment yields for these regional gauged basins vary by a factor of over 50, from 0.0016 mm to 0.093 mm. There is no strong correlation with drainage area because of the varying basin and channel conditions. The mean annual sediment yield for the Muskeg River, at about 0.0016 mm, is the lowest in the region and indicative of the influence of the large percentage of lowland area in the basin. The suspended sediment and corresponding discharge data shows the general trend of increasing concentrations with discharge with the expected wide scatter representing varying hydrologic conditions and times of the year. Averaging the annual sediment yield data, excluding the large sand bed Athabasca River, produces 0.028 mm (about 10 t/y/km^2). This is expected to be indicative of most watersheds in the study area. This is a moderately low sediment yield consistent with boreal forest areas with numerous wetlands that will retain sediment.

Table 6.10-1 Mean Annual Sediment Yield

Station ID	Name	Drainage Area (km^2)	Period of Record	Years of Record	Annual Sediment Yield (mm) [2]
07DA007	Poplar Creek near Fort McMurray [1]	151	1974 -1986	9	0.0193
07DA018	Beaver River above Syncrude	165	1976 - 1980	4	0.0236
07DA016	Joslyn Creek near Fort MacKay	257	1976 - 1992	15	0.0647
07DA009	Jackpine Creek near Fort MacKay	358	1976 - 1990	15	0.0027
07CD004	Hangingstone River at Fort McMurray	959	1978 -2001	11	-
07DA006	Steepbank River near Fort McMurray	1,320	1975 - 2000	19	0.0246
07CA005	Pine Creek near Grassland	1,450	1974 - 1997	17	-
07DA008	Muskeg River near Fort McKay	1,460	1976 - 1990	15	0.0016
07DB001	Mackay River near Fort Mackay	5,570	1975 - 1989	14	0.0175
07DC001	Firebag River near the Mouth	5,990	1966 - 1990	21	0.0114
06AD006	Beaver River at Cold Lake Reserve	14,500	1975 - 1997	18	-
07CD001	Clearwater River at Draper	30,800	1966 - 1990	21	0.0219
07DA001	Athabasca River below McMurray	133,000	1967 - 1972	6	0.159

[1] Poplar Creek sediment data prior to diversion of flow from Beaver River

[2] Annual sediment yield values taken from Golder, 2002

6.11 Impact Assessment and Mitigation Measures

6.11.1 Land Use and Disturbance Area

Figure 6.8-1 presents an overview of the footprint of the proposed Project within the North American lease area overlain with local watershed boundaries. A detailed description of the Project facilities is provided in Volume 1, Section 3; however, Table 6.11-1 summarizes the disturbance (both existing and proposed) to sub-watersheds by area and percent. Existing disturbance includes burned and logged areas and linear corridors such as roads. Proposed land disturbance includes those facilities, amenities and works that exist within the Project footprint, such as new roads, well pads, pipelines and central plant facilities. A more detailed list of Project components that may potentially affect the hydrologic conditions within the LSA are as follows:

- Central processing facilities (CPF) consisting of plant sites, buildings, storage and stockpile areas. Each CPF is approximately 800 m by 550 m, which includes the operational CPF, and construction lay down areas.

- Well pads and CPFs will be connected by roads, and above ground and below ground pipelines. Connector areas (Table 6.11-1) also include transmission lines and underground pipelines. Rights-of-way widths are set at 20 m for roads, 30 m for aboveground pipelines and 40 m for sales/diluent pipelines. Roadside ditches will collect and contain local road runoff.

- Well pads dimensions range from approximately 80 m by 75 m for source and disposal wells to approximately 300 m by 160 m for multi-well pads.

- Borrow areas will be located in topographic mounds so that depressions will not be created.
- New access road watercourse crossings are required and include crossings of the Christina River mainstem.

The total area of existing baseline surface disturbance is estimated at 21,491 ha (Table 6.11-1), which is approximately 5% of the total LSA (434,184 ha). Existing disturbance includes land clearing from burns, logging, seismic lines, permanent roads, and trails. The highest levels of disturbance are in the Pony Creek (15%) and May River (16%) sub-watersheds, attributed primarily to wildfires. Other sub-watersheds are 9.8% or less disturbed. The disturbance values in Table 6.11-1 are considered conservative as they do not reflect the amount of hydrologic recovery from planting or natural regeneration that would effectively reduce hydrologic impact.

Surface disturbances attributed to the Project from proposed works (i.e., linear connectors, camps, central plant facilities, and wells) totals 3,030 ha. This includes modification of existing disturbance, for example, widening of an existing road. Regardless, the footprint disturbance area corresponds to approximately 0.7% of the total LSA area. The proposed disturbance in sub-basins ranges from 0.08% in the Waddell Creek sub-basin, to a maximum of 1.1% in the Christina River Residual and the Pony Creek watersheds. Ninety-four percent of Project disturbance is located in the Christina River watershed; the remaining 6% is split between the Hangingstone River and House River watersheds. The incremental disturbance area, attributable to the Project (less than 1%), represents a negligible overall effect on the hydrology of the LSA. Therefore, potential hydrologic impacts attributable to the Project are anticipated to be localized.

Table 6.11-1 Existing and Proposed Project Disturbance Area

		Existing Disturbance[1]		Proposed Disturbance[2] (North American Footprint)		Existing plus Proposed Disturbance (Existing + North American Footprint)	
Sub-Watershed Name	**Sub-watershed Area**	**Area**	**As Percent of Sub-watershed**	**Area**	**As Percent of Sub-watershed**	**Area**	**As percent of Sub-watershed**
	ha	**ha**	**%**	**ha**	**%**	**ha**	**%**
Christina River Residual	129,273	1,520	1.18	1,371	1.06	2,891	2.24
East Tributary	36,795	365	0.99	346	0.94	711	1.93
Hangingstone River	14,435	5	0.04	102	0.71	107	0.74
House River	16,753	20	0.12	78	0.46	97	0.58
Kettle River	29,978	1,363	4.55	29	0.10	1,393	4.65
May River	65,749	10,583	16.10	91	0.14	10,674	16.23
Pony Creek	26,877	3,954	14.71	284	1.06	4,238	15.77
Waddell Creek	36,437	2,742	7.53	29	0.08	2,771	7.61
West Tributary	71,147	279	0.39	700	0.98	979	1.38
Christina Face Unit	6,740	659	9.78	0	0.00	659	9.78
Total	**434,184**	**21,491**	**4.95**	**3,030**	**0.70**	**24,521**	**5.65**

1. Includes the following: burns, logging, seismic lines, permanent roads and trails.

2. Includes linear connectors (sum total of ROW clearing for all roads, well pads, and pipelines), central plant facilities (CPFs) camps & borrow areas. Wells include source and disposal wells and SAGD well pads.

6.11.2 Water Use

Surface water use for the Project will be minimal and restricted to short-term tanker truck withdrawals for construction, drilling and dust control. These uses will be individually reviewed and permitted.

The principal water used for operations will be sourced from the Lower Grand Rapids Aquifer, Basal McMurray Aquifer, and the Clearwater A and B Aquifers. Disposal will be to the Basal McMurray aquifer. These aquifers are located approximately 250 m to 350 m below the surface.

The estimated water demand for the Project will vary temporally; lowest at the start up in 2010 (950 m^3/d), ramping up to a peak in 2029 (12,440 m^3/d) and then ramping down towards Project end in 2053 (Volume 3, Section 5). The water withdrawal from the Basal McMurray aquifer is balanced by water disposal.

Groundwater diversion applications will be made for potable water (for consumption, washing, toilets, and emergency showers) to be supplied by the potable water supply system. Utility water (for pump seals, plant maintenance, etc.) will also be provided by these groundwater wells. Current licensed groundwater for potable use at North American camps is 74 m^3/d.

Groundwater withdrawal, required to supply water to the steam generation facilities, may impact surface water due to the hydraulic connection that exists between the source aquifers and surficial aquifers and waterbodies. As discussed in Volume 3, Section 5.6.3, this is estimated to result in a maximum change in flux at the surface (i.e., drawdown effect of induced groundwater recharge) of 0.5 mm/y during the maximum water demand period. In comparison to surface flows, the estimated maximum surface flux is less than 1% of the mean annual flow of the Christina River near Chard. This will likely have no detectable impact on LSA surface water levels.

Management of solid and liquid waste, including sewage, will follow the practices and procedures identified in EUB Directive 58, with the intent to reduce waste and prevent soil and groundwater contamination. Because waste generation will be controlled and tracked, and waste receiving facilities will be monitored, no effects are expected on surface water hydrology.

6.11.3 Other Subsurface Operations

Differential surface ground heave as a result of SAGD operations is not expected to impact surface waterbodies or surface flow. Maximum heave is at the centre of a well pattern and tapers off to virtually no ground movement beyond the perimeter of the well pattern. Because any heave is expected to occur gradually over a 10+ year lifetime of the wells, the existing natural surface drainage pattern should adapt to these changes and no substantial shifts in drainage courses or sub-basin boundaries are expected.

The disposal of waste water into the Basal McMurray aquifer is proposed. This aquifer is over 450 m below the surface and well below the base of groundwater protection. Evaluations in Volume 3, Section 5 indicate that the potential for lateral and vertical migration is negligible.

6.11.4 Surface Facilities

Project facilities that have the potential to affect surface water hydrology include the plant site and camp areas, roads and pipelines, and the various well pads. These facilities may affect near-surface water tables, flows and water levels in receiving streams, water levels in lakes and wetlands, as well as increase sediment loads in receiving streams and waterbodies. Underlying mechanisms are described below:

- The compacted surfaces of plant site and camp areas, well pads and access roads will be less permeable than natural surfaces, and will result in higher volumes of water runoff from these areas than occurs under natural conditions.

- Compaction of wetland/bog areas may result in blockage between surface and near-surface flows. This may result in the localized raising of the near-surface water table, modification or blockage of sub-surface flow paths, increasing evaporation losses, and blockage or retardation of downstream surface flows.

- Grading and earthworks associated with plant site, road, pipeline, and well pad construction have the potential to interrupt local drainage patterns, increase local runoff and potentially increase sediment loads. Disturbed areas during construction may also result in local erosion and increased sediment loads.

The sections that follow describe surface water mitigation controls that will be in place for the various facilities associated with the Project.

6.11.4.1 Well Pad and Plant Runoff Controls

The topography over much of the Project area consists of low-lying terrain (e.g., bog and fen); however, plant sites will be located at areas of higher ground for increased stability. Field facilities will also utilize existing disturbed/cleared sites or share corridors to minimize site disturbance.

Well pad and plant storm water retention pond design, operating concepts, and other mitigation measures are as follows:

- Drainage management plans will be developed that address the containment of surface runoff and potential contaminant release. All stormwater runoff from pad/plant areas will be collected, tested, and if suitable, released into the surrounding environment. Runoff not suitable for release will either be recycled or sent for proper disposal. Retention ponds should be designed to fully retain the 1:25 year, 24-hour storm event (equivalent to 77 mm based on the rainfall intensity duration frequency curves for the LSA).

- Runoff, for the well pad ponds, is estimated to be 33% to 66% higher than natural watershed runoff rates, which typically range between 39 mm and 95 mm (Table 6.8-1). However, delayed and controlled releases from the ponds to the surrounding forest will occur, and the ponds are not directly hydraulically connected to waterbodies (streams or lakes); rather, pond release is dispersed over an open, low gradient slope. Therefore, the actual volume of runoff that may reach a defined watercourse may be comparable to natural conditions. In low flow periods, the net runoff may be reduced slightly due to higher evaporative losses or from ground infiltration, although fall or early winter releases to drain the ponds may be locally beneficial in dry years. In wet years, there may be slightly more runoff with more frequent releases and less opportunity for downstream losses due to saturated ground conditions, thus, more direct local flow paths to streams may develop. In both dry and wet years, the delayed release effect of the ponds may be considered beneficial by either extending low flow or reducing peak events in the watersheds. In terms of magnitude, the net effect of a typical pond operation might be considered similar to the effects of a small beaver dam.

6.11.4.2 Roads and Corridors

Corridor ROWs will typically consist of a compacted gravel road surface for a portion of the overall width (e.g., up to 25%), with side ditches and elevated pipelines and powerlines located in cleared yet vegetated areas. Increased runoff is anticipated over the road surfaces, with flow directed into ditches, then into cross-drains or culverts. There may also be slightly reduced evapotranspiration and therefore, slightly higher runoff from the cleared areas adjacent to roads. The net effect will be an advance in runoff from the roads, and an overall increase (estimated at 10% to 15%) in runoff from the ROWs.

Surface flow changes, as a result of roads, will be highly localized. Drainage patterns will be maintained with appropriately spaced culverts. Erosion and sediment controls will be applied (e.g., seeding of cut banks, sediment traps) to minimize sediment delivery to channels.

Specific protective measures at watercourse crossings are presented below.

Watercourse Crossings

Based on the Project footprint, there will be numerous watercourse or wetland/ephemeral draw crossings to provide access to well pads. The access road crossings will be designed and installed in accordance with AENV's *Code of Practice for Watercourse Crossings* (AENV, 2007a) under the *Water Act* and the federal *Fisheries and Navigable Waters Protection Act*, where appropriate. Crossing designs will meet legislative requirements and all appropriate provincial and federal authorizations will be obtained.

Watercourses will be crossed with culverts or bridges depending on stream width and class. Smaller waterbodies and wetlands crossings will be minor crossings that may not be flowing or not have defined channels and typical culvert installations or rock drains may be adequate. Culverts and/or rock drains will be provided at local drainage lows and wetlands. Instream structures will be designed to facilitate fish passage at fish bearing streams. Depending upon final routing and construction staging it may be possible to reduce the number of crossings.

Minimizing the amount and duration of instream work, conducting the work at low or no flow periods, and separating the work site from flowing water will result in minimal disturbance of the watercourse during construction. An erosion and sediment control plan will be developed and implemented for all watercourse crossings prior to construction. This is designed to minimize sediment generated by surface water runoff from newly excavated approach slopes and disturbed bank areas. Water and sediment control management practices may include use of silt fencing around disturbed areas, localized armouring, re-establishment of vegetative cover as soon as practical, and directing local road runoff away from watercourses into adjacent vegetation.

Any defined watercourse pipeline crossing will be installed in accordance with AENV's Code of Practice under the Water Act (AENV, 2007b) and the Fisheries and Oceans Canada (DFO) Operational Position Statement for pipeline crossings (DFO, 2006). For aboveground pipelines, clear spans on piles will be used with adequate clearance provided above the 100-year flood level or maximum expected beaver dam flood levels. Any buried crossings will use either trenchless or flow isolation methods. The method selected will be that considered most appropriate according to fisheries habitat considerations and flow conditions at the time of construction.

Watercourse crossings will be constructed as per AENV's Code of Practice. This will minimize the potential for sedimentation and channel alteration. With appropriate best management practices employed during construction, crossings are predicted to have low environmental consequences on suspended sediment levels in receiving waterbodies and watercourses during the construction and restoration periods. Therefore, impacts from watercourse crossings are anticipated to be negligible.

Other Facilities

Other facilities associated with the Project include borrow areas, gravel pits, sumps, and well sites for groundwater supply and disposal wells. These sites will be graded and bermed, or comprise low areas to contain local runoff. These areas may, therefore, result in reduced local runoff effects. Other plant facilities such as camps, offices, laydown areas and parking lots will have increased runoff. Runoff from these areas will be contained and tested before being discharged to stable low gradient areas. Together, these areas are expected to have a negligible net basin wide effect on runoff conditions.

6.11.5 Summary of Project-related Impacts

The combined hydrologic effects of the associated Project facilities were assessed for the major sub-watersheds potentially affected by the Project. Almost half (45%) of the Project footprint, in terms of total area, is concentrated in the Christina River Residual sub-watershed, primarily on the west side of the Christina River mainstem. The 380 ha of proposed linear connectors, pads, camps, and borrow areas are distributed on gentle slopes that drain by way of small streams or sub-surface pathways dispersed over a 30 km section of the Christina River. As a result of these variable and distributed processes, no measurable change in flow is anticipated for the Christina River that is associated with the Project footprint.

Similar low impacts to surface water flows are anticipated in the other sub-watersheds where facilities are located. Any changes in runoff will be localized and below detection levels at the sub-watershed scale. This is considering that:

- Streamflow measurement accuracy, using standard methods, is plus or minus 3% for a good location and typically greater than plus or minus 5% at gauging stations in this region.
- There is substantial natural variability in annual runoff. For the Christina River watershed near Chard, the maximum seasonal runoff is over 11 times greater than the minimum (230 mm in 1996, versus 20 mm in 1999).
- Hydraulic channel characteristics determine the magnitude of impact of a flow change on flow depths, velocities and wetted perimeters (considerations in assessing impacts on aquatic resources). In narrow confined streams, water levels and velocities can change dramatically in response to changes in flow. However, in streams with wide floodplains or wetlands (streams that are typical over large portions of the Project area), water levels and velocities change little in response to flow changes. Beaver dams or wide stream channels result in minimal water level changes for a wide range of flows. Impacts on water levels and flow velocities will not be detectable due to these variable characteristics.

6.11.6 Cumulative Effects Assessment

Cumulative Effects Assessment (CEA) considers the effects of the Project in addition to existing, approved, and planned developments and activities within the RSA. Two approved projects are located near Christina Lake in the RSA. Minimal increased runoff (e.g. 1% to 2%) is predicted from developed areas at the Jackfish Phase 2 Project (Devon, 2006) and the Christina Lake

Project (MEG, 2005). There are currently no project footprints that have been publicly disclosed within the Project's LSA.

Water table drawdown is predicted to be not detectable from the Project in any area of the RSA or LSA. Measurable water table drawdown is anticipated northeast of the LSA in the lower reaches of the Christina River from two approved EIA projects (Nexen/OPTI 2003 and 2006 provide details on impacts of each project). However, the Project is not anticipated to affect the amount of drawdown attributed to the Nexen/OPTI projects.

Based on the above information, the Project is predicted to have negligible impacts on flows, water levels and drainage patterns of rivers, streams and waterbodies in the LSA and RSA.

6.12 Mitigation and Monitoring

6.12.1 Mitigation

The following mitigation measures will be implemented, as part of the surface water management plan, to minimize potential changes to water levels, flows, erosion potential, and sediment loading to receiving streams and waterbodies:

- Industrial runoff management facilities consisting of local retention areas, berms and drainage ditches will be utilized to collect and contain surface water runoff from the plant site and well pad areas. These will be designed, as previously described, to allow for full containment and use of runoff water along with controlled releases from well pad areas (after water quality sampling indicates the water is suitable for release). Providing releases late in the year could be considered to augment low flow conditions.

- Well pads will be set back at least 100 m from waterbodies, where possible, to minimize potential disturbance to riparian conditions and impacts on local flow patterns. This will also provide an area for dispersion of stormwater releases from pads prior to discharging water to any natural waterbodies.

- Potential erosion concerns will be minimized due to the natural low gradient terrain of the area. Cut and fills are expected to be used to minimize site disturbance areas, maintain stable slopes and balance material use.

- Culverts will be installed at defined watercourse crossings, ephemeral drainages and low points along road alignments. The culverts will be designed and installed to eliminate potential flow restrictions, maintain natural drainage patterns and maintain balanced water levels on both sides of a road, especially in wetland areas where the water table is typically at or near the surface. This will minimize potential ponding or drying of wetlands areas. Culverts and ditch checks will also be provided for long sloping road sections, where appropriate.

- In most cases, a minimum culvert size of 500 mm will be used. Although larger than required in many instances, it reduces the potential for blockage due to ice, sediment, beaver activities, and vegetation.

- The 1:25 year peak discharge water level should not exceed the crown of the culvert. This capacity should also allow for partial blockage by vegetation or sediment where culverts are installed in a wetland environment.

- In places where the water table is close to the surface (e.g., peatlands), culverts will be installed to maintain equal water levels and natural drainage on both sides of the road to reduce excessive ponding or drying of muskeg and wetland areas. Rock drains may be used in areas with extensive peatlands and depths of over 1.5 m.

- Roads and pipelines that extend to the well pads, will be routed along common corridors to reduce surface disturbance.

- Best management practices will be used to reduce erosion potential and provide runoff control during construction of the plant site, roads, drainage ditches, and pipelines. This will include: appropriate planning, scheduling and layout of works, installation of sediment/runoff retention structures (e.g., silt fences), and incorporation of bio-technical erosion control measures (i.e., maintaining buffers and minimizing disturbances in the vicinity of streams).

- Sub-grade construction in areas of wetland areas will be scheduled to occur during frozen ground conditions, typically following fall clearing, where practical. This will permit access, ensure that confined and controlled excavation/stripping of peat soils can be achieved, and minimize the extent of surficial soil compaction during construction.

- The plant sites and well pads will be reclaimed, as soon as practical following decommissioning, through grading and re-vegetation to restore natural drainage patterns. Further details on reclamation are provided in Volume 1, Section 8 (Conservation and Reclamation). All road crossing culverts will be removed and natural drainage patterns and runoff conditions restored.

6.12.2 Monitoring

Project operations will include implementation of a surface water monitoring program and remedial maintenance where and when required. This program will continue until Project decommissioning activities have ceased. The program will include the following:

- Regular monitoring of stormwater ponds to ensure adequate available storage capacity and prevent uncontrolled releases from the plant site and well pad drainage systems. Annual inspections of the downstream drainage path, resulting from any releases, will occur to ensure that the terrain is absorbing water with no effect on the surrounding vegetation and that no downstream channel development or erosion is occurring. If required, remedial measures such as re-directing the drainage, spray irrigation, the incorporation of bio-technical erosion control measures, or revegetation efforts would be employed to correct potential areas of concern before they become a problem.

- Culvert installations at road crossings will be monitored, on a regular basis, during or following high runoff periods and at spring break-up. Any constricting sediment or debris accumulation or excessive ice build-up will be removed to maintain the flow capacity of the culvert. Any excessive settlement of a culvert will be corrected to maintain flow patterns. Screens may be added to culvert inlets to prevent blockage in areas of potential beaver activity.

- In wetland areas, water levels on either side of access roads will be monitored to ensure that they remain equal. If required, larger or additional culverts or rock drains will be installed.

- Re-graded areas will be inspected for evidence of erosion or instability, and repaired or stabilized as required. Re-vegetation efforts will be monitored and maintained to ensure growth and survival. Re-planting will occur if survival of vegetation is inadequate.

- Drainage courses disturbed during construction will be inspected to ensure that riparian vegetation and stable drainage conditions have been re-established.

- Streamflows and lake levels were monitored at several locations as part of the EIA baseline program. Any necessary additional monitoring, including water levels will be conducted as needed.

6.13 Summary of Impacts

Implications of the hydrologic impacts for the Project are summarized in Table 6.13-1. Criteria ratings reflect a combination of qualitative and quantitative assessments as well as professional judgment.

Table 6.13-1 is designed to synthesize the predicted importance of Project effects and cumulative effects for various indicators (listed in the left column). Indicators are selected hydrologic parameters that serve to contribute to the assessment of hydrologic conditions. These indicators are then assessed against eight criteria, which rate the residual environmental effects (i.e., effects remaining after the application of mitigation measures). Each criteria rating has an influence on the next, beginning with the direction of impact and concluding with a final impact rating or environmental impact (far right column). Assigned ratings are discussed in the following paragraphs.

Potential changes to the surface water hydrology in the LSA from the Project will be highly localized and mitigated with a series of measures. Non-detectable changes are, therefore, anticipated for the first three indicators (Table 6.13-1) in both the LSA and RSA as a result of the Project surface activities. For this reason, the direction of impact is rated as neutral, as there would be neither a net benefit nor net loss to the water resource for the those indicators. The extent of impact is sub-regional as it refers to the sub-watershed scale. Since there is no discernible contribution of the Project to flows and water levels in streams and waterbodies, the magnitude of impact is rated as negligible. However, there may be some localized drainage and flow effects attributable to the construction of Project facilities, hence the duration of impacts is rated as short-term. Short-term is considered to be a time period of less than one year, and more likely on the order of hours or days. These localized impacts will be isolated in terms of where and how often the effect will occur, and will be dependent on the type of works, and local topography and drainage conditions. Effects are rated as reversible in the short-term (i.e., less than one year) due to the implementation of the mitigation measures previously discussed. These mitigation measures are common and well known; therefore, the level of confidence is high. The integration of the various ratings results in a final ‘no impact’ rating for environmental impact criteria.

The direction of impact is negative for the erosion and sedimentation in local waterbodies indicator based on the possibility of sediment introduced to waterbodies from construction activities. Negligible changes in long-term averages or variations in basin sediment yields and sediment concentrations are anticipated as a result of Project construction and operation, although localized increases in erosion and sedimentation are possible at crossings. The impact of sedimentation is expected to be short-term and localized and cause no detectable change to the water resource. The final environmental impact rating is low impact in recognition of the possibility of some sediment entering streams.

The effect of Project groundwater withdrawals from the Lower Grande Rapids, Clearwater and Basal McMurray aquifers on surface flows is expected to be minor and not detectable. The conclusion is that the Project will not substantially contribute to cumulative hydrologic effects on nearby rivers, streams and lakes.

Table 6.13-1 Hydrologic Ratings for Project Indicators

Indicators	Direction	Extent	Magnitude	Duration	Frequency of Occurrence	Permanence	Level of Confidence	Final Impact Rating
Changes in water levels in local waterbodies	Neutral	Sub-regional	Negligible	Short-term	Isolated	Reversible in the short-term	High	No impact
Changes in flow in local waterbodies	Neutral	Sub-regional	Negligible	Short-term	Isolated	Reversible in the short-term	High	No impact
Water level and flow changes from drainage patterns changes	Neutral	Sub-regional	Negligible	Short-term	Isolated	Reversible in the short-term	High	No impact
Erosion and sedimentation in local waterbodies	Negative	Sub-regional	Low	Short-term	Occasional	Reversible in the short-term	High	Low impact

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TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

7 SURFACE WATER QUALITY

7.1 Introduction

The surface water quality section considers watercourses and waterbodies that may be affected by the Project. For the Project, watercourses and waterbodies are defined as per AENV:

> Any permanent or intermittent surface water body supporting an aquatic and terrestrial environment (including soil types, plant and animal species) (e.g. slough/marsh wetlands, alkali sloughs, prairie potholes, shallow open water, ephemeral wetlands, bogs, fens, lakes, peat lands, oxbows, swamps, muskeg, water courses) and a water body created solely as a compensatory wetland as a mitigative measure due to the loss or destruction of a previous natural surface water body, or a wetland control project (AENV, 2001).

Surface water chemistry was assessed for waterbodies and watercourses in the LSA. For the purposes of this report, peat lands, bogs and fens were excluded because they are not easily recognized as having “surface water.” Waters in these landforms may be sub-surface and outside of the scope of the surface water quality assessment. Peat lands, bogs and fens are assessed in Volume 4, Section 10 (Vegetation).

Water quality data from historic sources and Project water quality sampling were used to characterize surface waters in the study areas (Section 7.5). The approach included characterization of the regional water quality by studying representative waterbodies and watercourses in the area. Assessments and predictions were based on this information, recognizing that unique locations may require additional site specific sampling to verify predictions as the Project develops.

The following provides the regional baseline characterization of water quality. Included is a description of the study areas, methods, results of the water quality sampling program and a summary of all available water quality data. Following the baseline characterization are assessments of potential future impacts and cumulative effects, plus discussions on future monitoring.

7.2 Study Areas

Two study areas were selected to document the baseline water conditions and assess the effects of the Project. The LSA encompasses all lease boundaries and proposed Project activities (Figure 7.2-1). A field program was conducted in the LSA to characterize water quality in the waterbodies and watercourses that may be directly or indirectly affected by Project activities. The RSA includes areas outside of the LSA where water quality may be indirectly (e.g., cumulative effects of the Project and nearby projects) affected by all activities associated with the Project (e.g., aerial deposition). Activities associated with the project vary in temporal scope. The temporal scope of the EIA reflects the timing and nature of the Project phases as well as information available on other proposed projects. Project and cumulative Project effects are assessed for the Construction, Operations, Decommissioning and Reclamation, and the Closure phases of the Project. Each phase is assessed at the peak of project activity. The timing of Project phases is:

- Construction - 2008 through 2016
- Operations - 2010 through 2050

- Decommission and Reclamation - progressive with final decommissioning in 2051 through 2053
- Closure - 2053

7.2.1 Local Study Area

The surface water and aquatic resources LSA was established to assess the potential for localized effects on surface water quality, hydrology and fish and fish habitat. The LSA boundaries were based on local drainage areas and watershed boundaries and include each of the Project lease areas. The LSA encompasses the waterbodies and watercourses that, due to location, have the potential to be directly affected by Project disturbance activities including development, operation and reclamation of pads, roads, pipelines, utilities, disposal wells and plant facilities.

The LSA is composed of portions of the Christina River, Hangingstone River and House River watersheds (Figure 7.2-1). The majority of the LSA is within the Christina River watershed. The mainstem of the Christina River initially flows south from its headwaters, then east and north towards the Clearwater River. Most of the Hangingstone and Thornbury leases and the entire Corner and Leismer leases are within the Christina River watershed. A portion in the north of the Hangingstone lease drains northwest to a tributary of the Hangingstone River. A small portion of the northwest corner of the Thornbury lease drains east and south into the headwaters of the House River watershed. The watersheds included in the LSA are further described in Volume 3, Section 6; Hydrology.

7.2.2 Regional Study Area

The areal extent upon which the cumulative effects of the Project will be assessed is based on the RSA. Beyond the RSA, there is expected to be negligible water resource impact attributable to the Project. Possible effects include changes to flows and water levels in regional rivers, lakes and streams, which can influence surface water quality. Consideration was given to locations potential for impacts to surface water/groundwater interactions exists. Also included are all waterbodies that may be affected by aerial deposition of acidifying emissions.

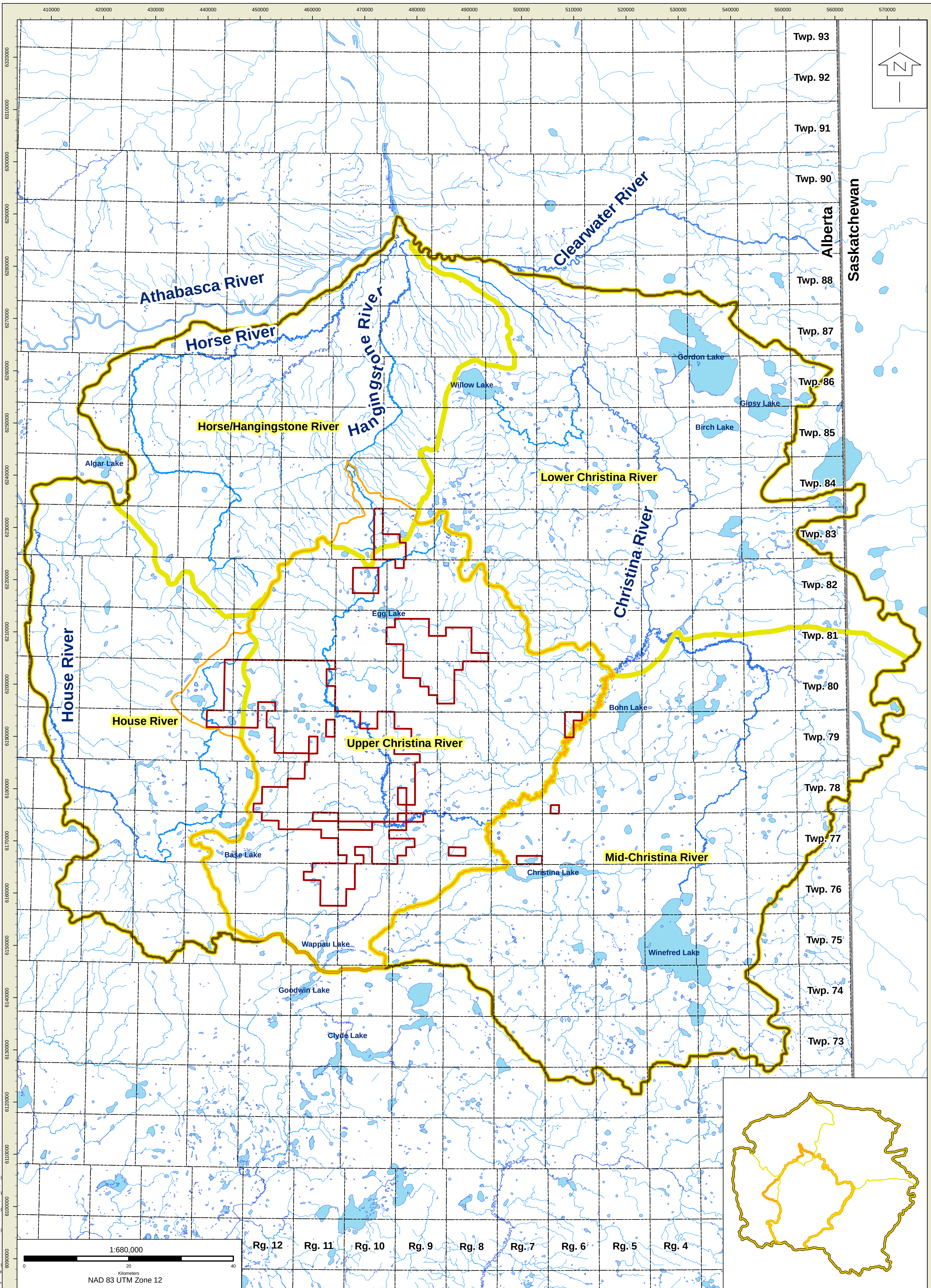
The Christina River watershed forms the south and east borders of the RSA boundary; the Horse River watershed defines the west and northwest limits, and a section of the Clearwater River is the northeast border. These watersheds are further described in Volume 3, Section 6.

The presence and availability of historic surface water quality from waterbodies and watercourses denoted how the RSA was organized into drainage basins (Figure 7.2-1). Smaller basins with few data points were combined with larger basins for ease of discussion. These five areas include:

- The Hangingstone and Horse River Basin (Figure 7.2-2);
- The House River Basin (Figure 7.2-3);
- The Upper Christina River Basin (upstream of Jackfish River and west of the mid-reaches of the Christina River; this includes most of the LSA) (Figure 7.2-4);
- The mid-reaches of the Christina River (the area west of the mid-reach of the Christina River and the Winifred River Basin) (Figure 7.2-5); and

- The lower portions of the Christina River basins (the Gregoire River and Gordon River basins, the lower section of the Clearwater River and a few minor tributaries of the lower Clearwater River) (Figure 7.2-6).

Potential effects associated with aerial deposition were assessed in an area encompassed by the 0.17 keg H^+/ha/y potential acid input isopleths from the air quality modelling (Volume 2, Section 2; Figure 7.2-7).



Project Location

Legend

- North American Lease Boundary
- Local Study Area
- Regional Study Area
- Watershed
- Lake
- Stream
- Alberta Boundary

Title:

SUB-BASINS WITHIN THE SURFACE WATER REGIONAL AND LOCAL STUDY AREAS

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:
Lyndsay Doetzel	May 15, 2007

File: Fig1_Sub-basins_Within_RSA_LSA_20070515.mxd

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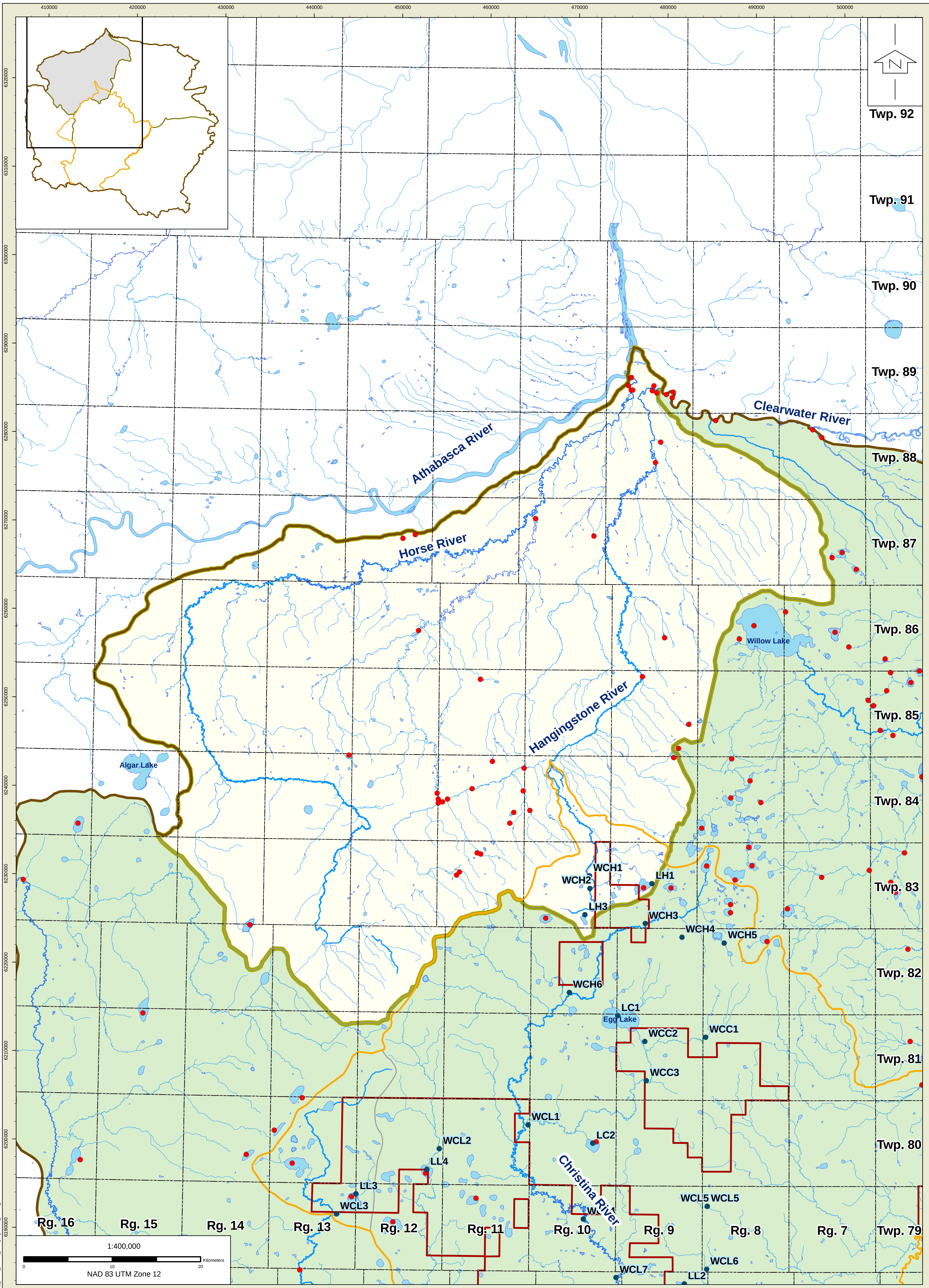

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Legend

- North American Lease Boundary
- Local Study Area
- Regional Study Area
- Watershed
- Project Water Quality Sites
- Historical Water Quality Sites
- Lake
- Stream

Title:

WATER QUALITY DATA SITES IN THE HORSE AND HANGINGSTONE BASIN

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:
Lyndsay Doetzel	May 14, 2007

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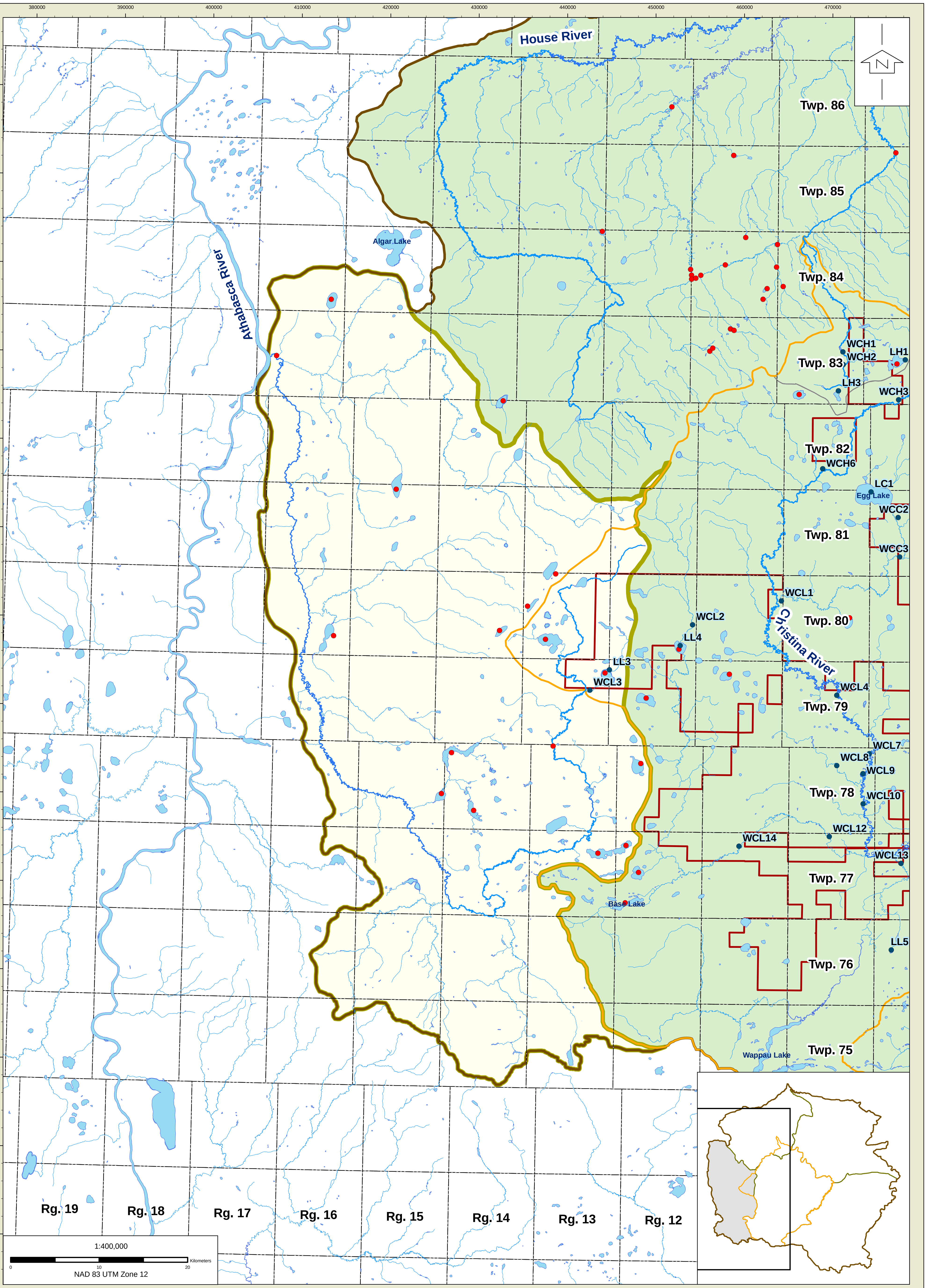

Legend

- North American Lease Boundary
- Local Study Area
- Regional Study Area
- Watershed
- Project Water Quality Sites
- Historical Water Quality Sites
- Lake
- Stream
- Alberta Boundary

Title:

WATER QUALITY DATA SITES IN THE HOUSE BASIN

NORTH AMERICAN OIL SANDS CORPORATION

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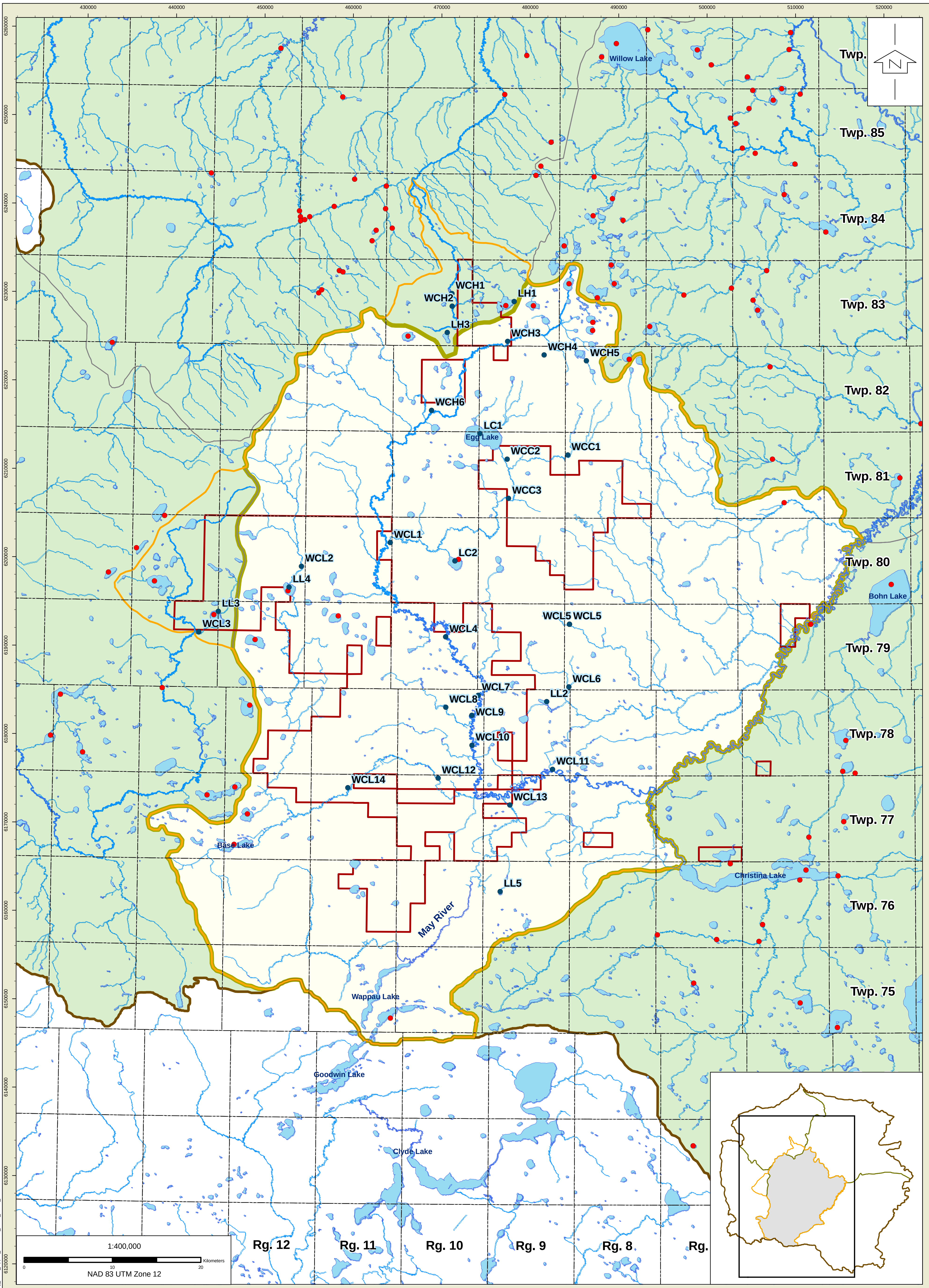

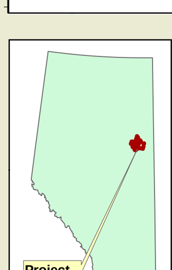

Legend

- North American Lease Boundary
- Local Study Area
- Regional Study Area
- Watershed
- Project Water Quality Sites
- Historical Water Quality Sites
- Lake
- Stream

Title:

WATER QUALITY DATA SITES IN THE UPPER CHRISTINA RIVER BASIN

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:	
Lyndsay Doetzel	May 14, 2007	
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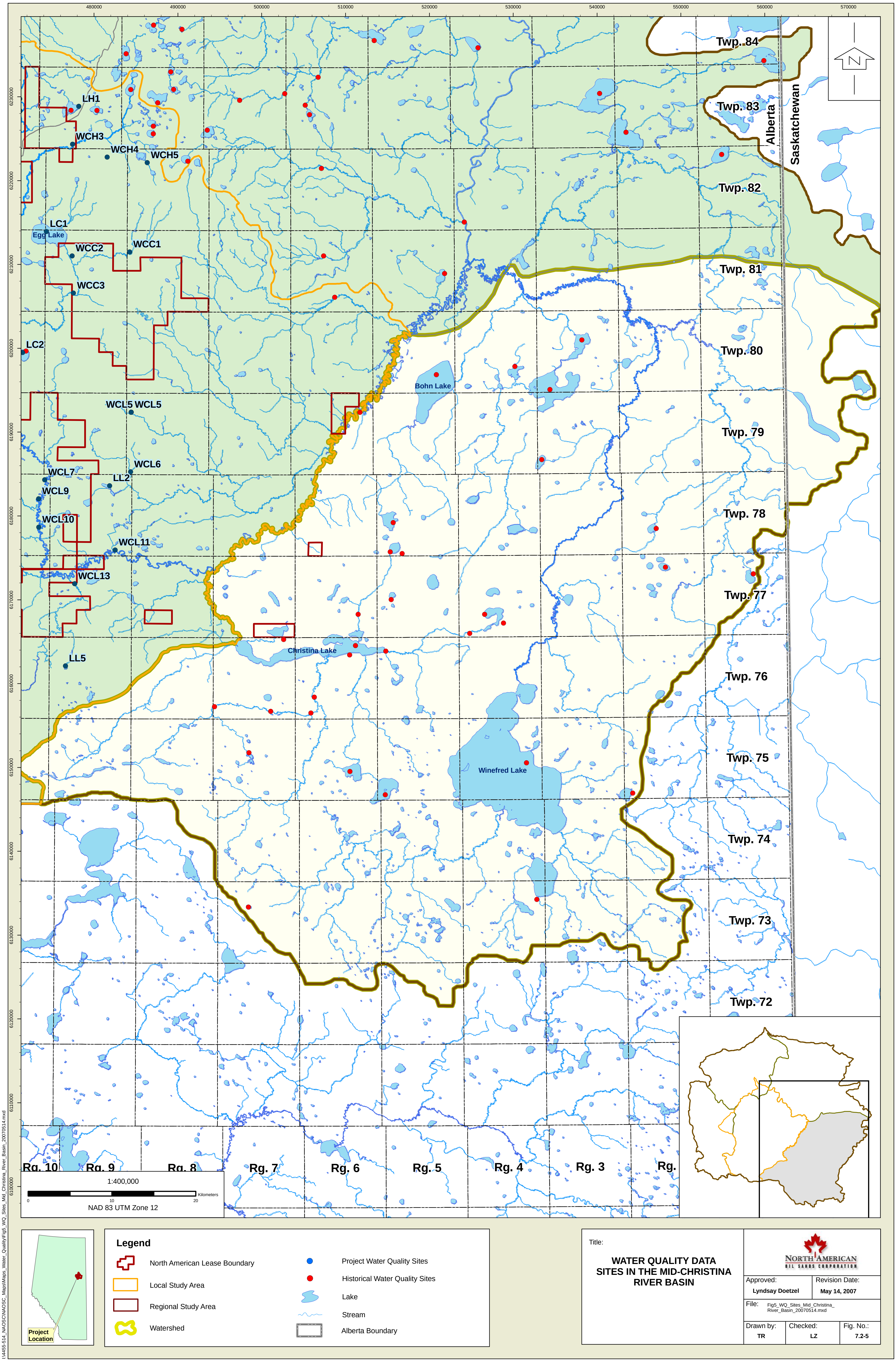

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Twp. 73
Twp. 72
Rg. 10
Rg. 9
Rg. 8
Rg. 7
Rg. 6
Rg. 5
Rg. 4
Rg. 3
Rg.
Alberta
Saskatchewan
N
LH1
WCH3
WCH4
WCH5
LC1
Egg Lake
WCC1
WCC2
WCC3
LC2
WCL5 WCL5
WCL6
WCL7
LL2
WCL9
WCL10
WCL11
WCL13
LL5
Bohn Lake
Christina Lake
Winefred Lake
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NAD 83 UTM Zone 12
Project Location
Legend
North American Lease Boundary
Local Study Area
Regional Study Area
Watershed
Project Water Quality Sites
Historical Water Quality Sites
Lake
Stream
Alberta Boundary
Title:
WATER QUALITY DATA SITES IN THE MID-CHRISTINA RIVER BASIN
NORTH AMERICAN OIL SANDS CORPORATION
Approved: Lyndsay Doetzel
Revision Date: May 14, 2007
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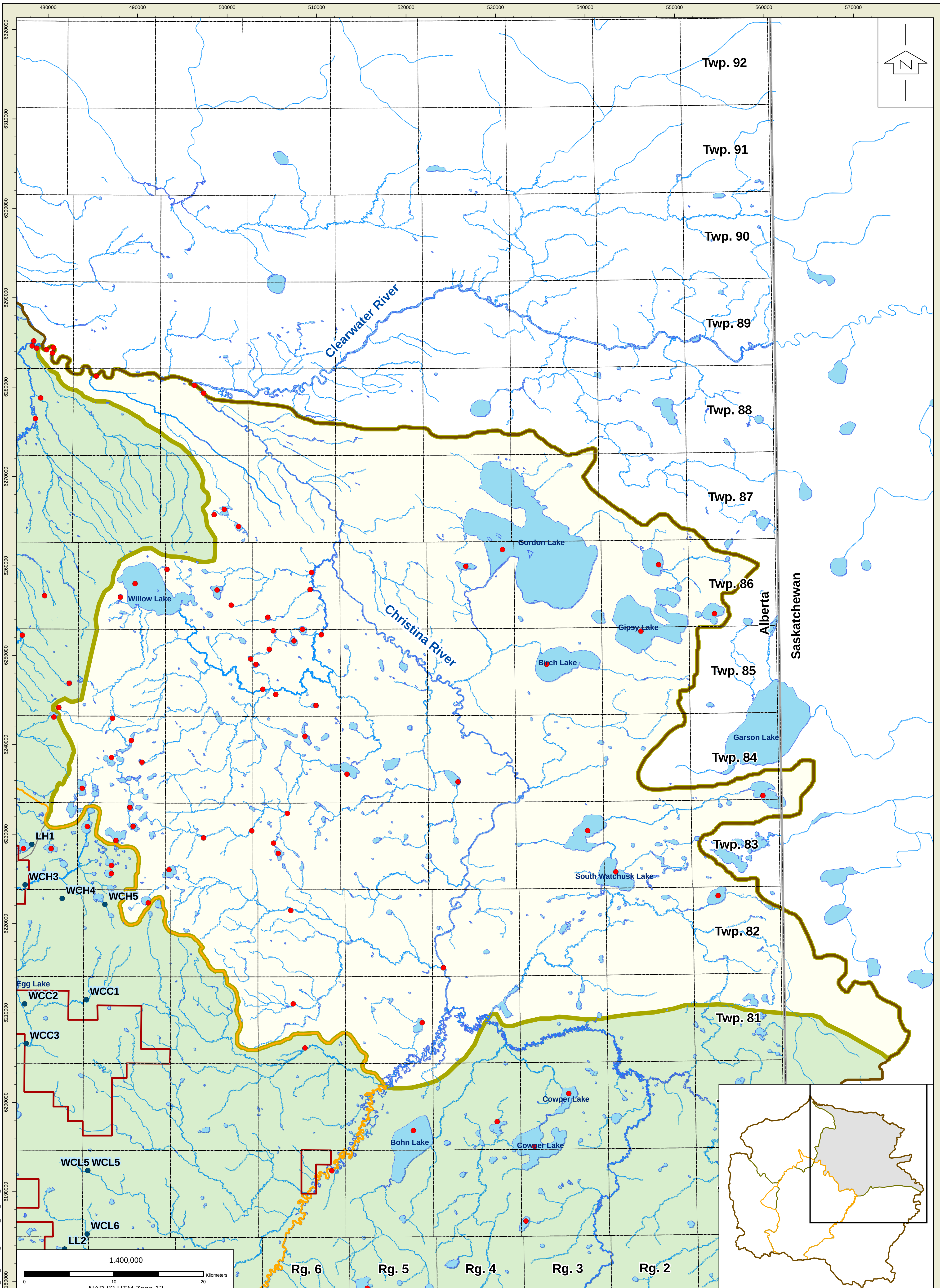

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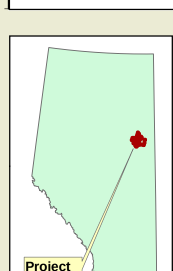

Legend

- North American Lease Boundary
- Local Study Area
- Regional Study Area
- Watershed
- Project Water Quality Sites
- Historical Water Quality Sites
- Lake
- Stream
- Alberta Boundary

Title:

WATER QUALITY DATA SITES IN THE LOWER CHRISTINA AND CLEARWATER RIVER BASIN

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:
Lyndsay Doetzel	May 15, 2007

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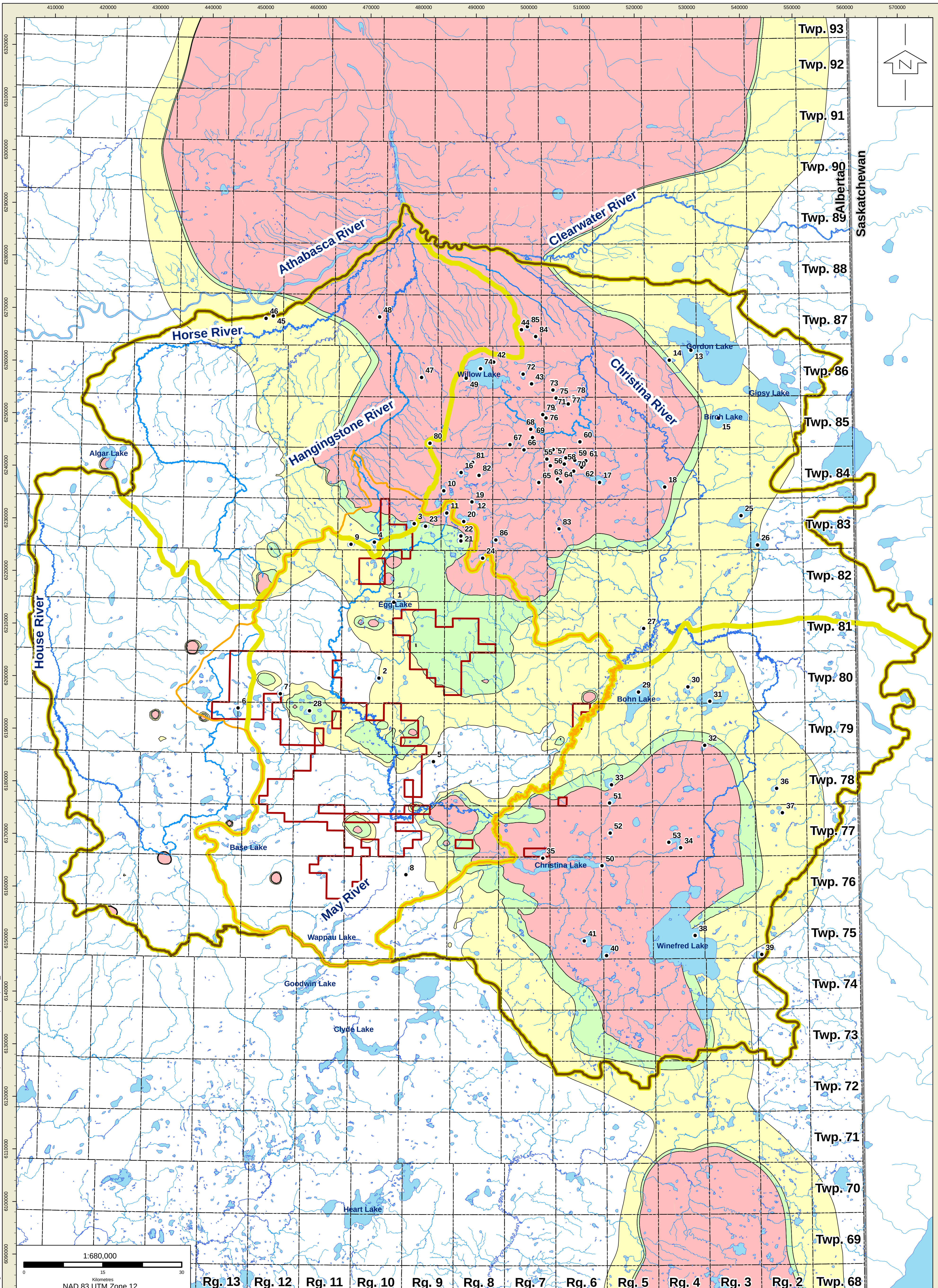

Legend

- North American Lease Boundary
- Local Study Area
- Regional Study Area
- Watershed
- Lake
- Stream
- Alberta Boundary
- 0.17 keq H^{+}-ha^{-1}y^{-1} PAI (under Baseline Scenario)
- 0.17 keq H^{+}-ha^{-1}y^{-1} PAI (under Application Scenario)
- 0.17 keq H^{+}-ha^{-1}y^{-1} PAI (under Cumulative Scenario)
- Waterbody ID (See table 7.5-4 for Description)

Project Location

Title:
WATERBODIES WITH CRITICAL LOAD CALCULATIONS LOCATED IN THE RSA

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:
Darrel Jobson	May 15, 2007

File: Fig 7.5-13 Waterbodies with Critical Load Calculations Located in the 0.17 keq H+Potential Acid Input Isopleth_20070504.mxd

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I:\4455-514_NAOSC\NAOSC_Maps\Maps_Water_Quality\Fig 7.5-13 Waterbodies with Critical Load Calculations Located in the 0.17 keq H+Potential Acid Input Isopleth_20070515.mxd

7.3 Issues and Assessment Criteria

Activities associated with construction, operation and reclamation of the Project may result in changes to the surface water quality in watercourses and waterbodies within the local and regional study areas. Potential effects to surface water quality from SAGD developments have been identified based on public and regulatory consultation, professional experience and anecdotal experience at other SAGD developments in the oil sands area including:

- Potential water quality changes from the release of sediments during construction and operations (land-clearing, runoff, stream crossings, etc., assessed in Volume 3, Section 6);
- Potential water quality changes from the release of process-related chemicals (accidental spills or direct discharges);
- Potential water quality changes due to changes to surface water flows;
- Potential water quality changes due to reduced surface water levels (drawdown effects); and
- Potential changes in water quality due to deposition of acidifying emissions.

Changes in water quality that may occur from the identified issues were assessed according to assessment criteria (Volume 2, Section 1). These criteria provide a framework to predict or measure environmental effects on various indicators. Two components of the criteria were slightly modified to address unique water quality characteristics and are further defined as follows:

- **Direction** describes any net benefit, net loss or net balance to water quality, as result of the impact. The direction is classified as either a positive, neutral or negative effect.
- **Extent** describes the area within which the effect occurs. It is classified as local (within a localized area of the watershed such as a stream reach or individual waterbody), sub-regional (within a given sub-basin), regional (within the RSA), or extra-regional (effect extends beyond the RSA) effect.

Scientific thresholds and established/accepted protective standards mentioned in the criteria refer to the following:

- Surface Water Quality Guidelines for Use in Alberta (AENV, 1999);
- Canadian Environmental Quality Guidelines (CCME, 1999, updated 2001, 2002); and
- Application of Critical, Target and Monitoring Loads for the Evaluation and Management of Acid Deposition (CASA, 1999).

7.4 Methods

This section outlines the methods used to characterize water quality in the study areas including data quality assurance methods, field sampling methods and data summary methods.

7.4.1 Historic Data

Sources of historic water quality data in the area included:

- AENV Water Data System (WDS), 2004
- Devon Jackfish EIA, 2003
- JACOS Project EIA, unpublished, Golder 2002
- MEG Christina Lake Project EIA, 2005
- OPTI Canada Inc. Long Lake EIA, 2000
- Nexen Inc. and OPTI Canada Inc. Long Lake South EIA, 2006
- Hatfield, 2006
- Petro-Canada Meadow Creek Project EIA, 2001
- Regional Aquatics Monitoring Program (RAMP), 2000, 2002, and 2004 data
- Gulf Canada Resources Surmont Project EIA, 2001
- Erickson, 1987
- Western Resource Solutions (WRS), 2000 and 2004

Any necessary conversions were made where data was presented in units other than those used in this water quality assessment. Alkalinity data, in some sources including WRS 2000 and 2004, and Erickson (1987), was reported in ueq/L. These data were converted to mg/L using the formula (Hounslow, 1995):

$$\text{meq/L } CaCO_3 = \frac{\text{mg/L } CaCO_3}{50}$$

where 50 is the equivalent weight of $CaCO_3$.

7.4.2 Project Water Quality Field Program

The field program was designed to collect data to characterize water quality in waterbodies and watercourses on and around the Project lease areas. Sampling sites off of the lease areas were selected to collect baseline data for locations that may be influenced by potential downstream effects from the Project. This includes the transportation of potential contaminants through watercourses from lease areas, or downwind aerial deposition of contaminants in waterbodies.

The field program consisted of five trips, in 2005 and 2006, to the Project study area. All seasons were represented in the sampling program. The surface water sampling sites generally correspond to sites used in the Fish and Fish Habitat component of the EIA (Volume 3, Section 8). The site coordinates and sampling dates are summarized in Table 7.4-1. The location of each sampling site, including samples taken as part of the Project water sampling program, and historic data sampling locations are shown in Figures 7.2-1 to 7.2-6.

Field water quality parameters were collected in. These included water temperature, electrical conductance (EC), pH, and dissolved oxygen (DO). The laboratory parameters are summarized below:

- Routine Parameters
  - Conductivity, pH, Total Dissolved Solids (TDS), Major Cations (Sodium, Potassium, Calcium, Magnesium), Major Anions (Chloride, Sulphate, Carbonate/Bicarbonate), Total Suspended Solids (TSS), Alkalinity, Hardness
- Nutrients
  - Nitrate, Nitrite, Total Kjeldahl Nitrogen (TKN), Ammonia, Total Phosphorus (TP), Phenols
- Total Metals
  - Aluminum (Al), Antimony (Sb), Arsenic (As), Barium (Ba), Beryllium (Be), Boron (B), Cadmium (Cd), Chromium (Cr), Cobalt (Co), Copper (Cu), Iron (Fe), Lead (Pb), Lithium (Li), Magnesium (Mg), Manganese (Mn), Mercury (Hg), Molybdenum (Mo), Nickel (Ni), Selenium (Se), Silicon (Si), Silver (Ag), Strontium (Sr), Thallium (Tl), Titanium(Ti), Uranium (U), Vanadium (V), and Zinc (Zn)
- Organic Materials
  - Naphthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, Anthracene, Acridine, Fluoranthene, Pyrene, Benz[a]anthracene, Chrysene, Benzo[b]fluoranthene, Benzo[k]fluoranthene, Benzo[a]pyrene, Indeno[1,2,3-cd]pyrene, Dibenz[a,h]anthracene, Benzo[g,h,i]perylene, CCME B(a)P Carc Equivalent

Appropriate water quality sampling protocols were used when handling samples to avoid damage/breakage or contamination (RAMP, 1999; AENV, 2002). In situ field water quality parameters were measured using a YSI sonde multimeter that was calibrated daily. Grab samples were collected for laboratory analysis. Samples collected in watercourses were obtained just below the water surface when water was open and below the ice during the winter. Water samples from waterbodies were collected at the mid-depth of the deepest location using a Van Dorn sampler.

Water quality samples were sent to Maxxam Analytics Inc. in Edmonton, Alberta, for laboratory analysis. Mercury samples were sent to Alberta Research Council in Vegreville, Alberta, and analyzed with lower detection limits and are referred to as low level mercury analyses.

Table 7.4-1 Sampling Sites and Corresponding Sampling Dates and Coordinates

Watercourse Study Site ID	Sampling Date	UTM (NAD 83-Zone 12)		Waterbody Study Site ID	Sampling Date	UTM (NAD 83-Zone 12)	
		Easting	Northing			Easting	Northing
Hangingstone Lease Area							
WCH1 Hangingstone River	07-Aug-05 01-Oct-05 04-May-06	471136	6229758	LH1	07-Aug-05 01-Oct-05 07-Feb-06 05-May-06	476739	6228430
WCH2 Hangingstone River	07-Aug-05 01-Oct-05 09-Feb-06 04-May-06	471172	6228332	LH3 Soho (Owl) Lake	07-Aug-05 03-Oct-05 08-Feb-06 04-May-06	470668	6224715
WCH3	07-Aug-05 30-Sep-05 09-Feb-06 04-May-06	477437	6224349				
WCH4	06-Aug-05 03-Oct-05 04-May-06	481578	6222806				
WCH5	06-Aug-05 03-Oct-05 05-May-06 20-Aug-06	486353	6222149				
WCH6	06-Aug-05 29-Sep-05 05-May-06	468847	6216553				
Corner Lease Area							
WCC1	06-Aug-05 29-Sep-05 05-May-06 20-Aug-06	484253	6211504	LC1 Egg Lake	06-Aug-05 01-Oct-05 10-Feb-06 05-May-06 19-Aug-06	474318	6213929
WCC2	06-Aug-05 29-Sep-05 05-May-06	477385	6211024	LC2	06-Aug-05 03-Oct-05 07-May-06	471488	6199513
WCC3	05-Aug-05 29-Sep-05 09-Feb-06 05-May-06	477546	6206582				
Leismer Lease Area							
WCL1 Christina River	10-May-06 20-Aug-06	464171	6201591	LL2	04-Aug-05 04-Oct-05 10-Feb-06 07-May-06	481855	6183602
WCL2	08-Aug-05 28-Sep-05 08-Feb-06 06-May-06	454134	6198898	LL3	10-May-06 19-Aug-06	444725	6193800
WCL3	10-May-06 20-Aug-06	442515	6191507	LL4	08-Aug-05 04-Oct-05 10-Feb-06 07-May-06 19-Aug-06	452729	6196552
WCL4	05-Aug-05 29-Sep-05 09-Feb-06 06-May-06	470431	6190933	LL5	04-Aug-05 04-Oct-05 10-Feb-06 10-May-06	476598	6162118
WCL5	06-Aug-05 28-Sep-05 08-Feb-06 06-May-06	484440	6192371				

Watercourse Study Site ID	Sampling Date	UTM (NAD 83-Zone 12)		Waterbody Study Site ID	Sampling Date	UTM (NAD 83-Zone 12)	
		Easting	Northing			Easting	Northing
WCL6	06-Aug-05 28-Sep-05 08-Feb-06 06-May-06	484370	6185273				
WCL7 Christina River	29-Sep-05	474119	6184326				
WCL8	05-Aug-05 28-Sep-05 06-may-06 20-Aug-06	470442	6182976				
WCL9	04-Aug-05 28-Sep-05 10-Feb-06 07-May-06 20-Aug-06	473396	6182053				
WCL10 Christina River	04-Aug-05 28-Sep-05 07-May-06	473415	6178659				
WCL11	03-Aug-05 27-Sep-05 07-Feb-06 03-May-06	482528	6175937				
WCL12	04-Aug-05 28-Sep-05 11-Feb-06 07-May-06	469593	6174937				
WCL13 May River	07-Feb-06 03-May-06 20-Aug-06	477695	6171918				
WCL14	08-Aug-05 30-Sep-05 07-May-06	459378	6173854				

7.4.3 Quality Assurance

To ensure the quality of the data used in characterizing the baseline conditions, quality assurance (QA) and quality control (QC) protocol were employed. Water quality data trip blanks, field blanks and duplicate samples were used to evaluate effects of collection, handling and laboratory analysis on data quality.

Trip Blanks - One trip blank was included on every field trip to determine if bottle storage, labelling, shipping, and handling had any effect on analyses. Trip blanks were filled with deionized water in the laboratory, and were carried, unopened, throughout the field trip.

Field Blanks - Field blank bottles were filled with deionized water (provided by the laboratory), in the field to assess any effects of water sampling or bottle handling on the subsequent analysis. Field blanks were analyzed for the same parameters listed in Section 7.4.2. Field blanks with concentrations greater than five times the analytical detection limit were considered to have potentially been contaminated.

Duplicates - Duplicate samples were also collected on every field trip to assess the repeatability of field sampling procedures.

All QA/QC results from the water quality program can be found in Appendix 7D, Tables 7D-1 to 7D-5.

Quality assurance for water quality data manipulation and data summary calculations included:

- Logic checks on selected parameters, including verifying values outside of expected ranges. Historic data, acquired from different sources, can include unverifiable data that is outside of normal limits. Additionally, historic analyses may not be as accurate as current methods; therefore, some results may appear unreasonable.
- Comparison of a subset of database data with historic original source.
- Confirming the accuracy of calculations used to generate summary statistics. Any errors found were corrected in the final tables.

7.4.4 Baseline Data Analysis

The historic water quality data and the data from the baseline field study were summarized in tables (appendices 7A, 7B and 7C). Summary statistics were calculated including the median, minimum, maximum, 25th percentile and 75th percentile values for each parameter. Non-detectable concentrations were set to one-half the detection limit to conduct summary statistics. The relative ion concentrations of the waterbodies were presented in piper plots (Güler et al., 2002; Freeze and Cherry, 1979; Back and Hanshaw, 1965). Water quality parameters were compared to the relevant published water quality guidelines (Table 7.4-2).

7.4.5 Critical Load Assessment Framework

Over the past several decades, development in northern industrialized nations has lead to efforts to evaluate potential environmental changes related to industrial activities. The effects of aerial emissions, particularly acid deposition, have been a concern and consequently various approaches to investigate the effects of acid deposition have been used. AENV has adopted an integrated acid deposition management framework for managing aerial deposition (CASA, 1999).

Table 7.4-2 Applicable Water Quality Guidelines

Parameter	Unit	AENV Freshwater Aquatic Life*	CCME Water Quality Guidelines - Freshwater^	U.S. EPA Freshwater Water Quality***
Field Parameters				
Temperature	°C	NS	NS	NS
pH		6.5 – 8.5	6.5 - 9.0	6.5 - 9[CC]
Conductivity (EC)	uS/cm	NS	NS	NS
Dissolved oxygen (DO)	mg/L	5.0[AA]	5.5 - 9.53	NS
Conventional Parameters				
pH		6.5 - 9	6.5 - 9.0	6.5 - 9[CC]
Conductivity (EC)	uS/cm	NS	NS	NS
Hardness ($CaCO_3$)	mg/L	NS	NS	NS
Alkalinity ($CaCO_3$)	mg/L	NS	NS	20[CC]
Total Dissolved Solids	mg/L	NS	NS	NS
Total Suspended Solids	mg/L	NS	NS	NS
Turbidity	NTU	NS	NS	NS
Major Ions				
Carbonate (CO_3)	mg/L	NS	NS	NS
Bicarbonate (HCO_3 ($CaCO_3$))	mg/L	NS	NS	NS
Sodium (Na)	mg/L	NS	NS	NS
Potassium (K)	mg/L	NS	NS	NS
Calcium (Ca)	mg/L	NS	NS	NS
Magnesium (Mg)	mg/L	NS	NS	NS
Chloride (Cl)	mg/L	NS	NS	860[MC]/230[CC]
Sulphate (SO_4)	mg/L	NS	NS	NS
Nutrients				
Nitrite (NO_2-N)	mg/L	0.018	0.018	NS
Nitrate (NO_3-N)	mg/L	NS	2.9	NS
Nitrate + nitrite (NO_3 + NO_2 -N)	mg/L	0.018***	NS	NS
Nitrogen - Ammonia (NH_4-N)	mg/L	1.37 - 2.20	0.015	NS
Nitrogen - Kjeldahl (TKN)	mg/L	NS	NS	NS
Total nitrogen (TKN+NO_3 + NO_2)	mg/L	1.0[C]	NS	NS
Phosphorus, total	mg/L	0.05[C]	NS	NS
Total organic carbon	mg/L	NS	NS	NS
Dissolved organic carbon	mg/L	NS	NS	NS
Organics				
Total Phenolics	mg/L	0.005[C]	NS	NS
Total recoverable hydrocarbons	mg/L	NS	NS	NS
Total Metals				
Aluminum (Al)	ug/L	5^[1]/100^[2]	100a	750[MC]/87[CC]
Antimony (Sb)	ug/L	NS	NS	NS
Arsenic (As)	ug/L	5.0	5	340[MC]/150[CC]
Barium (Ba)	ug/L	NS	NS	NS
Beryllium (Be)	ug/L	NS	NS	NS
Boron (B)	ug/L	NS	NS	NS
Cadmium (Cd)	ug/L	0.003 – 0.127[H^]	0.017b	20[MC,H]/0.25[CC,H]
Chromium (Cr)	ug/L	8.9	8.9	570[MC,H]/74[CC,H]
Cobalt (Co)	ug/L	NS	NS	NS
Copper (Cu)	ug/L	1 - 74[H^]	2b	13[MC,H]/9[CC,H]
Iron (Fe)	ug/L	300	300	1000[CC]
Lead (Pb)	ug/L	1 – 4[H^]	2b	65[MC,H]/2.5[CC,H]
Lithium (Li)	ug/L	NS	NS	NS
Manganese (Mn)	ug/L	NS	NS	NS
Mercury (Hg)	ug/L	0.013[A]/0.005[C]	0.026^^	1.4[MC,H]/0.77[CC,H]
Molybdenum (Mo)	ug/L	73	73	NS
Nickel (Ni)	ug/L	25 - 150[H^]	65b	470[MC,H]/52[CC,H]
Selenium (Se)	ug/L	1.0	1	5[CC]
Silicon (Si)	ug/L	NS	NS	NS
Silver (Ag)	ug/L	0.1	0.1	3.2[MC,H]
Strontium (Sr)	ug/L	NS	NS	NS
Sulphur (S)	ug/L	NS	NS	NS
Thallium (Tl)	ug/L	0.8	0.8	NS
Tin (Sn)	ug/L	NS	NS	NS
Titanium (Ti)	ug/L	NS	NS	NS
Uranium (U)	ug/L	NS	NS	NS
Vanadium (V)	ug/L	NS	NS	NS
Zinc (Zn)	ug/L	30	30	120[M,H]/120[CC,H]

Parameter	Unit	AENV Freshwater Aquatic Life*	CCME Water Quality Guidelines - Freshwater^	U.S. EPA Freshwater Water Quality***
Zirconium (Zr)	ug/L	NS	NS	NS
Dissolved Metals				
Aluminum	ug/L	NS	NS	$750^{MC}/87^{CC}$
Antimony	ug/L	NS	NS	NS
Arsenic	ug/L	NS	NS	$340^{MC}/150^{CC}$
Barium	ug/L	NS	NS	NS
Beryllium	ug/L	NS	NS	NS
Bismuth	ug/L	NS	NS	
Boron	ug/L	NS	NS	NS
Cadmium	ug/L	NS	NS	$20^{MC,H}/0.25^{CC,H}$
Chromium	ug/L	NS	NS	$570^{MC,H}/74^{CC,H}$
Cobalt	ug/L	NS	NS	NS
Copper	ug/L	NS	NS	$13^{MC,H}/9^{CC,H}$
Iron	ug/L	NS	NS	1000^{CC}
Lead	ug/L	NS	NS	$65^{MC,H}/2.5^{CC,H}$
Lithium	ug/L	NS	NS	NS
Manganese	ug/L	NS	NS	NS
Mercury	ug/L	NS	NS	$1.4^{MC,H}/0.77^{CC,H}$
Molybdenum	ug/L	NS	NS	NS
Nickel	ug/L	NS	NS	$470^{MC,H}/52^{CC,H}$
Silver	ug/L	NS	NS	$3.2^{MC,H}$
Strontium	ug/L	NS	NS	NS
Sulphur	ug/L	NS	NS	NS
Thallium	ug/L	NS	NS	NS
Tin	ug/L	NS	NS	NS
Titanium	ug/L	NS	NS	NS
Vanadium	ug/L	NS	NS	NS
Zinc	ug/L	NS	NS	$120^{M,H}/120^{CC,H}$
Polycyclic Aromatic Hydrocarbons				
Naphthalene	ug/L	1.1	1.1	NS
Acephthylene	ug/L	NS	NS	NS
Acenaphthene	ug/L	5.8	5.8	NS
Fluorene	ug/L	3	3	NS
Phenanthrene	ug/L	0.4	0.4	NS
Anthracene	ug/L	0.012	0.012	NS
Acridine	ug/L	4.4	NS	NS
Fluoranthene	ug/L	0.04	0.04	NS
Pyrene	ug/L	0.025	0.025	NS
Benz[a]anthracene	ug/L	0.018	0.018	NS
Chrysene	ug/L	NS	NS	NS
Benzo[b]fluoranthene	ug/L	NS	NS	NS
Benzo[k]fluoranthene	ug/L	NS	NS	NS
Benzo[a]pyrene	ug/L	0.015	0.015	NS
Indeno[1,2,3-cd]pyrene	ug/L	NS	NS	NS
Dibenzo[a,h]anthracene	ug/L	NS	NS	NS
Quinoline	ug/L	NS	NS	NS
Benzo[g,h,i]perylene	ug/L	NS	NS	NS
CCME BP Equivalent	ug/L	NS	NS	NS

Notes:
- NS - not specified
- ^ - Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME, 2006)
- * - AENV Surface Water Quality Guidelines for use in Alberta (AENV, 1999)
- CC - continuous concentration guideline, National Recommended Water Quality Criteria (U.S. EPA, 2006)
- MC - maximum concentration guideline, National Recommended Water Quality Criteria (U.S. EPA, 2006)
- *** - National Recommended Water Quality Criteria (U.S. EPA, 2006)
- 1 - value if pH <6.5, Ca <4.0, DOC <2
- 2 - value if pH ≥6.5, Ca ≥4.0, DOC ≥2
- ^^ - 1 day minimum, acute guideline
- a - value if pH>6.5, Ca>4.0, DOC>2
- b - dependent on hardness value
- C - Chronic Aquatic Life guideline
- **A** - Acute Aquatic Life guideline
- **H** - dependent on hardness value

This includes evaluating the magnitude of acidic deposition and assessing the effects of deposition on recipient systems.

The management framework uses a Critical Load approach to set acid deposition benchmarks. When these benchmarks are exceeded, management actions are initiated. The critical load is defined as “the maximum level of acidic atmospheric deposition that affords long term protection from adverse ecological consequences and that is politically and practically achievable” (CASA, 1999). The critical load is based on a waterbody’s acid neutralizing capacity (ANC) and is defined as the highest rate of deposition that will not cause adverse biological effects to a lake and its catchment basin (Nilsson and Grennfelt, 1988; WRS, 2004).

Aerial deposition that includes sulphur- and nitrogen-containing compounds may lead to acidification. Base cations in receiving waters are capable of neutralizing acidifying compounds. The critical load is therefore an inherent property of a waterbody’s individual chemistry.

The management framework categorizes areas of the Province of Alberta according to sensitivity to acid deposition and sets loading levels that are protective of local receptors. Critical loads for the province were set according to the following limits:

- 0.25 keq H^+/ha/y (sensitive receptor areas)
- 0.50 keq H^+/ha/y (moderate sensitive receptor areas)
- 1.00 keq H^+/ha/y (low sensitive receptor areas)

The areas located in the northeast region of the province that encompass most of the oil sands projects are considered sensitive and therefore have been assigned the lowest allowable critical loading levels.

Model predictions and receptor sensitivity databases will contain a level of uncertainty. To provide an additional level of safety to ensure protection for receptors, target levels were set at 90 percent of the critical load levels. Boundaries for the management framework are built around the target loads.

The following limits were set for target load levels:

- 0.22 keq H^+/ha/y (sensitive receptor area)
- 0.45 keq H^+/ha/y (moderate sensitive receptor area)
- 0.90 keq H^+/ha/y (low sensitive receptor area)

These levels were considered practically and politically achievable.

An additional layer of safety was incorporated into the management framework to ensure potentially affected waterbodies were monitored for changes before they were influenced by acid deposition. Thus, monitoring load levels were set to provide information to base management decisions on monitoring data rather than modelling estimations. Management decisions regarding emission reductions are not affected by monitoring load levels; however, acid deposition predicted to be greater than monitoring levels initiate monitoring and/or additional research. Currently, monitoring loads are set low enough to provide time for acid deposition information and receptor sensitivity data to be collected before target loads are reached or exceeded. Monitoring load limits are set at the following levels:

- 0.17 keq H^+/ha/y (sensitive receptor area)
- 0.30 keq H^+/ha/y (moderate sensitive receptor area)
- 0.70 keq H^+/ha/y (low sensitive receptor area)

The Henriksen Steady State Model (WRS, 2004) was used to calculate the acid deposition critical loading limits to waterbodies located in the area where deposition is expected to be greater than 0.17 keq H^+/ha^-/y. The calculation is as follows:

$$C.L. = \left(BC - \left[ANC_{LIM}\right]\right) \cdot Q$$

where:

BC is the pre-industrial base cation concentration

ANC_{LIM} is the acid neutralizing capacity considered protective of the most sensitive species

Q is the mean annual runoff

Surface runoff from catchment basins is assumed to be the only source of alkalinity for a waterbody. This assumes that acid neutralizing capacity (ANC) is natural, not anthropogenic, and that base cation concentrations are to be pre-industrial levels. Current concentrations in the oil sands region south of Fort McMurray are considered at pre-industrial levels (WRS, 2004). This suggests the waterbody can maintain the current level of ANC, which is determined by base cations and bicarbonate ions rather than organic anions or aluminum.

The Henriksen Model assumes that the critical load of acidity in a waterbody is equal to the alkalinity generated by the catchment basin minus a critical chemical threshold of ANC that may affect biological processes and organisms (ANC_{LIM}). The limiting ANC value used in this model was 75 ueq/L, which roughly corresponds to a pH of 6.0 (WRS, 2004; Environment Canada, 1997) and is considered protective of sportfish populations.

The critical load for each waterbody was compared to potential acid input (PAI) predictions greater than 0.17 keq H^+/ha/y (Volume 2, Section 2; Air). Waterbodies that may receive PAI greater than their calculated critical loading limits were identified. When the PAI exceeds a critical load for a waterbody, the potential exists for acidification at that rate of PAI. The model suggests only that there is a potential for this to occur, not that acidification is imminent or certain. Critical loads for waterbodies not sampled by the water quality program for the Project were obtained from previous studies (WRS, 2004; Nexen/OPTI, 2006).

7.5 Existing Conditions

7.5.1 Baseline Water Chemistry

The following discussion provides a baseline characterization of the chemistry of the surface water located in the study areas. Physical characteristics that influence water chemistry are considered followed by a discussion of relevant water chemistry thresholds (i.e., discussions on what levels are considered high, medium and low) and concentrations reported for the study areas. Water chemistry analytical results from samples collected in 2005 and 2006 are provided in Appendix 7A, Tables 7A-1 through 7A-3. Summary statistics of historic data are provided in Appendices 7B and 7C, Tables 7B-1 to 7B-5 and 7C-1 to 7C-6.

A series of 15 water chemistry parameters was selected to graphically display and summarize general water quality trends (Figures 7.5-1 through 7.5-11). Box and whisker plots display seasonal variation for each parameter while scatter plots show variation in long-term water quality data. Trends observed in these indicators are considered typical of general water chemistry in the region.

Major ion chemistry is shown using Piper plots (Figures 7.5-12a - e).

Watershed Features

Water quality is strongly affected by various watershed factors including local geology, topography and vegetation community. Much of the LSA is dominated by the Lower Boreal Highland Subregion of the Boreal Forest Natural Region (Strong and Leggat, 1992). The climate is generally moist and cool with short summers and long, cold winters. The Central Mixedwood Subregion is most common in the surrounding area of the RSA. The climate in this sub-region is similar to the Lower Boreal Highland; however, summers tend to be warmer.

The Lower Boreal sub-region has rolling upland areas and variably sloping inclines toward lowland areas. The Central Mixedwood Subregion tends to have gently rolling plains and with minor hummocky upland areas. Wetlands, including fens, bogs and shallow lakes, are common throughout the RSA.

Soils throughout the area are composed mainly of the following:

- Grey Luvisols: found mainly in moderately drained areas and developed from a variety of parent material. These soils often support deciduous-coniferous forests.
- Gleysols and Organic soils: found mainly in lowland areas and in wetlands with poor drainage and a high water table. The accumulation of peat or other organic debris contributes to the formation of organic soils.
- Brunisols: found generally on well-drained, sandy soils and will often support coniferous (often mainly pine) forests.
- Discontinuous permafrost: may occur anywhere bogs exist.

Carbon

One of the main constituents that characterize water quality in the boreal region is the presence of dissolved carbon originating from decaying plant material. The environment tends to be cool and moist, with sediments that are often saturated and anaerobic (i.e., without oxygen) which results in slow and incomplete plant and vegetation decomposition. Dissolved organic substances resulting from the slow decay of plant material includes humic compounds and other naturally-occurring organic acids (humic and fulvic acids) which give water a tea-coloured appearance. These dissolved organic substances have various features that affect water quality. They include:

- Humic and fulvic acids that can lower the pH of a waterbody;
- locations for other organic substances to adhere, and can therefore affect the transport and fate of organic chemicals;

- an affinity for metal ions, which can mobilize metals keeping them in solution. Consequently, Al and Fe are often observed at above guideline levels in these waters; and

- dark colouring, which absorbs ultraviolet light, thus affecting water temperatures and potentially inhibit some biological processes, such as photosynthesis.

Total organic carbon (TOC) is composed of dissolved and particulate forms of carbon derived from decaying plant and animal materials (e.g., decaying macrophytes and algae, runoff from agricultural land and livestock operations, etc). These materials are often resistant to microbial decay. Lakes and streams with TOC concentrations less than 3 mg/L are considered clear; however, naturally occurring TOC levels may vary between 1 mg/L and 30 mg/L (McNeely et al., 1979). In some areas where plant decay is slow, humic materials accumulate and result in brown water streams and lakes. Total organic carbon levels in brown water lakes can range between 10 mg/L and 40 mg/L (MEG, 2005).

Concentrations of dissolved organic carbon (DOC) in the study area were generally moderate to high with brown coloured water. Concentrations in waterbodies in the study area ranged from less than 1 mg/L to a high of 49 mg/L; however, the median value was greater than 15 mg/L. Concentrations of DOC in watercourses ranged from 2 mg/L to 46 mg/L, though DOC concentrations were somewhat less in the lower Christina and Clearwater rivers, which are visibly less tea-coloured than other waterbodies and watercourses in the RSA.

Carbon is considered a nutrient, and is often associated with bacterial growth. High concentrations (often from anthropogenic sources) can cause an increase in bacteria, which, combined with increase in respiration rates, can lead to a depletion of dissolved oxygen (DO) in a waterbody. This depletion of DO can, in turn, cause stress to aquatic organisms.

Dissolved Oxygen

The concentration of dissolved oxygen (DO) in water can be highly variable depending on environmental factors. An increase in water temperature or salinity will reduce the amount of oxygen that will remain dissolved in solution. Biological processes including photosynthesis and respiration affect DO concentrations. Response to low oxygen levels is organism-dependant. During certain life stages, some trout fry cannot tolerate levels below 10 mg/L (Mitchell and Prepas, 1990); whereas, other organisms including stickleback species and some benthic invertebrates can tolerate concentrations close to 0 mg/L for short times (Mitchell and Prepas, 1990). In general, most organisms cannot tolerate concentrations less than 2 mg/L (Wetzel, 2001). AENV (1999) has set the DO chronic guideline at 6.5 mg/L to be protective of aquatic organisms; however, the guideline is raised to 9.5 mg/L when embryonic or larval fish stages are present. In addition, AENV suggests the guideline should be increased to 8.3 mg/L from mid May to the end of June to protect emerging mayfly species.

Dissolved oxygen concentrations in the study areas were variable by season. Historic sources and current data showed concentrations of DO were lowest in the winter and varied between 0.3 mg/L and 15.9 mg/L, with a median of approximately 9 mg/L. Higher DO concentrations were generally found in rivers and streams. Smaller watercourses and shallow waterbodies tended to have lower DO concentrations in the winter months than larger watercourses and waterbodies. During the summer months, concentrations were higher, generally ranging between 6.7 mg/L and 15.1 mg/L. However, there were a couple of instances of very low (e.g., 0.8 mg/L), and very high levels (e.g., 22.2 mg/L) in all seasons.

Dissolved Ions

Ion concentrations (charged molecules) are of particular interest because they affect various chemical processes (e.g., acid neutralizing capacity, metal toxicity, and osmoregulation in aquatic organisms). Various measurements for ion concentrations include electrical conductance, salinity or total dissolved solids (TDS). The amount of ions in solution is dependant on different factors including:

- Surface water runoff, because slower flows result in higher ion concentrations;
- Abundance and solubility of ions in soils and parent rock material; and
- Upstream watershed area.

pH

The pH levels in the study area generally ranged between the AENV guideline values of 6.5 and 9.0. Some outliers, both above and below the guideline were present; however, no sampling location was continuously above or below guidelines.

Water pH can alter how other elements respond to the environment. Aluminum (Al^{3+}) becomes more available with decreasing pH and is most toxic to organisms at a pH of between 5 and 6. Many organisms cannot tolerate pH less than 5.7 (Mitchell and Prepas, 1990). Acidification often increases in a system with the deposition of sulphuric or nitric acids from industrial emissions (Dodds, 2002).

Alkalinity

Alkalinity indicates how sensitive water is to acid deposition. Water with alkaline properties has the ability to resist potential changes in pH from the input of strong acids. Alkalinity is often associated with carbonate and bicarbonate concentrations and is often described in terms of $CaCO_3$. The ability to resist change in pH from the addition of strong organic acids is termed the Acid Neutralizing Capacity (ANC) (Wetzel, 2001). Acid neutralizing capacity is generally measured in ueq/L $CaCO_3$ (mass per unit volume). Most lakes in Alberta have $CaCO_3$ concentrations greater than 100 mg/L and are considered highly alkaline; however, some brown water lakes in northern Alberta can be dilute and are considered sensitive (Mitchell and Prepas, 1990) (Table 7.5-1).

Table 7.5-1 Acid Sensitivity of Lakes and Ponds

Acid Sensitivity	Alkalinity ($CaCO_3$ mg/L) [1, 2]	Alkalinity ($CaCO_3$ ueq/L)[1]	Acid Neutralizing Capacity (ueq/L) [3]
Sensitive	0 – 10	0 – 200	0 - 50
Moderate Sensitivity	10 – 20	200 – 400	50 - 200
Low Sensitivity	21 – 40	400 – 800	> 200
Not Sensitive	> 40	> 800	-

[1] Saffran and Trew, 1996

[2] British Columbia, 1998 (waterbodies)

[3] Sullivan, 2000 (waterbodies in general)

Alkalinity in waterbodies in the RSA ranged from 0.5 mg/L to 285.0 mg/L. While most of the waterbodies had moderate to low sensitivity to acidification, there are a number of lakes, scattered among all the water basins within the RSA that are considered sensitive to acidification.

Trophic Status and Nutrients

Trophic status is used to describe lake or stream productivity. Biological activity often reflects water quality. For example, chlorophyll *a* concentration corresponds with available nutrient concentrations in a stream or lake (Environment Canada, 2004). Water quality can be affected by increased biological activity as increased algae and plant photosynthesis/respiration cycles can result in low DO levels and changes in some ion concentrations (e.g., calcium). Chlorophyll *a* levels are used to describe trophic status because they reflect overall productivity and biological processes in a waterbody. Secchi depth is also a good indicator of production levels in a waterbody (Environment Canada, 2004).

Trophic status can also be described as the availability of the most limiting nutrient (the nutrient in least supply) (Environment Canada, 2004). Phosphorus is often the primary factor limiting production in Alberta lakes and streams. Various authors have used phosphorus levels to determine productivity thresholds (Vollenweider and Kerekes, 1982; Wetzel, 2001; Dodds et al., 1998; Environment Canada, 2004) and assign trophic status (Table 7.5-2). Waterbodies and watercourses in the RSA were generally meso-eutrophic to Eutrophic (highly productive) (Appendices 7B and 7C).

Table 7.5-2 Trophic Levels in Lakes and Rivers

Trophic Level	Chlorophyll *a* (ug/L) [1,2]	Secchi Depth (m)	Trigger Ranges for Total Phosphorus	
			Lakes [1]	Rivers and Streams [1]
Ultra-oligotrophic	< 2.5	> 12	< 4	-
Oligotrophic	< 8	-	4 - 10	< 25
Oligo-mesotrophic	Occasionally > 8	> 6	-	-
Mesotrophic	8 – 25	-	10 - 20	27 - 75
Meso-eutrophic	8 – 25	6 – 3	20 - 35	-
Eutrophic	26 – 75	3 - 1.5	35 - 100	> 75
Hypereutrophic	>75	<1.5	>100	-

[1] Environment Canada, 2004

[2] Mitchell and Prepas, 1990

Nitrogen is another nutrient that often contributes to increases in productivity. The availability of nitrogen is often described in terms of total Kjeldahl nitrogen (TKN) which includes organic particulate nitrogen and ammonia. Total nitrogen is composed of nitrite + nitrate (NO_2 + NO_3-) and TKN concentrations. The concentration of total nitrogen typically ranges between 0.2 mg/L and 10 mg/L in Alberta surface waters (Mitchell and Prepas, 1990). Rivers that are not affected by large organic inputs generally have TKN levels that range between 0.1 mg/L and 0.5 mg/L (McNeely et al, 1979). Nitrogen threshold levels are presented in Table 7.5-3.

Table 7.5-3 Thresholds for Nitrogen

Threshold Level	Total Kjeldahl Nitrogen (mg/L)
Low	< 0.1
Moderate	0.1 - 0.5
High	> 0.5

Note: Based on McNeely et al., 1979

Concentrations of nitrogen and phosphorus in the Redfield Ratio, a molar ratio of 16:1, are considered optimal for algae and plant growth (Wetzel, 2001); however, variability from this ratio by as much as 20 percent may sustain productivity. Typically, optimal situation conditions do not occur; either nitrogen or phosphorus will be depleted by biological processes. Thus, the depleted nutrient is considered the limiting factor which ultimately affects productivity of the waterbody. In time, when the limiting factor becomes abundant and the N:P ratio becomes balanced closer to 16, algae and plant growth can become abundant, consequently increasing productivity of the waterbody.

Concentrations of nitrogen varied in the RSA from undetectable (<0.01 mg/L) to 26.61mg/L. Total phosphorus (TP) concentrations varied widely (0.002 mg/L to 2.4 mg/L). Approximately half of the phosphorus values were above the AENV guideline of 0.05 mg/L. Samples with concentrations that exceeded that guideline were not restricted to any one drainage basin, but rather scattered throughout all sample locations and sampling seasons. Elevated TP concentrations are historically present, and natural in origin.

In the 2005 and 2006 data, the N:P molar ratios in waters in the Hangingstone lease were variable and generally ranged from 20 to greater than 100. Watercourses and waterbodies had similar ratios. The Corner development area waters were less variable with N:P molar ratios ranging between 15 and greater than 50. The molar ratio of nitrogen to phosphorus in the Leismer and Thornbury development areas were generally between 20 and 40 except for two watercourses that were below 16 (sites WCL12 and WCL14). The N:P ratio in waterbodies in this area was variable; two had ratios between 20 and 30 (sites LL3 and LL4) whereas another was greater than 100 (Site LL2). In most cases, however, both nitrogen and phosphorus concentrations were elevated and at levels that did not indicate they were being depleted. Therefore, shifts in the N:P ratio away from the Redfield ratio value of 16 may not affect productivity in LSA waters.

Metals

Metals are naturally present in surface waters in northern Alberta. Local geology is often the major determinant of metal concentrations in surface waters, though anthropogenic sources can play a role. Historically, Al and Fe concentrations in the RSA were often greater than the AENV guidelines for the protection of freshwater aquatic life (100 ug/L and 300 ug/L, respectively). The extent to which metals are able to adversely affect biota is determined by their availability for biological uptake. Uptake is affected by water pH, hardness and DOC concentrations. Increases in pH and hardness lead to the precipitation of metal ions. When metals bind to suspended particles in the water column (e.g., organic matter, clay particles) they become less available for uptake by plants and animals. Conversely, metals such as Al and Fe are easily mobilized in the presence of fulvic acids.

Polycyclic Aromatic Hydrocarbons

Polycyclic aromatic hydrocarbon (PAH) compounds persist in the environment, and due to their ring structure, can bioaccumulate to toxic concentrations in the tissues of aquatic biota. Within the aquatic ecosystem, concentrations of PAHs are generally highest in sediment, followed by tissues of aquatic organisms, and finally, lowest in the water column. Sources of PAHs include the incomplete burning of oil or gas, coal, wood, garbage, and other organic materials. Nearly all water samples resulted in PAHs that were below detectable levels. Concentrations for PAHs were detected infrequently, and at only few locations.

Guideline Exceedances

Some baseline water quality parameters in the waterbodies and watercourses studied in this program routinely exceeded AENV surface water quality guidelines for the protection of aquatic life. Water chemistry parameters greater than guideline levels are identified in Appendices 7A, 7B, and 7C.

Dissolved oxygen concentration was below 5.0 mg/L, the AENV acute, one day guideline, in a number of the lakes and streams during the winter sampling season. This is often seen in northern Alberta waterbodies and watercourses once they are ice-covered and biological processes deplete under-ice oxygen. The pH values generally ranged from 5.0 to 9.5, some values fell outside of the AENV guideline of 6.5 to 9.0. High levels of naturally occurring organic acids may contribute to the observed lower pH levels.

Both total nitrogen and total phosphorus were often greater than the AENV guidelines of 1.0 mg/L and 0.05 mg/L, respectively. In historic and current (2005, 2006) data total phosphorus was above the guideline in a large number of samples, with values as high as 0.4 mg/L. High total nitrogen concentrations were seen in a few samples from all seasons and watersheds, with no spatial or temporal trends evident. High nutrient concentrations are common to the boreal area, and were commonly reported in the historic data.

Various metals were present in concentrations that were greater than AENV guidelines. Historic and current data shows that Al and Fe concentrations in northern Alberta waterbodies and watercourses are often near or above guideline concentrations.

A variety of other metals including Cd, Ag, Zn, Pb, and Hg were present in a small number of samples at concentrations greater than AENV guidelines. Some of the high concentrations were found in historic data from dates when laboratory methods were such that the detection limits were at or above current guideline levels. Elevated metal concentrations did not appear to be associated with specific locations; rather they were observed sporadically throughout the RSA.

7.5.2 Critical Load Calculations

Previous work has shown that a strong linear relationship exists between bicarbonate alkalinity and the sum concentration of base cations in waterbodies of the study area (WRS, 2004). This relationship indicates buffering in these systems is dominated by bicarbonates (Saffran and Trew, 1996; WRS, 2004), an important assumption in the Henriksen Model. Regression analyses on samples collected for the Project field program in 2005 and 2006 are also consistent with these earlier works ($r^2 = 0.99$; $df = 7$; $P<0.0001$). Ion concentrations graphed using piper plots further suggests that most waterbodies in the study areas are generally Ca-Mg-HCO_3 type water, buffering capacity resulting primarily from bicarbonates (Güler et al., 2002; Figures 7.5-12a - e).

The role of organic material (DOC) in affecting pH and buffering waterbodies is not considered in the Henriksen Model. Western Resource Solutions (2004) found that the relative importance of weak organic ions in buffering acidity (organic alkalinities) was highest in low pH conditions where bicarbonate concentrations are lowest. At higher pH levels, the proportion of acid neutralizing capacity (ANC) due to bicarbonates increases and the bicarbonate assumption holds true. Their conclusion was that the Henriksen Model may begin to lose validity when the waterbody pH is quite low; however, these same waterbodies have low DOC levels and consequently low organic alkalinity. In these situations where both bicarbonate and organic alkalinity are low, waterbodies remain sensitive to acid deposition and the results of the model hold true.

Critical loads limits for waterbodies in the RSA were obtained from historic documents (WRS, 2004; MEG, 2005; Nexen/OPTI, 2006; OPTI, 2000) or were calculated from water chemistry data collected during the Project water quality field program. In total, critical loads for 86 waterbodies were evaluated. Critical loads were variable; the median critical load was 1.42 keq H^+/ha/y and values ranged between 0.025 and over 7 keq H^+/ha/y (Table 7.5-4). Waterbodies with the lowest critical loading limits generally had low alkalinities, base cation concentrations and pH levels.

Table 7.5-4 Potential Acid Inputs for Critical Loads for Waterbodies in the Regional Study Area

Map Number [(a)]	Data Source	Waterbody Name and/or Site ID	UTM Coordinates (NAD 83) Zone	Easting	Northing	pH	Alkalinity ueq/L	Conductance uS/cm	Sum Base Cations ueq/L	Lake Surface Area km^2	Gross Drainage Area km^2	Annual Runoff m^3/s	Critical Load keq H+/ha/y	PAI (Background) keq H+/ha/y	PAI (Application) keq H+/ha/y	PAI (Cumulative) keq H+/ha/y
1	Project Field Program	Egg lake (LC1)	12	474318	6213929	7.61	503	63	585	843.70	78.3	0.101	0.207	0.146	0.165	0.187
2	Project Field Program	Unnamed Lake (LC2)	12	471488	6199513	7.74	637	80	865	155.90	14.9	0.020	0.344	0.132	0.155	0.170
3	Project Field Program	Unnamed Lake (LH1)	12	478188	6228862	6.34	54	20	187	186.53	12.7	0.040	0.110	0.168	0.190	0.228
4	Project Field Program	Soho (Owl Lake; LH3)	12	470619	6225356	6.65	56	18	159	48.80	5.2	0.008	0.039	0.156	0.168	0.201
5	Project Field Program	Unnamed Lake (LL2)	12	481855	6183602	8.17	1404	160	1681	29.90	14.6	0.020	0.698	0.134	0.155	0.166
6	Project Field Program	Unnamed Lake (LL3)	12	444725	6193800	7.69	864	116	993	146.40	14.4	0.020	0.400	0.122	0.135	0.144
7	Project Field Program	Unnamed Lake (LL4)	12	452729	6196552	7.85	847	104	1059	124.40	156.9	0.198	0.393	0.121	0.158	0.168
8	Project Field Program	Unnamed Lake (LL5)	12	476598	6162118	8.26	2557	279	3104	3.30	1.4	0.005	3.240	0.141	0.152	0.162
9	WRS (2004)	A29	12	466182	6224950	5.43	46	12	137	1.05	4.5	0.013	0.057	0.150	0.160	0.191
10	WRS (2004)	A21	12	483819	6235130	4.62	15	17	182	1.38	10.4	0.040	0.132	0.188	0.197	0.249
11	WRS (2004)	A24	12	484386	6230872	4.40	0	14	109	1.45	7.8	0.026	0.036	0.175	0.187	0.230
12	WRS (2004)	A26	12	489502	6230877	6.46	187	14	347	2.78	3.4	0.001	0.025	0.181	0.192	0.240
13	WRS (2004)	Gordon Lake	12	530780	6261842	8.36	2811	257	2982	117.22	535.3	0.650	1.112	0.156	0.158	0.188
14	WRS (2004)	Nora Lake	12	526686	6259959	9.11	1589	157	1782	1.12	4.9	0.009	0.937	0.172	0.174	0.209
15	WRS (2004)	Birch Lake	12	536018	6248898	8.67	3206	301	3356	17.53	73.7	0.126	1.775	0.162	0.165	0.199
16	WRS (2004)	Unnamed Lake	12	487107	6238562	7.35	553	61	706	0.84	40.7	0.188	0.917	0.211	0.217	0.272
17	WRS (2004)	Georges Lake	12	513419	6236708	8.44	3096	316	3490	2.78	155.8	0.543	3.755	0.191	0.195	0.248
18	WRS (2004)	Unnamed Lake	12	525809	6235838	7.88	1926	204	2274	1.71	54.0	0.184	2.358	0.165	0.169	0.206
19	WRS (2004)	Unnamed Lake	12	489154	6232991	6.91	210	26	284	0.65	18.8	0.067	0.237	0.190	0.199	0.248
20	WRS (2004)	Unnamed Lake	12	487594	6229285	5.23	40	12	110	2.18	7.8	0.022	0.031	0.174	0.187	0.229
21	WRS (2004)	Unnamed Lake	12	487068	6225576	6.09	90	17	183	0.54	3.2	0.012	0.130	0.168	0.184	0.221
22	WRS (2004)	Unnamed Lake	12	487070	6226504	5.17	41	11	99	0.59	21.5	0.102	0.036	0.169	0.183	0.222
23	WRS (2004)	Unnamed Lake	12	480350	6228385	5.61	54	15	122	0.95	6.4	0.025	0.058	0.168	0.189	0.226
24	WRS (2004)	Unnamed Lake	12	491196	6222320	6.61	148	24	296	0.77	14.2	0.067	0.331	0.180	0.195	0.234
25	WRS (2004)	Unnamed Lake	12	540312	6230385	7.90	2044	213	2440	10.37	201.5	0.540	2.195	0.143	0.147	0.175
26	WRS (2004)	Watchusk Lake	12	543469	6224850	8.64	1795	184	2131	8.99	301.8	0.883	1.896	0.140	0.144	0.171
27	WRS (2004)	Unnamed Lake	12	521815	6208917	8.14	2082	226	2539	1.11	27.8	0.095	2.652	0.147	0.152	0.177
28	WRS (2004)	Unnamed Lake	12	458295	6193296	7.28	405	47	559	0.93	2.7	0.006	0.325	0.130	0.211	0.222
29	WRS (2004)	Bohn Lake	12	520832	6196855	8.74	2018	193	2327	19.49	200.8	0.565	1.996	0.149	0.156	0.177
30	WRS (2004)	Unnamed Lake	12	530201	6197838	8.03	1613	157	1960	1.55	19.9	0.062	1.835	0.150	0.156	0.176
31	WRS (2004)	Cowper Lake	12	534391	6195087	9.07	1489	143	1717	14.62	280.5	0.912	1.683	0.147	0.153	0.172
32	WRS (2004)	Unnamed Lake	12	533411	6186731	7.89	1168	112	1361	1.13	11.3	0.039	1.389	0.164	0.171	0.192
33	WRS (2004)	Unnamed Lake	12	515689	6179212	7.26	429	53	608	2.50	8.5	0.016	0.319	0.169	0.179	0.198
34	WRS (2004)	Unnamed Lake	12	528841	6167222	7.67	955	98	1138	2.62	51.5	0.201	1.306	0.196	0.204	0.223
35	WRS (2004)	Unnamed Lake	12	502625	6165272	7.77	998	105	1246	1.96	25.8	0.092	1.320	0.176	0.186	0.202
36	WRS (2004)	Unnamed Lake	12	547077	6178511	8.09	1640	152	1921	0.83	49.6	0.205	2.404	0.156	0.161	0.179
37	WRS (2004)	Unnamed Lake	12	548176	6173885	8.29	1466	142	1667	0.91	6.5	0.021	1.629	0.157	0.163	0.181
38	WRS (2004)	Winefred Lake	12	531585	6150547	8.15	2037	195	2196	126.25	1185.9	4.087	2.305	0.158	0.163	0.178
39	WRS (2004)	Unnamed Lake	12	544256	6146947	8.95	1535	144	1729	1.54	8.7	0.029	1.743	0.152	0.156	0.170
40	WRS (2004)	Kirby Lake	12	514750	6146749	8.56	2470	228	2631	5.29	22.4	0.061	2.200	0.202	0.208	0.230
41	WRS (2004)	Unnamed Lake	12	510533	6149518	8.21	2025	198	2249	2.89	51.1	0.171	2.297	0.208	0.214	0.240
42	WRS (2004)	PF10	12	493296	6259592	7.66	440	65	703	0.06	1.1	0.004	0.667	0.241	0.244	0.283
43	WRS (2004)	PF12	12	500505	6255479	7.31	180	34	368	0.13	3.3	0.012	0.325	0.263	0.266	0.312
44	WRS (2004)	PF13	12	498560	6265738	7.47	1980	200	2156	0.08	1.6	0.005	2.058	0.226	0.229	0.264
45	WRS (2004)	PF5	12	451427	6268340	7.68	2220	212	2301	0.07	0.5	0.001	1.861	0.161	0.163	0.183
46	WRS (2004)	PF6	12	450031	6267922	7.80	1780	179	1906	0.04	0.7	0.002	1.867	0.158	0.160	0.180
47	WRS (2004)	PF7	12	479615	6256677	7.44	1660	190	2175	0.04	1.6	0.006	2.272	0.185	0.188	0.223
48	WRS (2004)	PF8	12	471629	6268172	7.78	1340	197	2053	0.08	1.6	0.005	1.853	0.182	0.184	0.209
49	WRS (2004)	PF9	12	488074	6256514	7.63	640	99	1081	0.09	1.3	0.004	1.018	0.205	0.207	0.246
50	MEG (2005)	Christina Lake (CL1)	12	513900	6163800	8.20	1918	192	---	---	---	---	1.512	0.245	0.253	0.272
51	MEG (2005)	Unnamed Waterbody (WB6)	12	515340	6175723	7.70	520	57	---	---	---	---	0.288	0.175	0.184	0.203
52	MEG (2005)	Unnamed Waterbody (WB7)	12	515450	6170023	7.70	620	69	---	---	---	---	0.416	0.202	0.211	0.230
53	MEG (2005)	Unnamed Waterbody (WB12)	12	526595	6168265	7.90	750	77	---	---	---	---	0.448	0.204	0.211	0.231

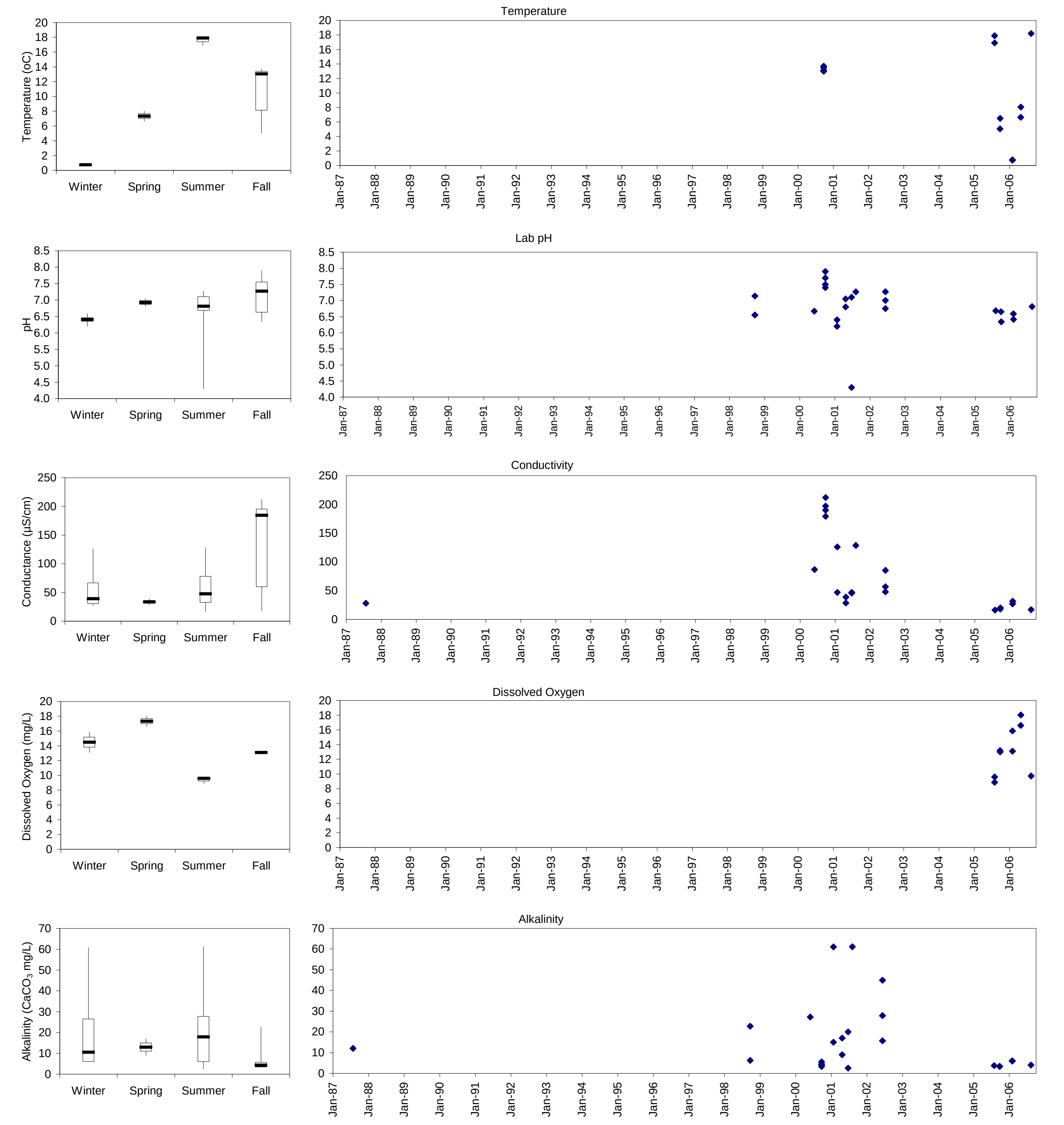
Table 7.5-4 Potential Acid Inputs for Critical Loads for Waterbodies in the Regional Study Area

Map Number [a]	Data Source	Waterbody Name and/or Site ID	UTM Coordinates (NAD 83)			pH	Alkalinity	Conductance	Sum Base Cations	Lake Surface Area	Gross Drainage Area	Annual Runoff	Critical Load	PAI (Background)	PAI (Application)	PAI (Cumulative)
			Zone	Easting	Northing		ueq/L	uS/cm	ueq/L	km^2	km^2	m^3/s	keq H+/ha/y	keq H+/ha/y	keq H+/ha/y	keq H+/ha/y
54	Nexen (2006)	WB-1	12	504601	6242959	7.71	3200	314	3609	0.06	8.2	0.035	4.834	0.218	0.221	0.288
55	Nexen (2006)	WB-2	12	503405	6241128	6.89	2080	370	4101	0.04	11.9	0.050	5.308	0.196	0.200	0.326
56	Nexen (2006)	Horse Lake (WB-3)	12	504065	6239889	6.95	2200	436	4545	0.26	8.9	0.037	5.874	0.191	0.195	0.346
57	Nexen (2006)	WB-4	12	507009	6241358	7.52	2300	223	2531	0.53	7.1	0.020	2.222	0.218	0.221	0.306
58	Nexen (2006)	WB-5	12	506710	6240218	8.11	2800	373	4169	0.41	13.6	0.055	5.251	0.204	0.208	0.299
59	Nexen (2006)	Long Lake (south; WB-6)	12	508712	6240941	8.03	2040	193	2105	0.91	5.3	0.016	1.988	0.219	0.222	0.299
60	Nexen (2006)	WB-7	12	509698	6244418	7.12	1580	158	1679	0.21	2.4	0.009	1.914	0.229	0.232	0.282
61	Nexen (2006)	WB-8	12	510796	6240826	8.37	3500	328	3781	0.38	6.2	0.024	4.604	0.213	0.217	0.280
62	Nexen (2006)	WB-9	12	510045	6239639	6.88	1100	116	1394	0.20	1.4	0.005	1.408	0.210	0.214	0.286
63	Nexen (2006)	WB-10	12	505462	6237321	7.04	3320	468	5379	0.08	7.3	0.031	7.213	0.186	0.190	0.280
64	Nexen (2006)	WB-11	12	505974	6236832	7.19	3320	468	5379	0.05	5.1	0.022	7.263	0.185	0.189	0.270
65	Nexen (2006)	WB-12	12	501879	6236679	6.81	2340	307	3355	0.05	2.2	0.010	4.436	0.183	0.188	0.306
66	Nexen (2006)	Kinosis Lake (WB-13)	12	499075	6242907	7.68	2940	292	3294	0.60	36.2	0.152	4.249	0.192	0.196	0.271
67	Nexen (2006)	Crazy Lake (WB-14)	12	496372	6243892	7.61	2260	248	2841	0.03	4.3	0.019	3.804	0.190	0.194	0.268
68	Nexen (2006)	WB-15	12	500338	6246824	7.09	1760	174	2024	0.04	3.1	0.013	2.662	0.212	0.215	0.285
69	Nexen (2006)	WB-16	12	500684	6245254	7.39	2200	251	2769	0.07	1.5	0.006	3.480	0.206	0.209	0.284
70	Nexen (2006)	WB-17	12	508515	6238866	7.52	860	97	1217	0.06	1.7	0.007	1.516	0.197	0.201	0.277
71	OPTI (2000)	Birch Lake	12	504735	6250684	7.50	40	90	1077	0.10	3.8	0.016	1.334	0.681	0.684	0.731
72	OPTI (2000)	Canoe Lake	12	498893	6257306	6.75	41	94	1015	1.21	6.1	0.018	0.859	0.247	0.250	0.295
73	OPTI (2000)	Frog Lake	12	504560	6254263	7.69	88	181	2244	0.23	8.3	0.035	2.858	0.269	0.272	0.314
74	OPTI (2000)	Gregoire Lake	12	490791	6258330	7.90	52	113	1223	26.80	260.3	0.856	1.113	0.221	0.224	0.262
75	OPTI (2000)	Poison Lake	12	505163	6252734	8.00	96	187	2160	0.21	3.2	0.012	2.586	0.341	0.345	0.388
76	OPTI (2000)	Push Up Lake	12	503243	6248993	7.70	38	94	892	0.17	0.9	0.003	0.780	0.335	0.338	0.392
77	OPTI (2000)	Rat Lake	12	507479	6251618	7.70	103	206	2388	0.52	23.1	0.094	2.964	0.376	0.379	0.419
78	OPTI (2000)	Sucker Lake	12	508438	6252919	8.27	113	219	2537	0.57	28.0	0.111	3.066	0.299	0.302	0.340
79	OPTI (2000)	Lake 1	12	502641	6249587	5.99	8	26	268	0.08	2.3	0.010	0.255	0.307	0.310	0.364
80	OPTI (2000)	Lake 11	12	481200	6244167	5.90	7	---	241	0.07	0.8	0.003	0.199	0.214	0.219	0.287
81	OPTI (2000)	Surmont Lake	12	489293	6240490	8.00	21	---	630	0.65	87.5	0.298	0.596	0.216	0.222	0.280
82	OPTI (2000)	Lake 8	12	490500	6238041	7.40	18	---	556	0.06	0.8	0.003	0.606	0.209	0.216	0.270
83	OPTI (2000)	Engstrom Lake	12	505720	6227876	---	---	---	---	---	---	---	3.080	0.185	0.192	0.403
84	OPTI (2000)	Caribou Horn	12	501287	6264415	7.64	92	185	2022	0.51	8.5	0.033	2.414	0.219	0.222	0.256
85	OPTI (2000)	Kiskatinaw Lake	12	499693	6266314	7.90	74	182	1985	0.87	30.1	0.124	2.472	0.221	0.223	0.257
86	OPTI (2000)	Unnamed Lake	12	493712	6225765	8.05	42	84	758	1.35	33.8	0.125	0.795	0.177	0.189	0.237

Note(s)

--- No data or not applicable

(a) Refers to Figure 7.2-3



Legend

Box and Whisker Plots:

- Dark bar: median
- Upper and lower box limits: 75th and 25th percentiles
- High and low lines: data range

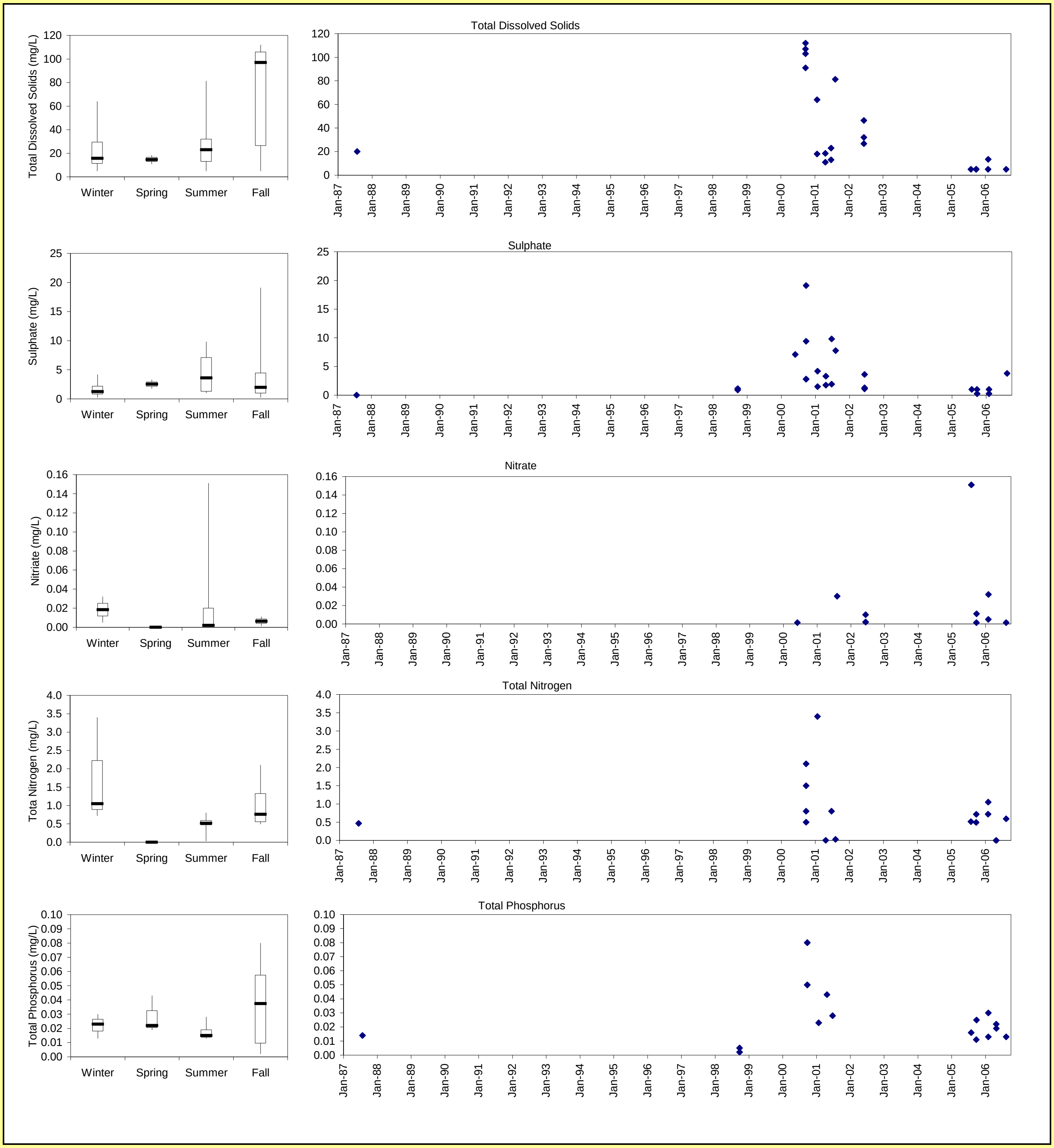
Title:

Water Chemistry Indicators in Waterbodies in the Hangingstone and Horse River Basin

NORTH AMERICAN OIL SANDS CORPORATION

Approved: DJ	Revision Date: March 31, 2007
File:	

Drawn by: DJ	Checked: LD	Fig. No.: 7.5-1a



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Box and Whisker Plots:

Dark bar: median

Upper and lower box limits: 75^{th} and 25^{th} percentiles

High and low lines: data range

Title:

Water Chemistry Indicators in Waterbodies in the Hangingstone and Horse River Basin

NORTH AMERICAN OIL SANDS CORPORATION

Approved: DJ	Revision Date: March 31, 2007
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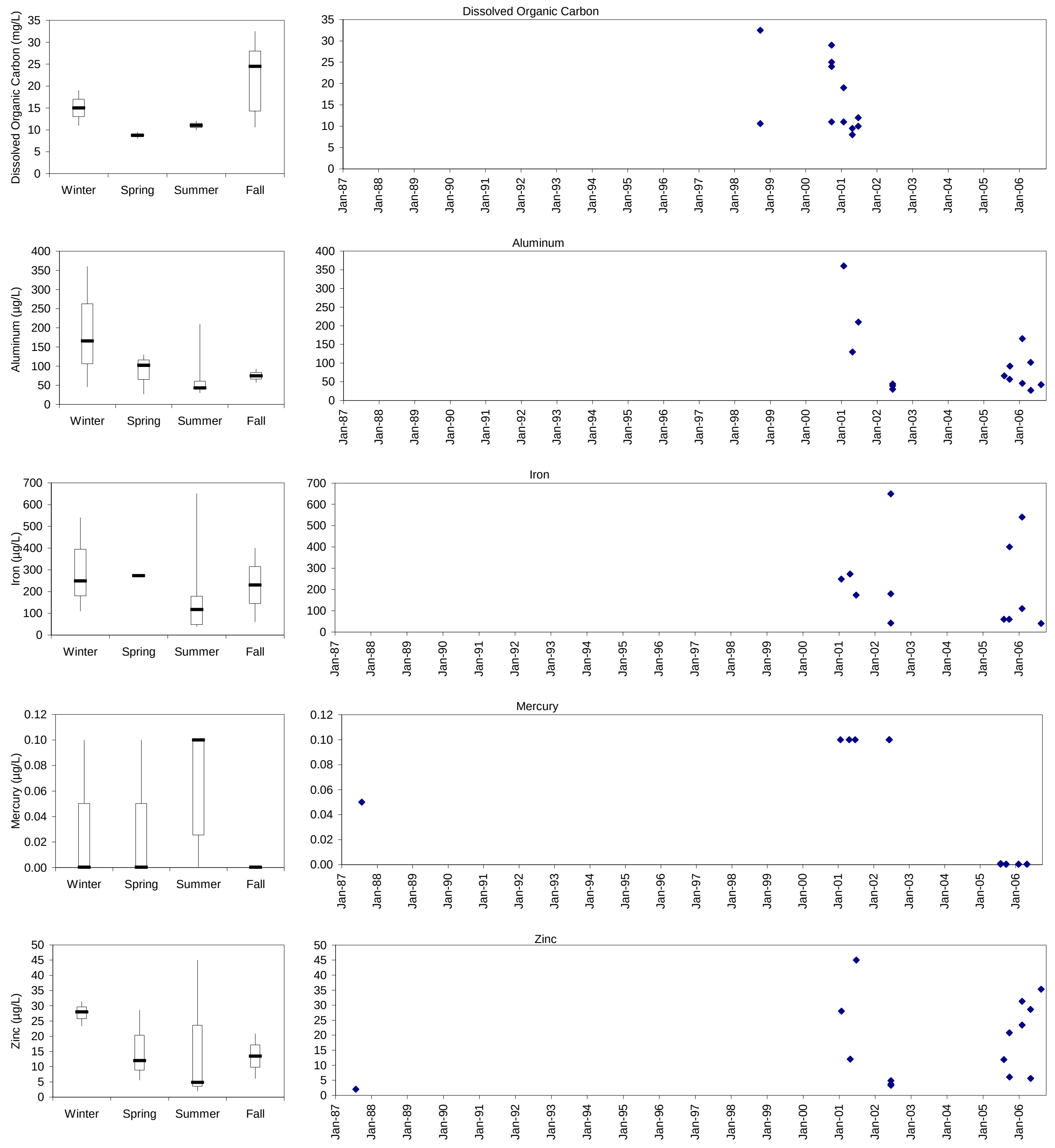

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Box and Whisker Plots:

- Dark bar: median
- Upper and lower box limits: 75th and 25th percentiles
- High and low lines: data range

Title:

Water Chemistry Indicators in Waterbodies in the Hangingstone and Horse River Basin

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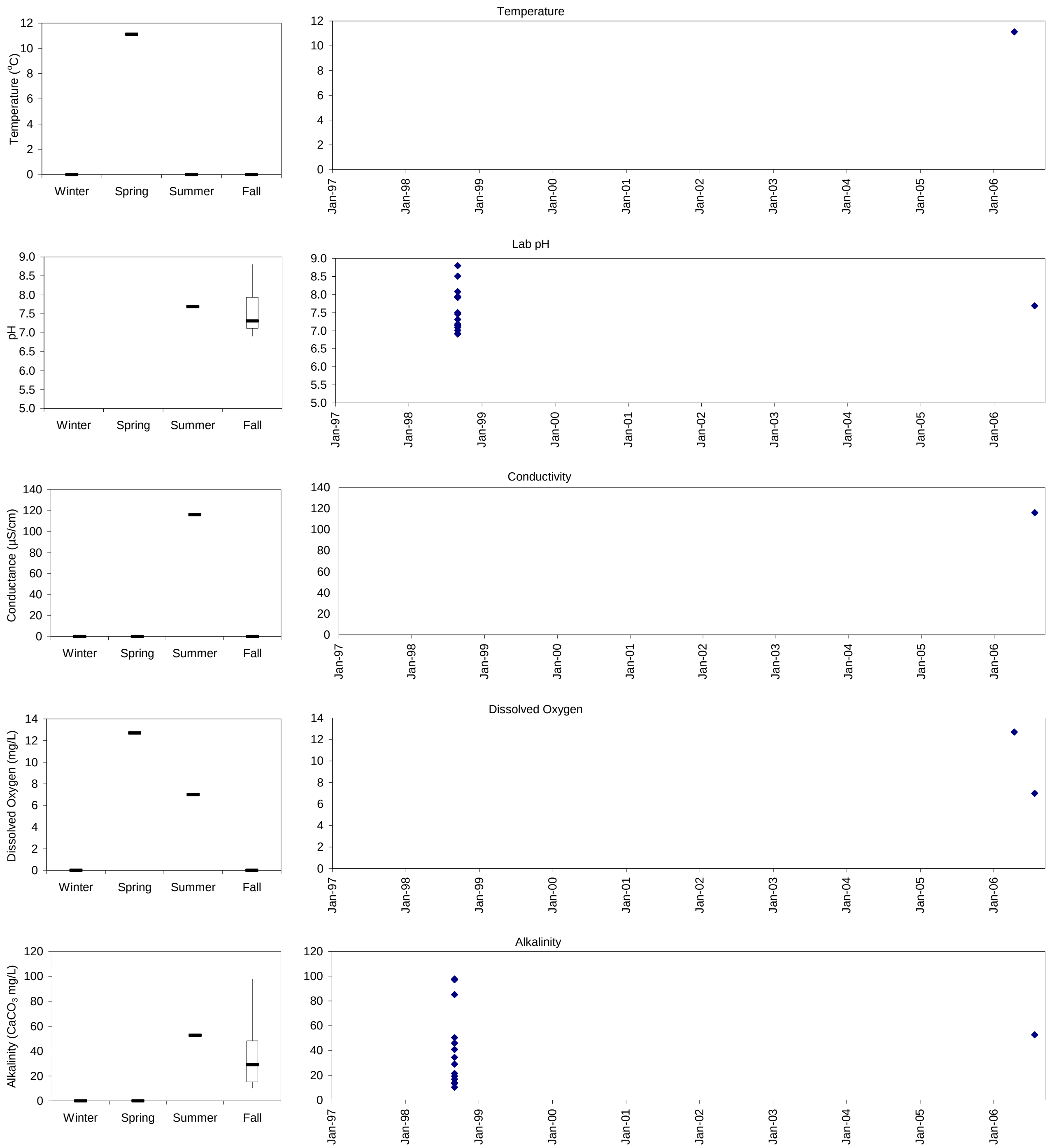

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Box and Whisker Plots:

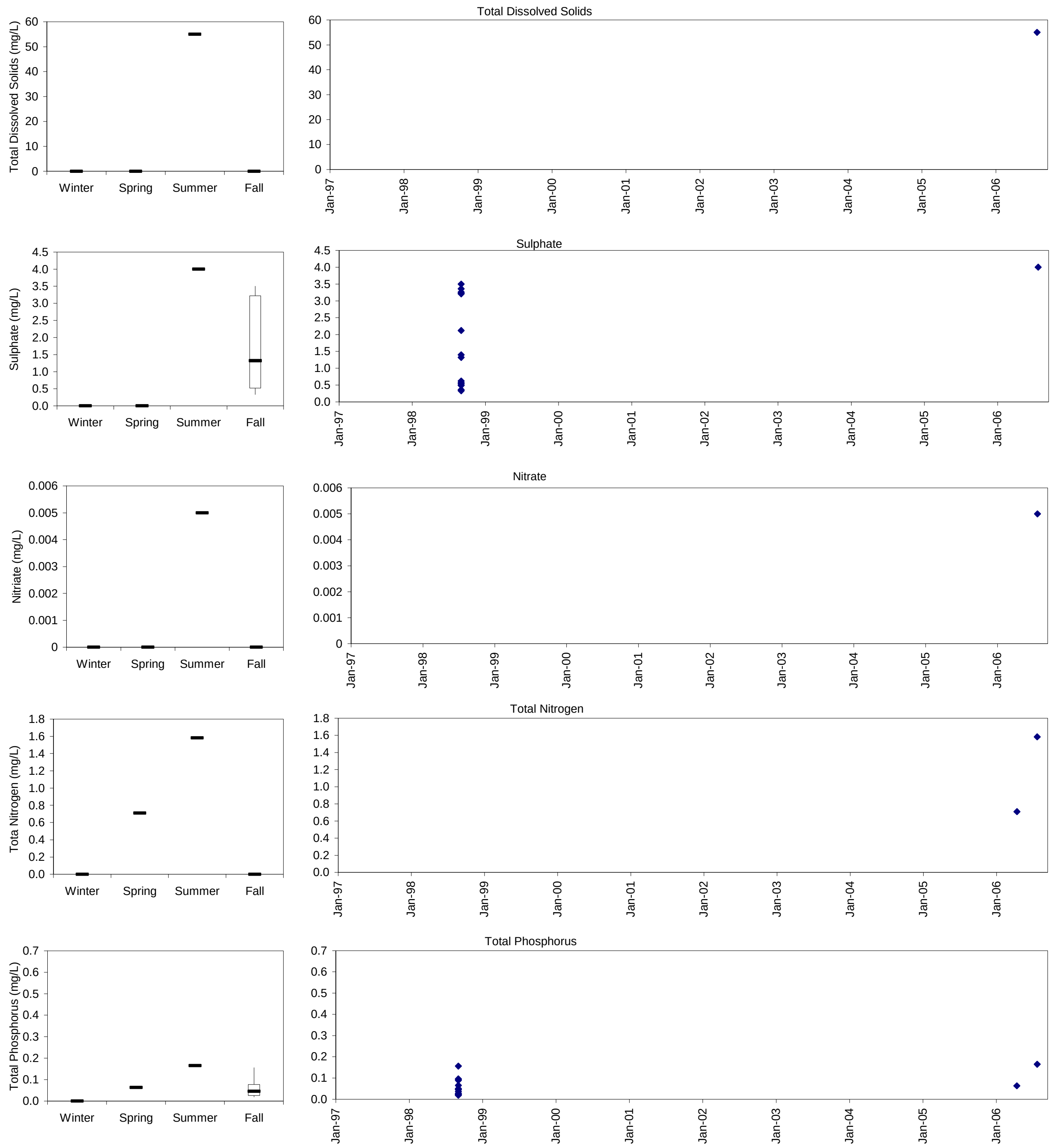
- Dark bar: median
- Upper and lower box limits: 75th and 25th percentiles
- High and low lines: data range

Title:

Water Chemistry Indicators in Waterbodies in the House River Basin

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date: March 31, 2007	
File:		
Drawn by: DJ	Checked: LD	Fig. No.: 7.5-2a



Legend

Box and Whisker Plots:

Dark bar: median

Upper and lower box limits: 75th and 25th percentiles

High and low lines: data range

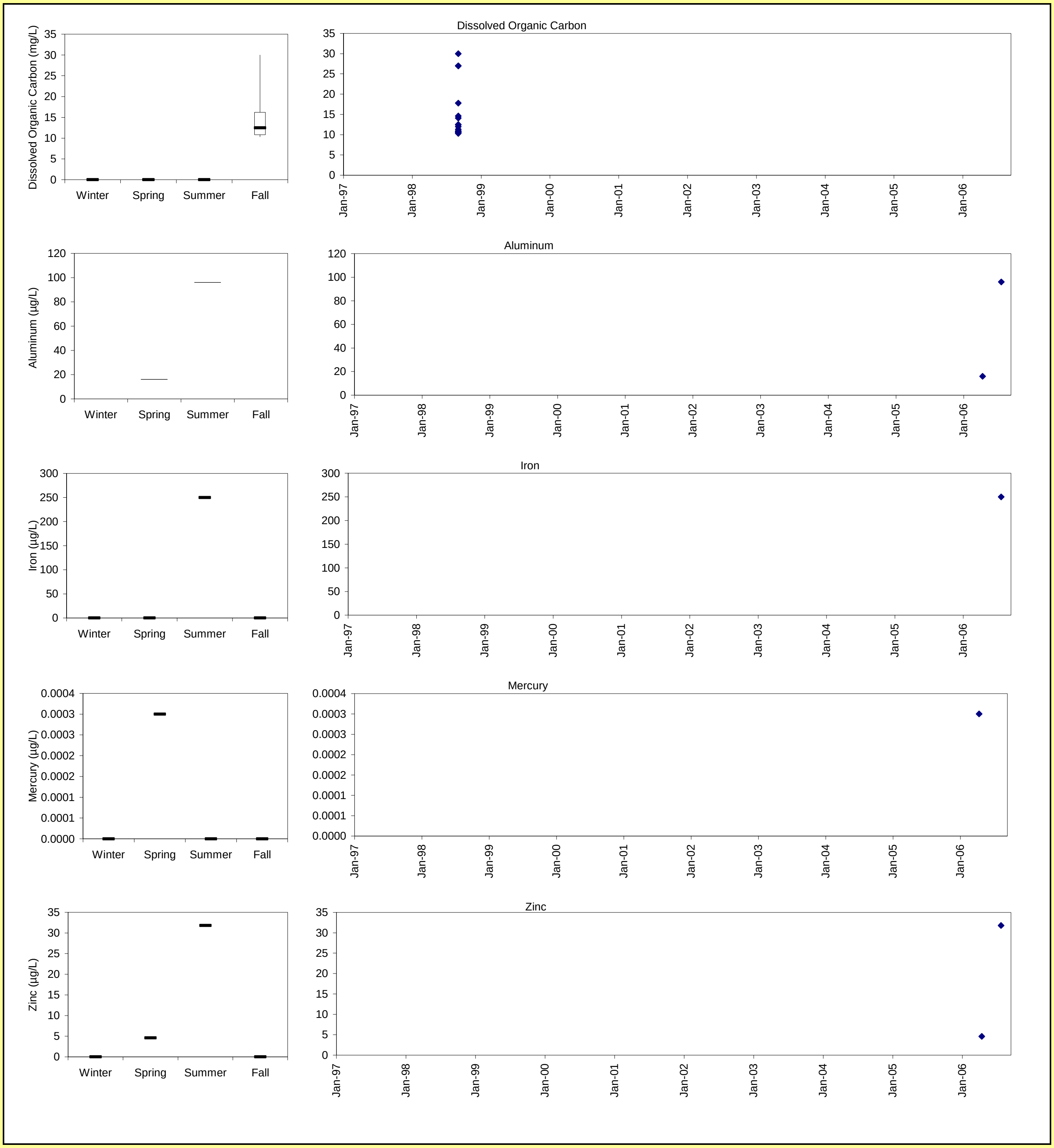
Title:

Water Chemistry Indicators in Waterbodies in the House River Basin

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date: March 31, 2007
File:	

Drawn by:	Checked:	Fig. No.:
DJ	LD	7.5-2b



Legend

Box and Whisker Plots:

Dark bar: median

Upper and lower box limits: 75th and 25th percentiles

High and low lines: data range

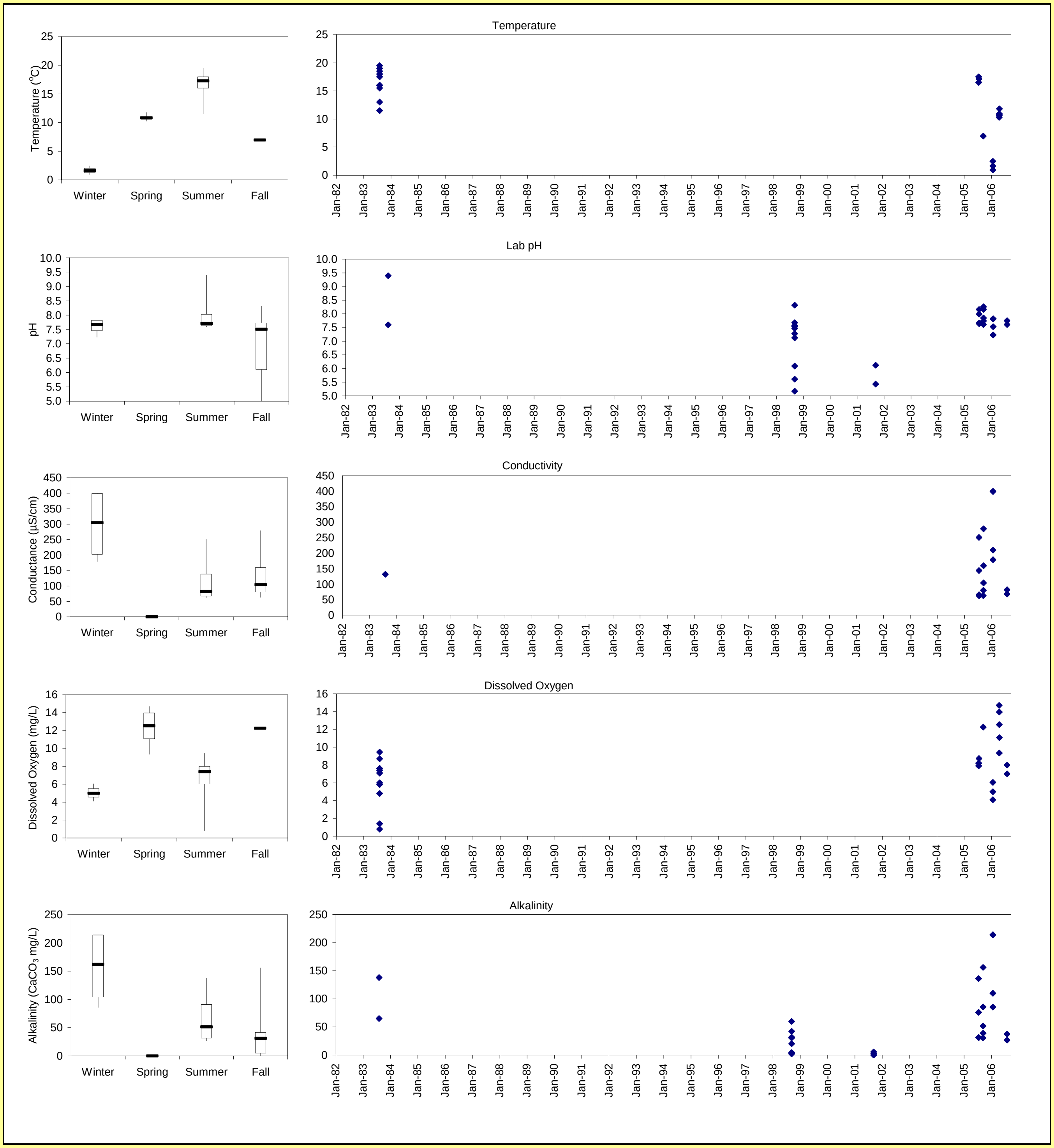
Title:

Water Chemistry Indicators in Waterbodies in the House River Basin

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date: March 31, 2007
File:	

Drawn by:	Checked:	Fig. No.:
DJ	LD	7.5-2c



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Box and Whisker Plots:

Dark bar: median
Upper and lower box limits: 75th and 25th percentiles
High and low lines: data range

Alkalinity value of 0 mg/L (October 1, 2001) reported by WRS, 2004

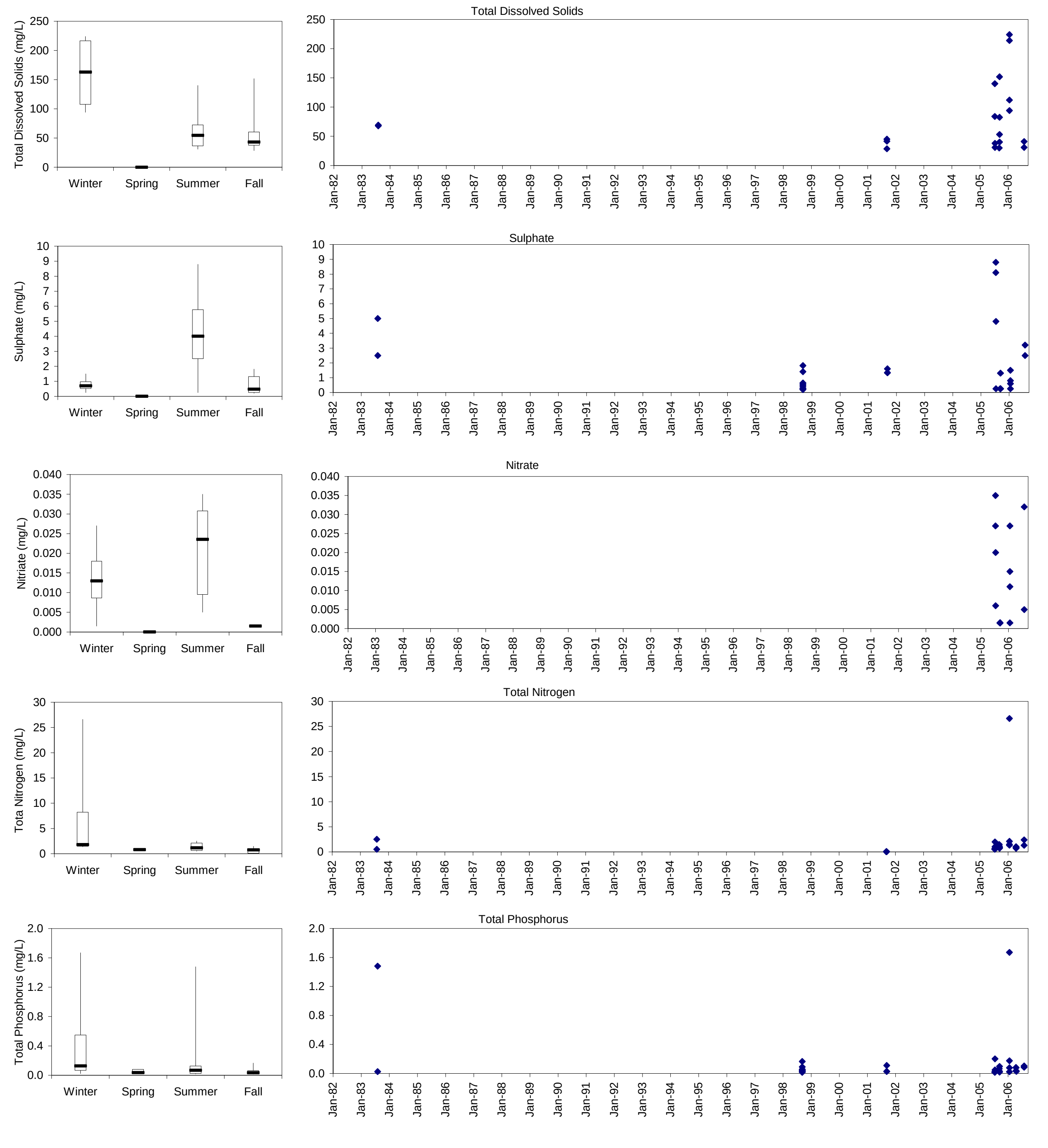
Title:

Water Chemistry Indicators in Waterbodies in the Upper Christina River Basin

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date: March 31, 2007
File:	

Drawn by:	Checked:	Fig. No.:
DJ	LD	7.5-3a



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Box and Whisker Plots:

- Dark bar: median
- Upper and lower box limits: 75th and 25th percentiles
- High and low lines: data range

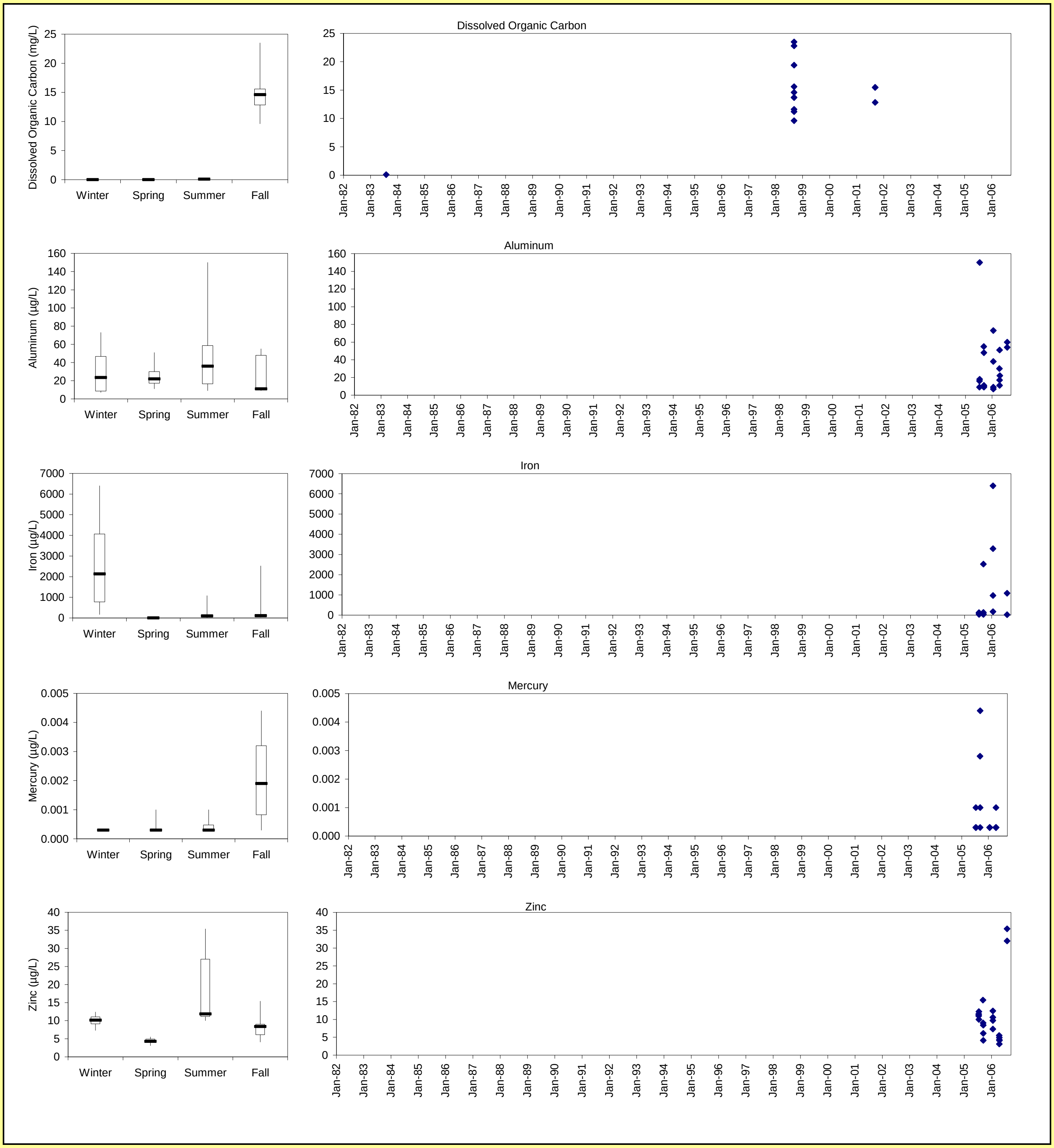
Title:

Water Chemistry Indicators in Waterbodies in the Upper Christina River Basin

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date: March 31, 2007
File:	

Drawn by: DJ	Checked: LD	Fig. No.: 7.5-3b



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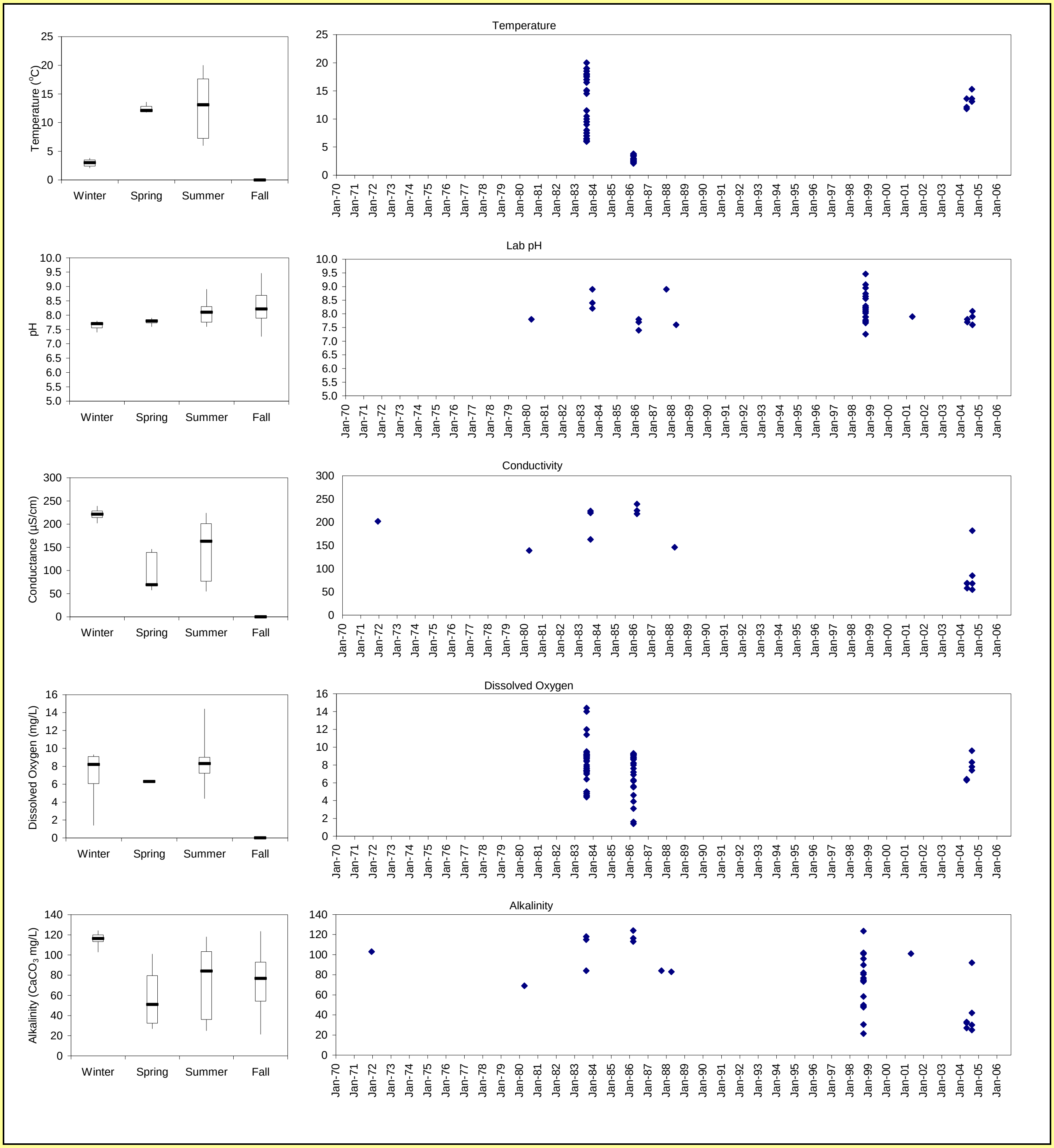
Box and Whisker Plots:

Dark bar: median

Upper and lower box limits: 75th and 25th percentiles

High and low lines: data range

Title: Water Chemistry Indicators in Waterbodies in the Upper Christina River Basin	NORTH AMERICAN OIL SANDS CORPORATION
Approved:	Revision Date: March 31, 2007
File:	
Drawn by: DJ	Checked: LD
Fig. No.: 7.5-3c	



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Box and Whisker Plots:

Dark bar: median

Upper and lower box limits: 75th and 25th percentiles

High and low lines: data range

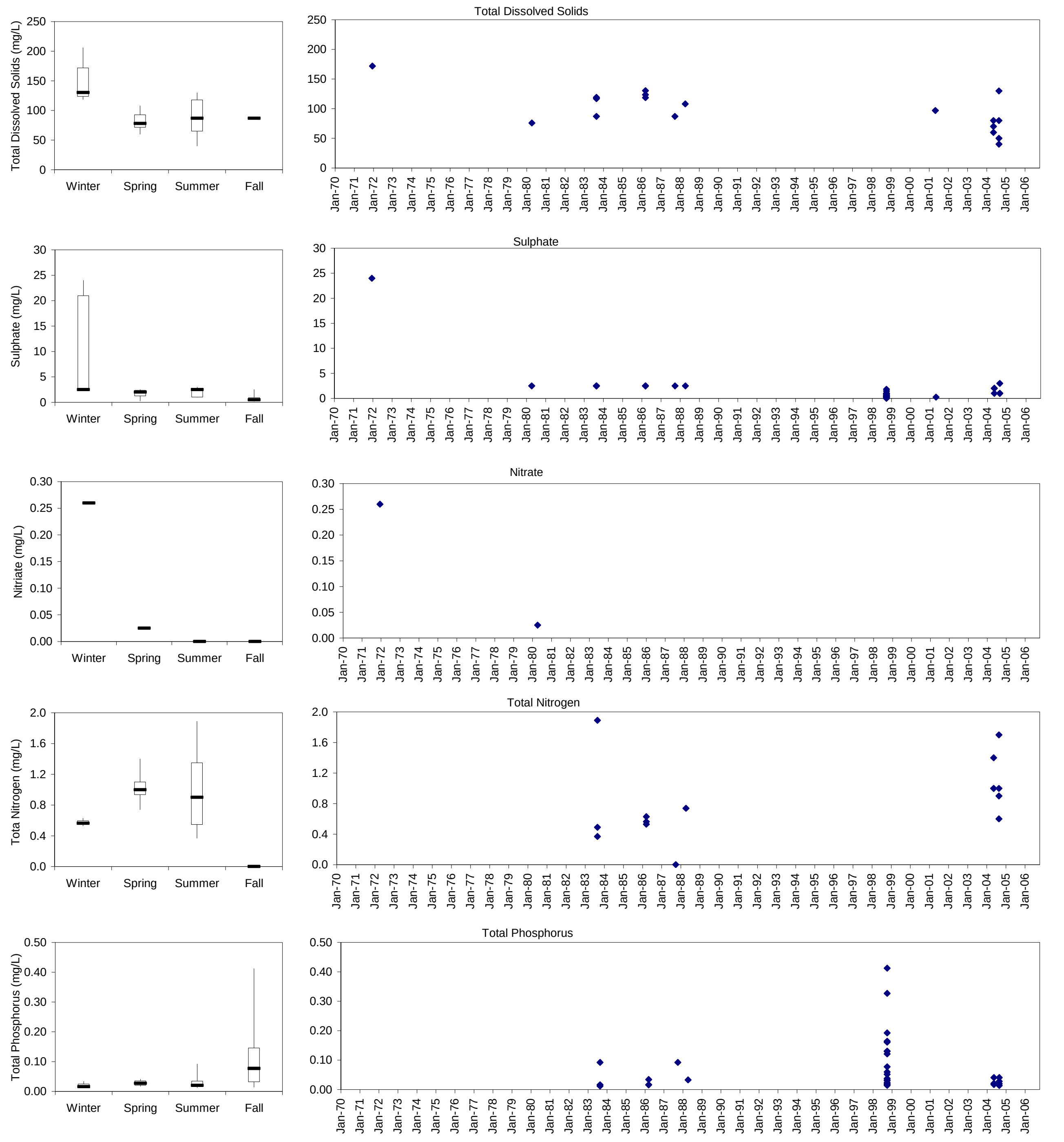
Title:

Water Chemistry Indicators in Waterbodies in the Mid-Christina River Basin

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date: March 31, 2007
File:	

Drawn by:	Checked:	Fig. No.:
DJ	LD	7.5-4a



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Box and Whisker Plots:

Dark bar: median

Upper and lower box limits: 75th and 25th percentiles

High and low lines: data range

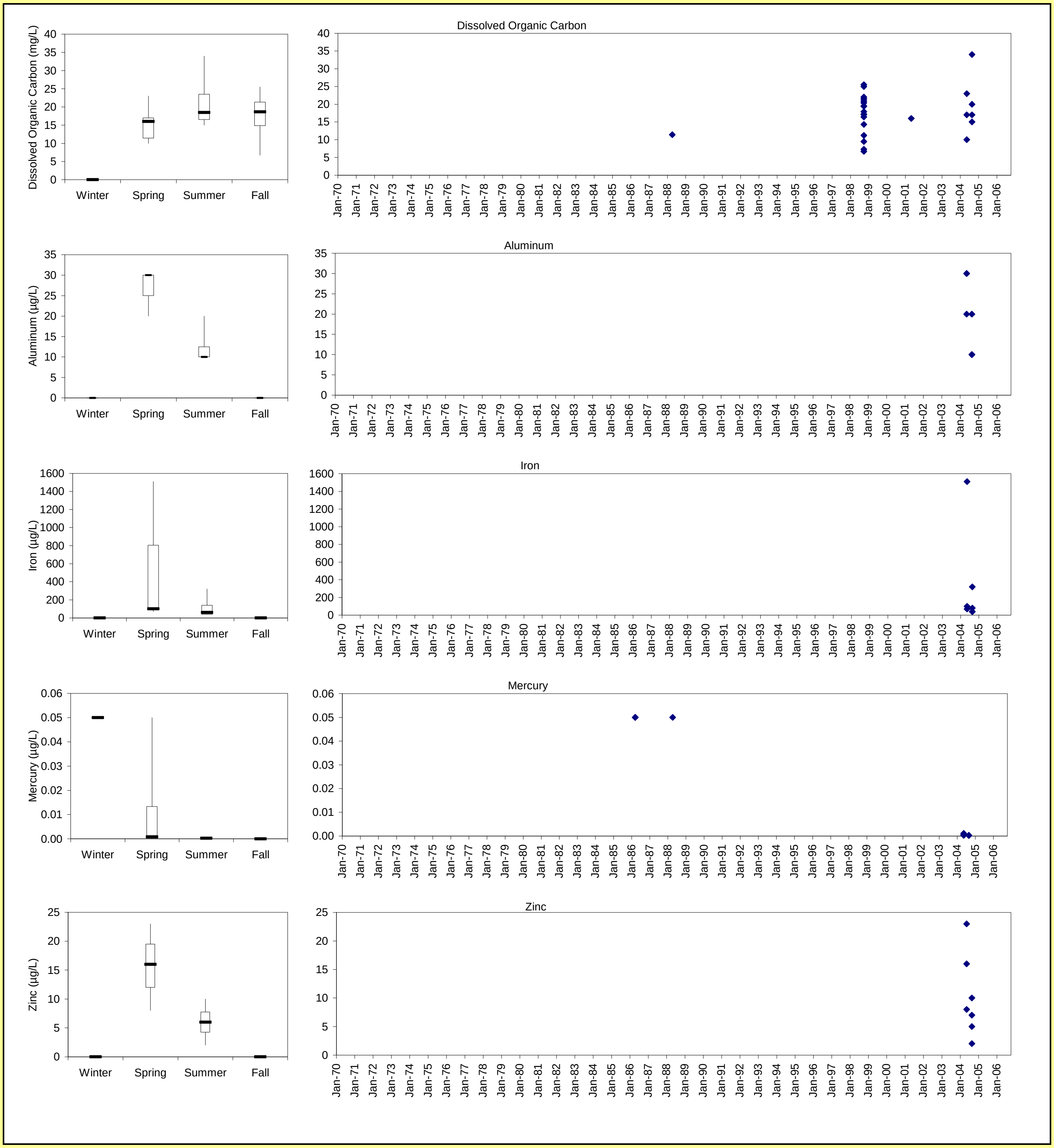
Title:

Water Chemistry Indicators in Waterbodies in the Mid-Christina River Basin

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date: March 31, 2007
File:	

Drawn by:	Checked:	Fig. No.:
DJ	LD	7.5-4b



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Upper and lower box limits: 75th and 25th percentiles

High and low lines: data range

Title:

Water Chemistry Indicators in Waterbodies in the Mid-Christina River Basin

NORTH AMERICAN OIL SANDS CORPORATION

Approved:

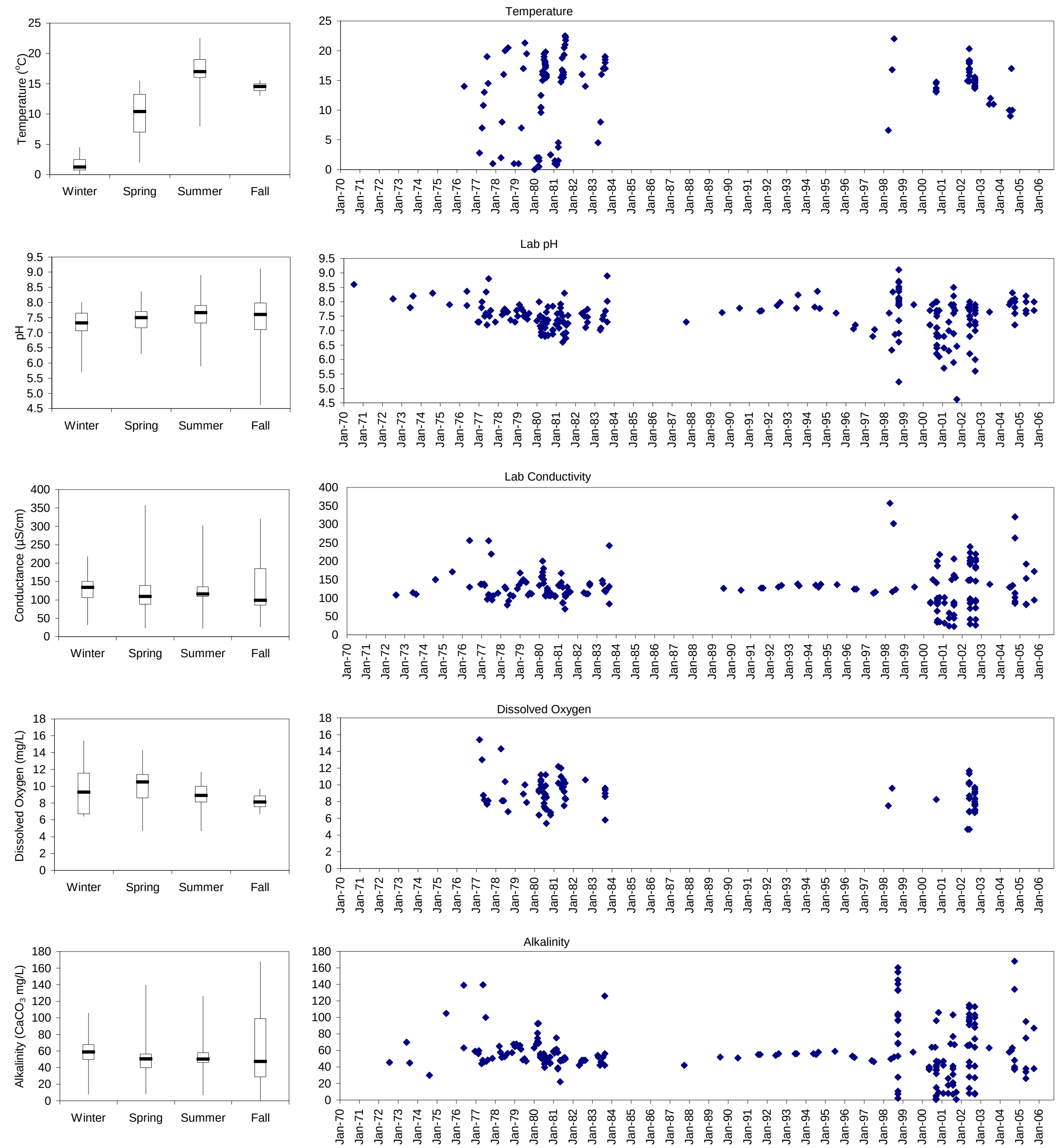
Revision Date: March 31, 2007

File:

Drawn by: DJ

Checked: LD

Fig. No.: 7.5-4c



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Box and Whisker Plots:

Dark bar: median
Upper and lower box limits: 75th and 25th percentiles
High and low lines: data range

Outlier(s) removed: Alkalinity 285 mg/L (July 22, 1970)

Title:

Water Chemistry Indicators in Waterbodies in the Lower Christina and Clearwater River Basin

NORTH AMERICAN OIL SANDS CORPORATION

Approved:

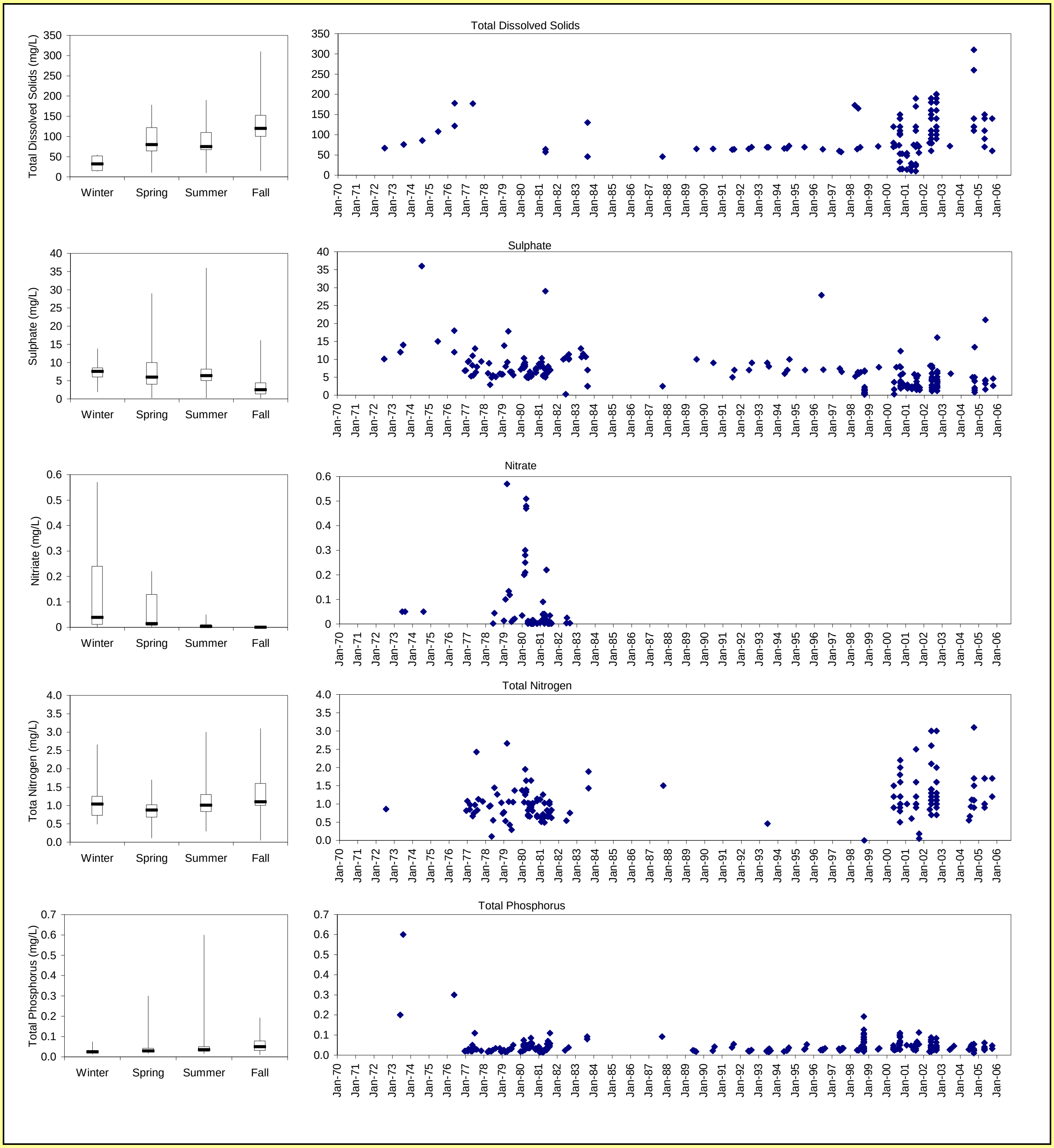
Revision Date: March 31, 2007

File:

Drawn by: DJ

Checked: LD

Fig. No.: 7.5-5a



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Box and Whisker Plots:

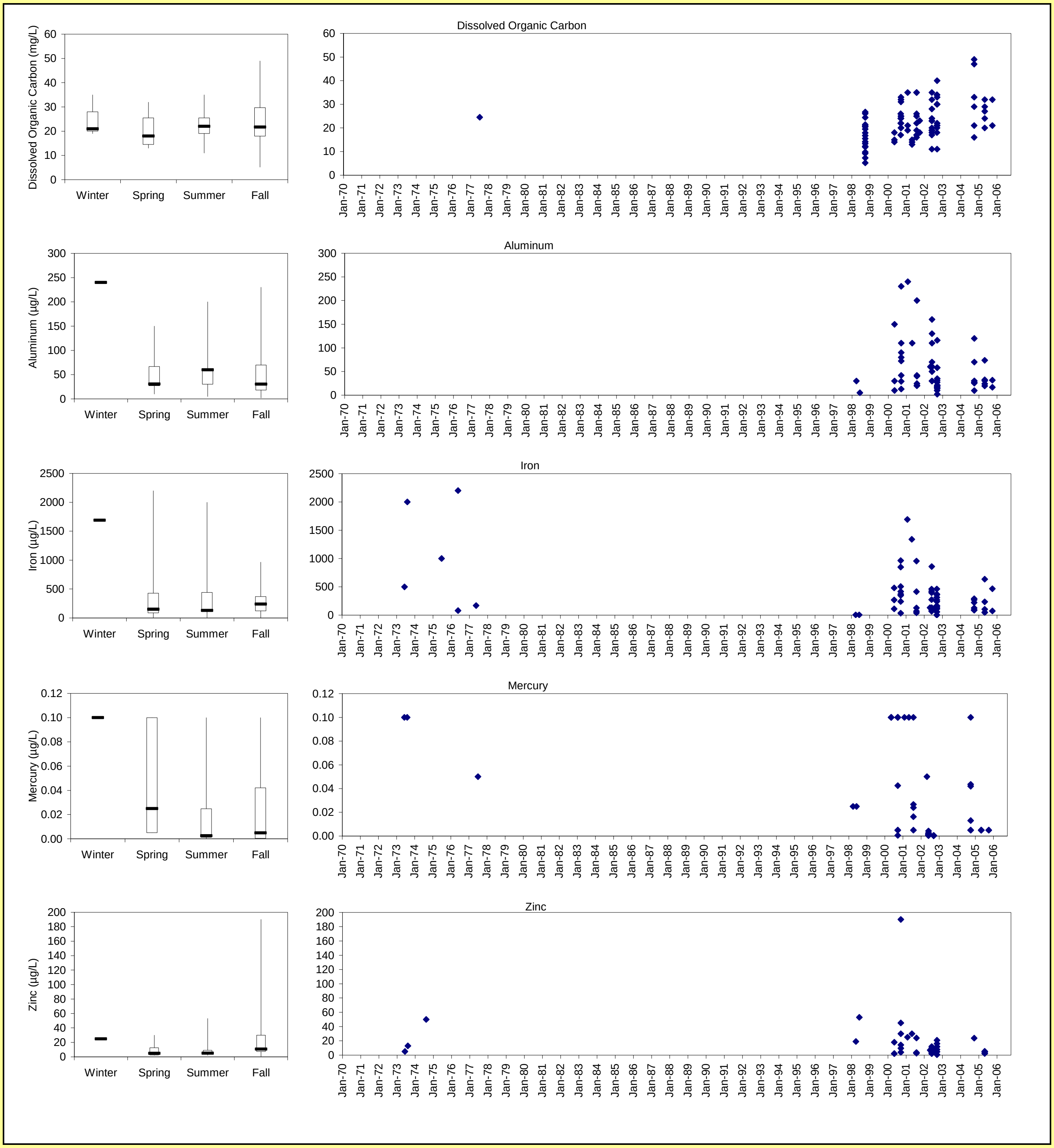
Dark bar: median

Upper and lower box limits: 75th and 25th percentiles

High and low lines: data range

Outlier(s) removed: Sulphate 96 mg/L (July 22, 1970); Total Phosphorus 2.4 mg/L (July 22, 1970)

Title: Water Chemistry Indicators in Waterbodies in the Lower Christina and Clearwater River Basin	NORTH AMERICAN OIL SANDS CORPORATION
Approved:	Revision Date: March 31, 2007
File:	
Drawn by: DJ	Checked: LD
Fig. No.: 7.5-5b	



Legend

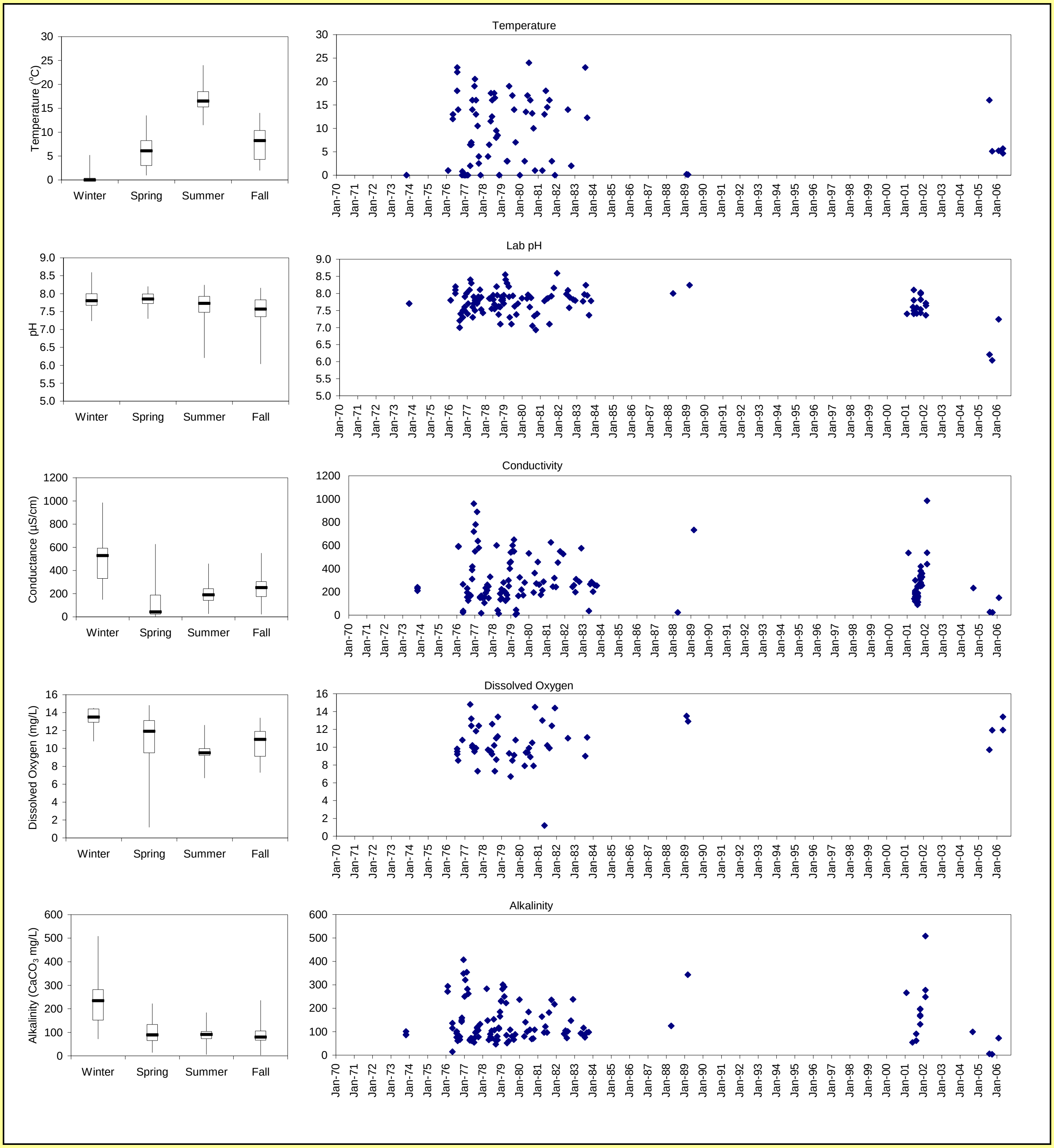
Box and Whisker Plots:

Dark bar: median

Upper and lower box limits: 75th and 25th percentiles

High and low lines: data range

Title: Water Chemistry Indicators in Waterbodies in the Lower Christina and Clearwater River Basin	NORTH AMERICAN OIL SANDS CORPORATION	
	Approved:	Revision Date: March 31, 2007
	File:	
	Drawn by: DJ	Checked: LD
	Fig. No.: 7.5-5c	



Legend

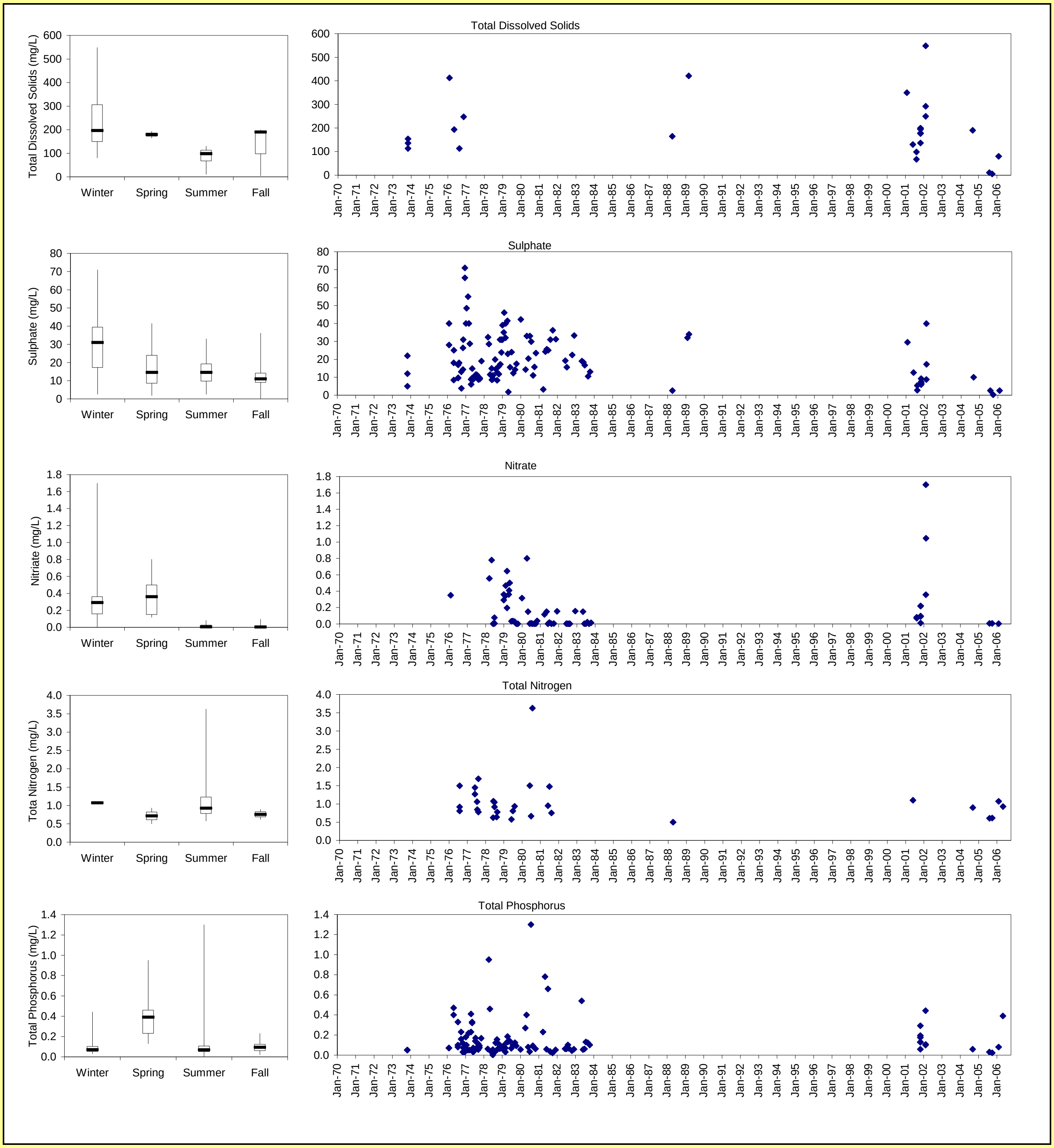
Box and Whisker Plots:

Dark bar: median

Upper and lower box limits: 75th and 25th percentiles

High and low lines: data range

Title: Water Chemistry Indicators in Watercourses in the Hangingstone and Horse River Basin	NORTH AMERICAN OIL SANDS CORPORATION
Approved:	Revision Date: April 1, 2007
File:	
Drawn by: DJ	Checked: LD
Fig. No.: 7.5-6a	



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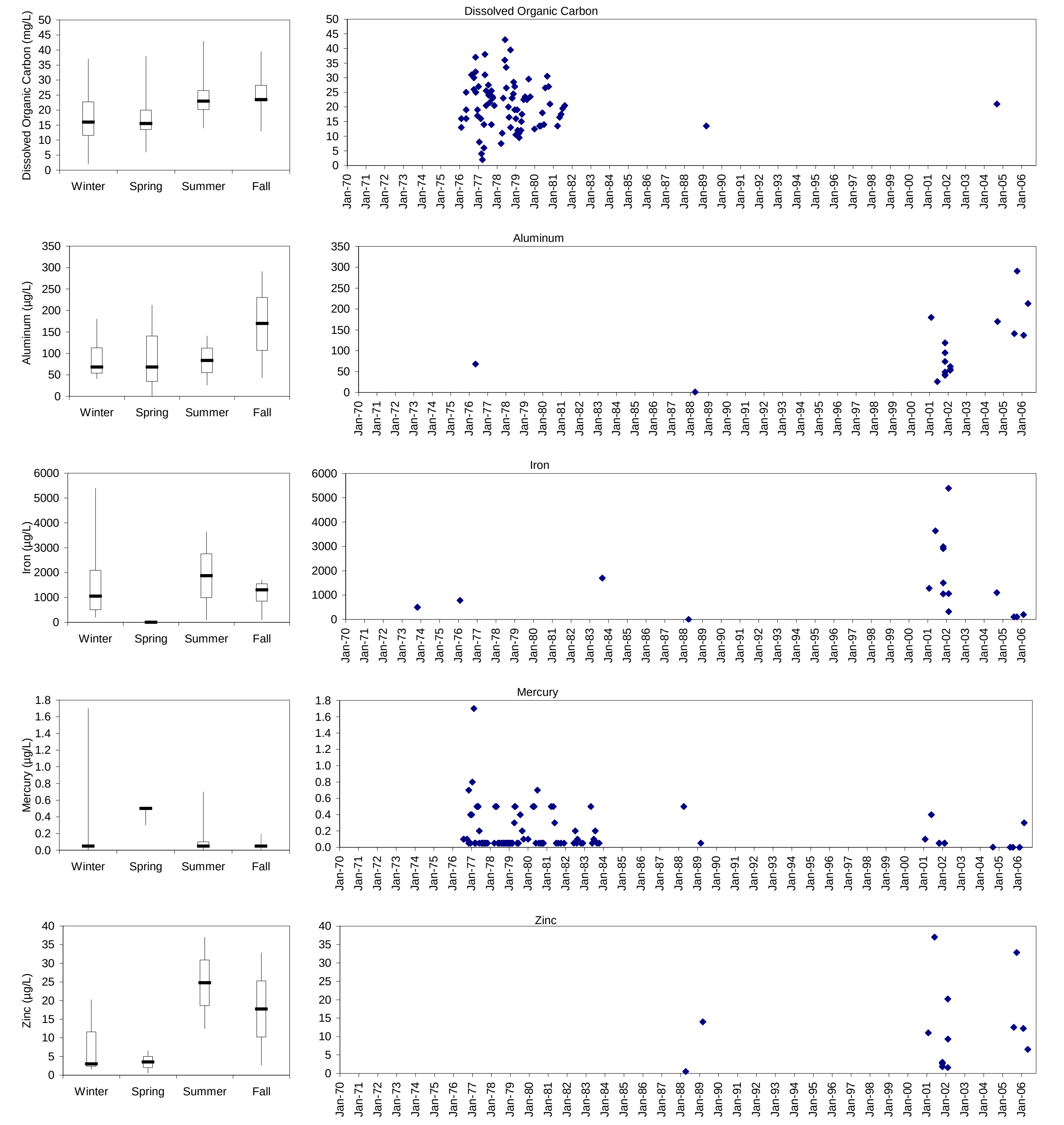
Box and Whisker Plots:

Dark bar: median

Upper and lower box limits: 75th and 25th percentiles

High and low lines: data range

Title: Water Chemistry Indicators in Watercourses in the Hangingstone and Horse Basin	NORTH AMERICAN OIL SANDS CORPORATION	
	Approved:	Revision Date: April 1, 2007
	File:	
	Drawn by: DJ	Checked: LD
	Fig. No.: 7.5-6b	



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Box and Whisker Plots:

Dark bar: median

Upper and lower box limits: 75th and 25th percentiles

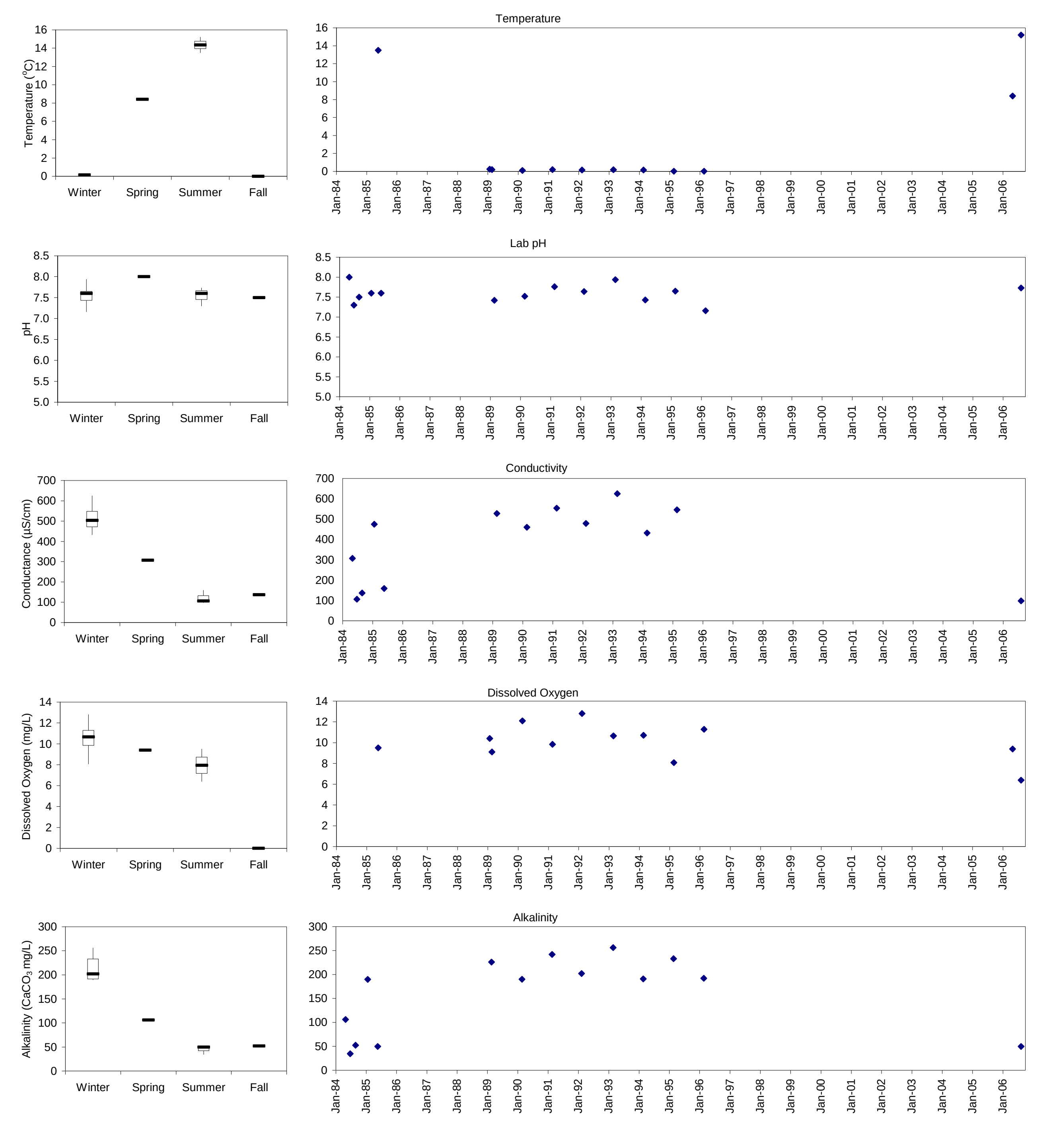
High and low lines: data range

Title:

Water Chemistry Indicators in the Watercourses in the Hangingstone and Horse Basin

NORTH AMERICAN OIL SANDS CORPORATION

Approved:		Revision Date: April 1, 2007
File:		
Drawn by: DJ	Checked: LD	Fig. No.: 7.5-6c



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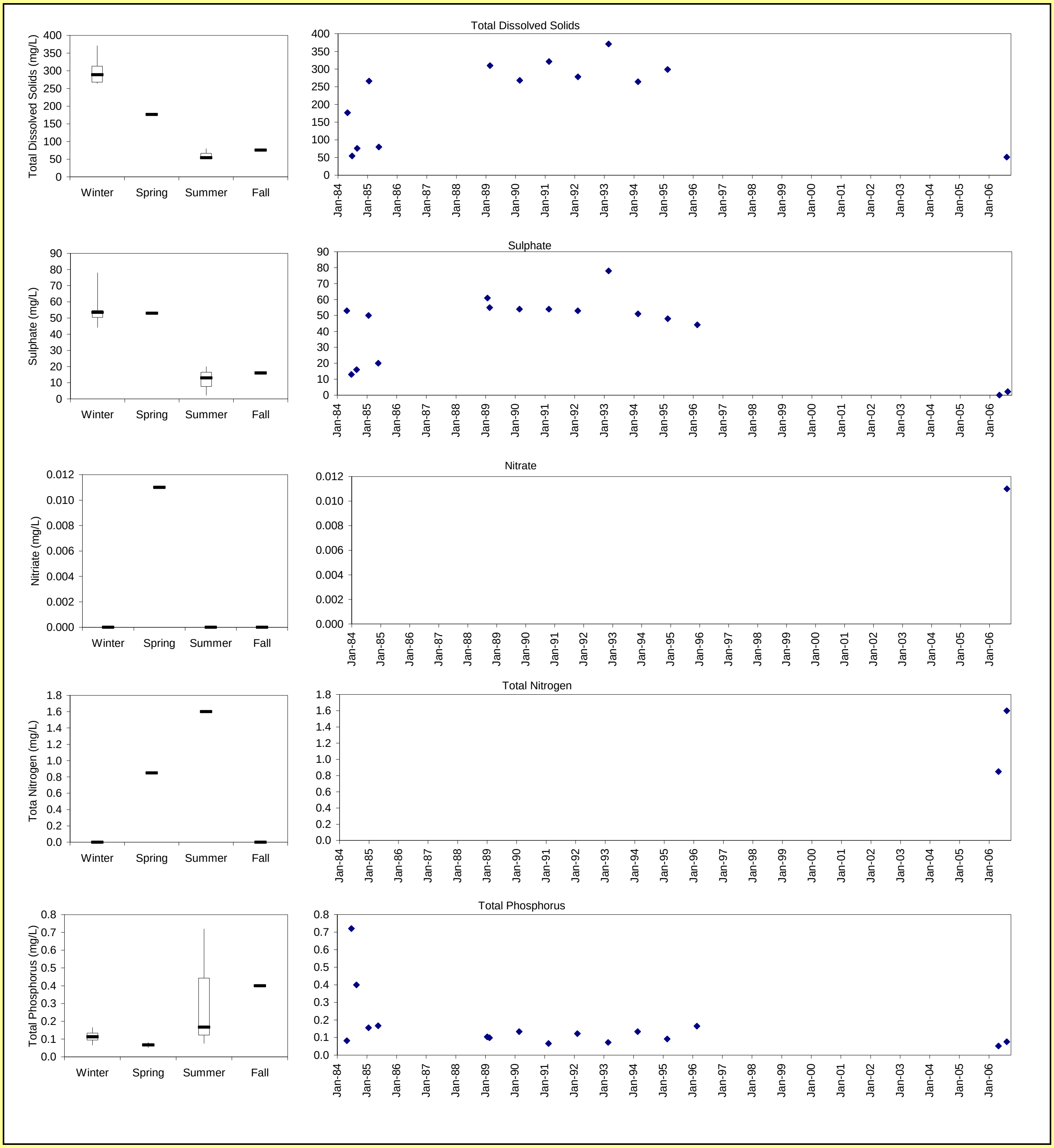
Box and Whisker Plots:

- Dark bar: median
- Upper and lower box limits: 75th and 25th percentiles
- High and low lines: data range

Title: Water Chemistry Indicators in Watercourses in the House River Basin	NORTH AMERICAN OIL SANDS CORPORATION
Approved:	Revision Date: April 1, 2007
File:	
Drawn by: DJ	Checked: LD
Fig. No.: 7.5-7a	



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Box and Whisker Plots:

Dark bar: median

Upper and lower box limits: 75th and 25th percentiles

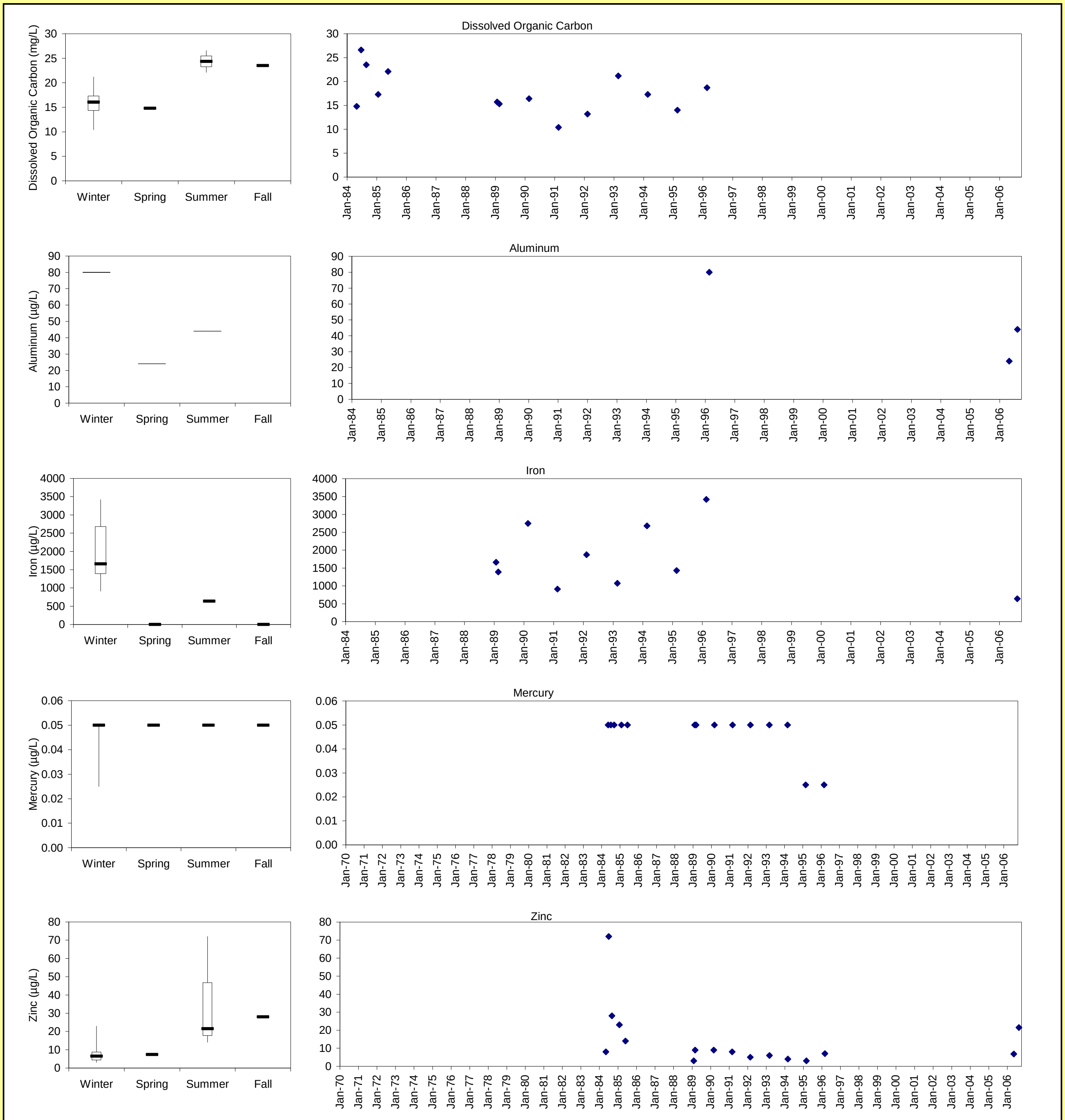
High and low lines: data range

Title:

Water Chemistry Indicators in Watercourses in the House River Basin

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date: April 1, 2007	
File:		
Drawn by: DJ	Checked: LD	Fig. No.: 7.5-7b



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Box and Whisker Plots:

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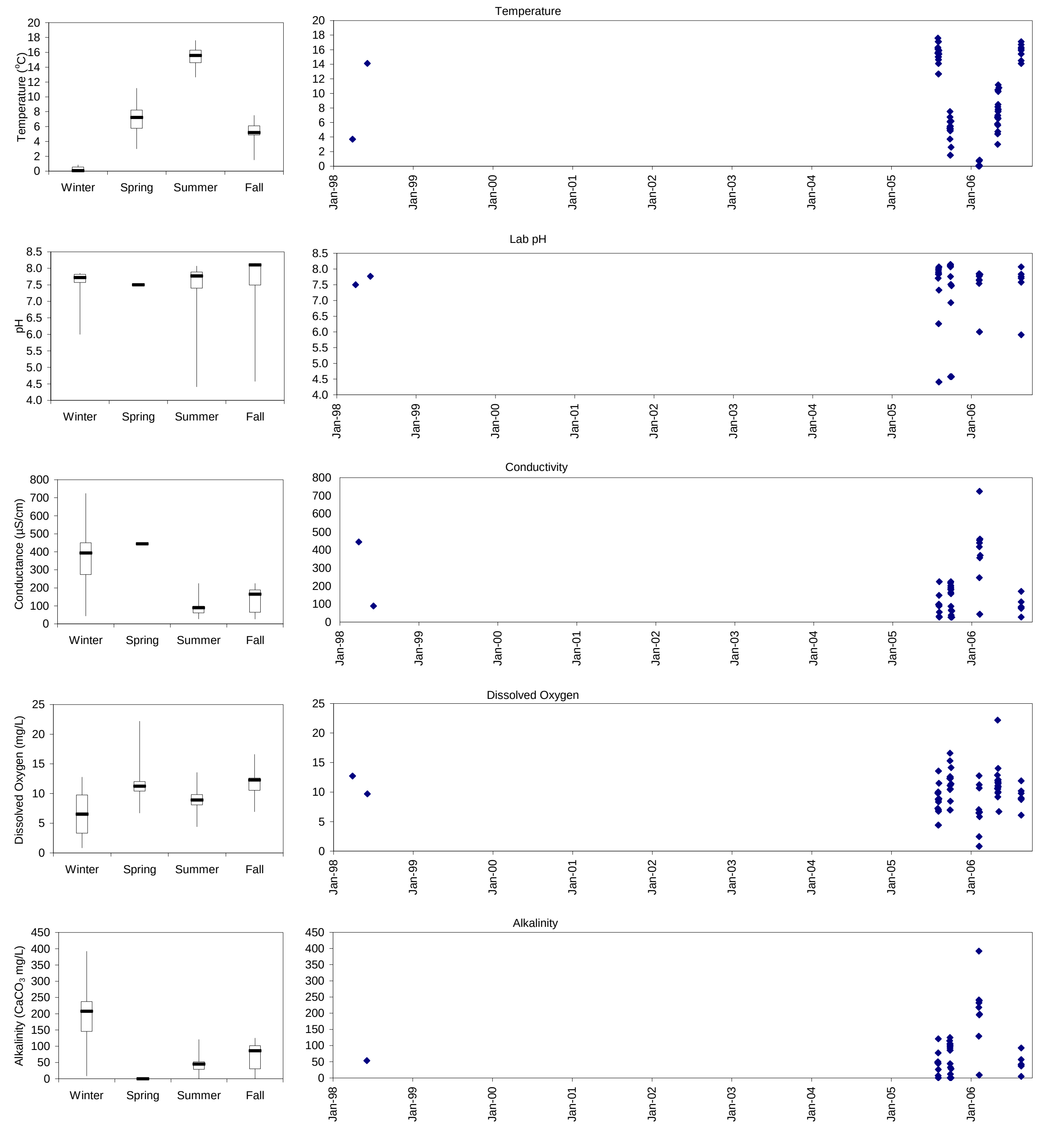
Upper and lower box limits: 75th and 25th percentiles

High and low lines: data range

Title: Water Chemistry Indicators in Watercourses in the House River Basin	NORTH AMERICAN OIL SANDS CORPORATION
Approved:	Revision Date: April 1, 2007
File:	
Drawn by: DJ	Checked: LD
Fig. No.: 7.5-7c	



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Box and Whisker Plots:

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Upper and lower box limits: 75th and 25th percentiles

High and low lines: data range

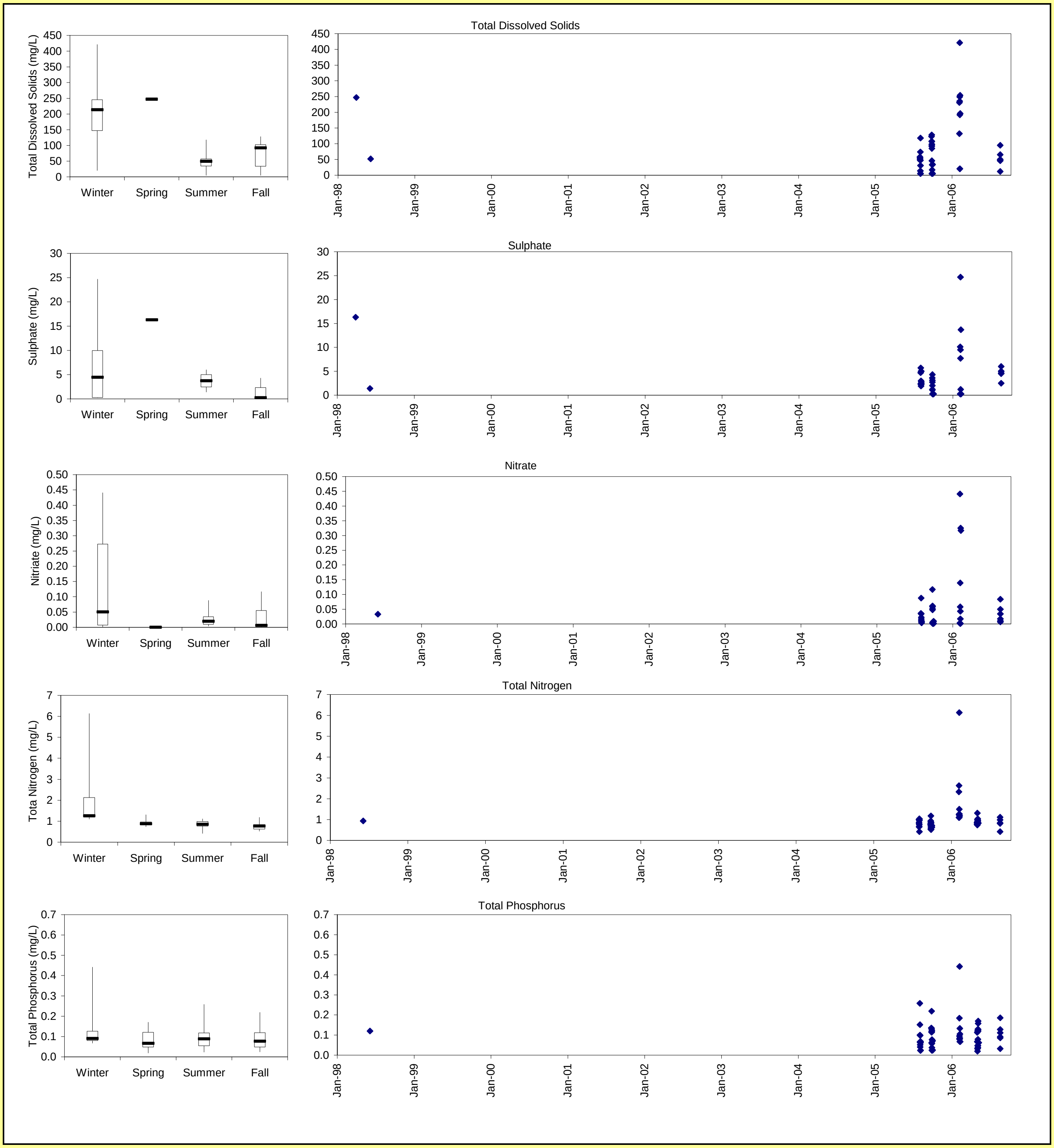
Title:

Water Chemistry Indicators in Watercourses in the Upper Christina River Basin

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date: April 1, 2007
File:	

Drawn by:	Checked:	Fig. No.:
DJ	LD	7.5-8a



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Box and Whisker Plots:

Dark bar: median

Upper and lower box limits: 75th and 25th percentiles

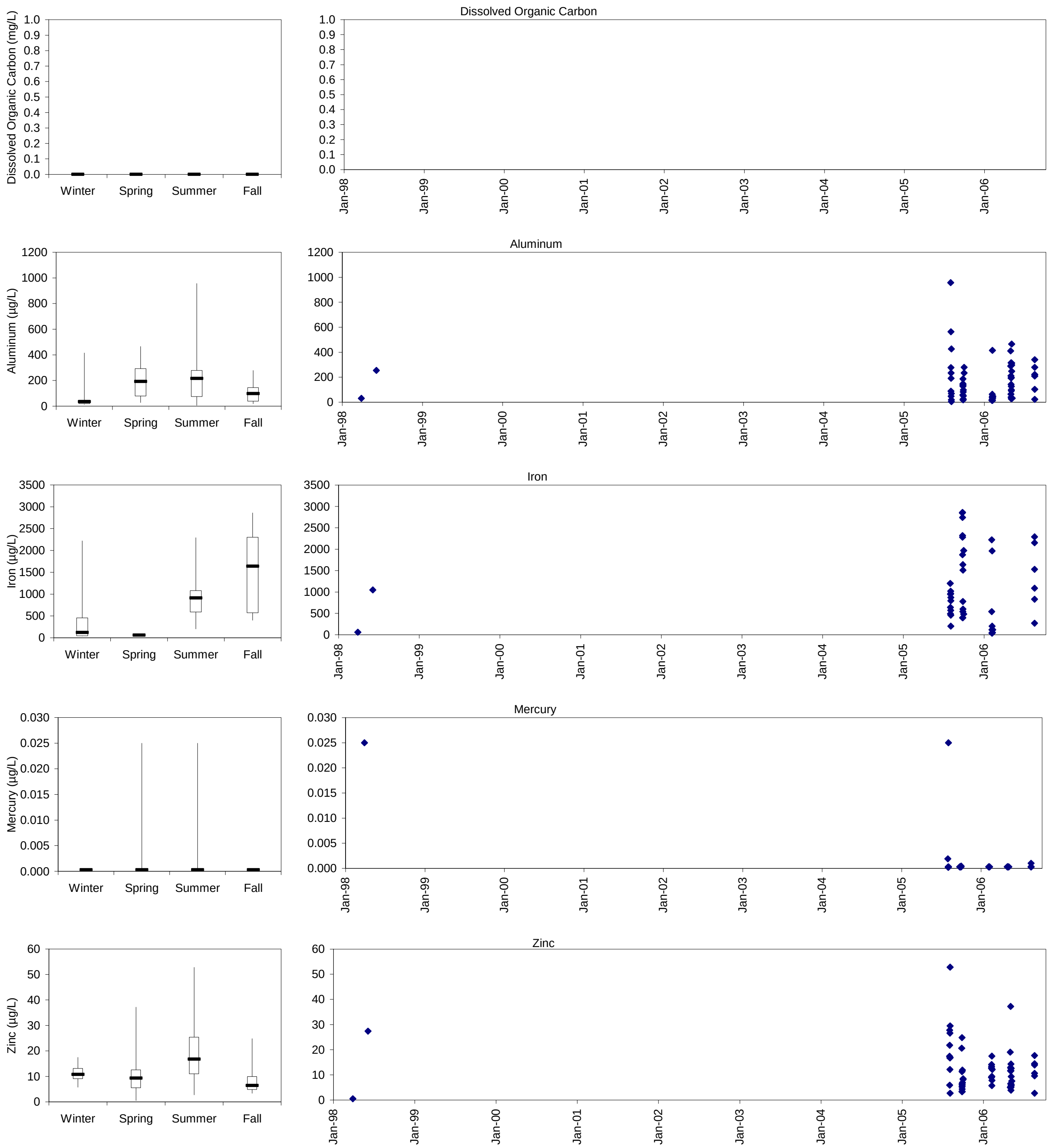
High and low lines: data range

Title:

Water Chemistry Indicators in Watercourses in the Upper Christina River Basin

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date: April 1, 2007	
File:		
Drawn by: DJ	Checked: LD	Fig. No.: 7.5-8b



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Box and Whisker Plots:

Dark bar: median

Upper and lower box limits: 75th and 25th percentiles

High and low lines: data range

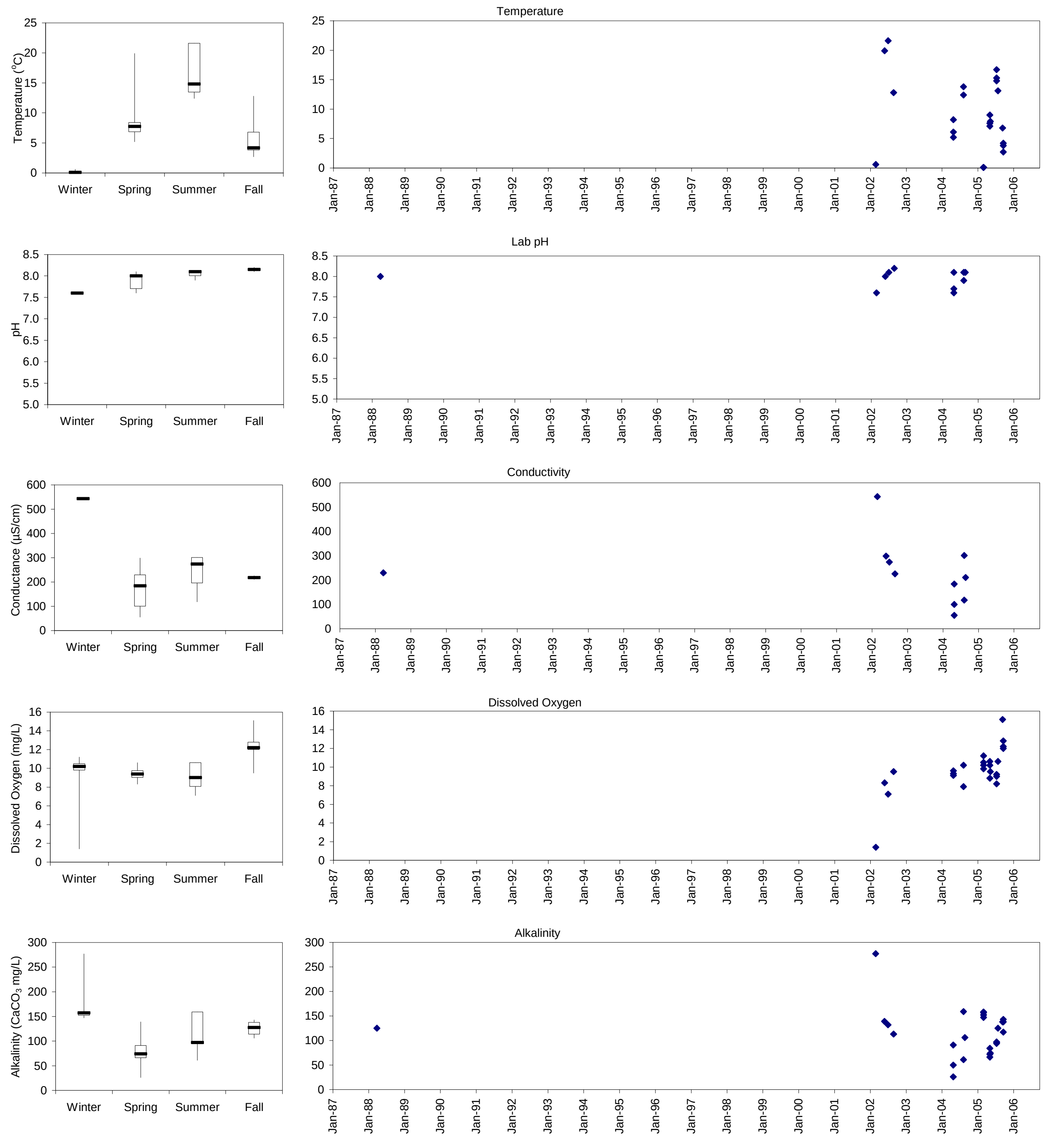
Title:

Water Chemistry Indicators in Watercourses in the Upper Christina River Basin

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date: April 1, 2007
File:	

Drawn by:	Checked:	Fig. No.:
DJ	LD	7.5-8c



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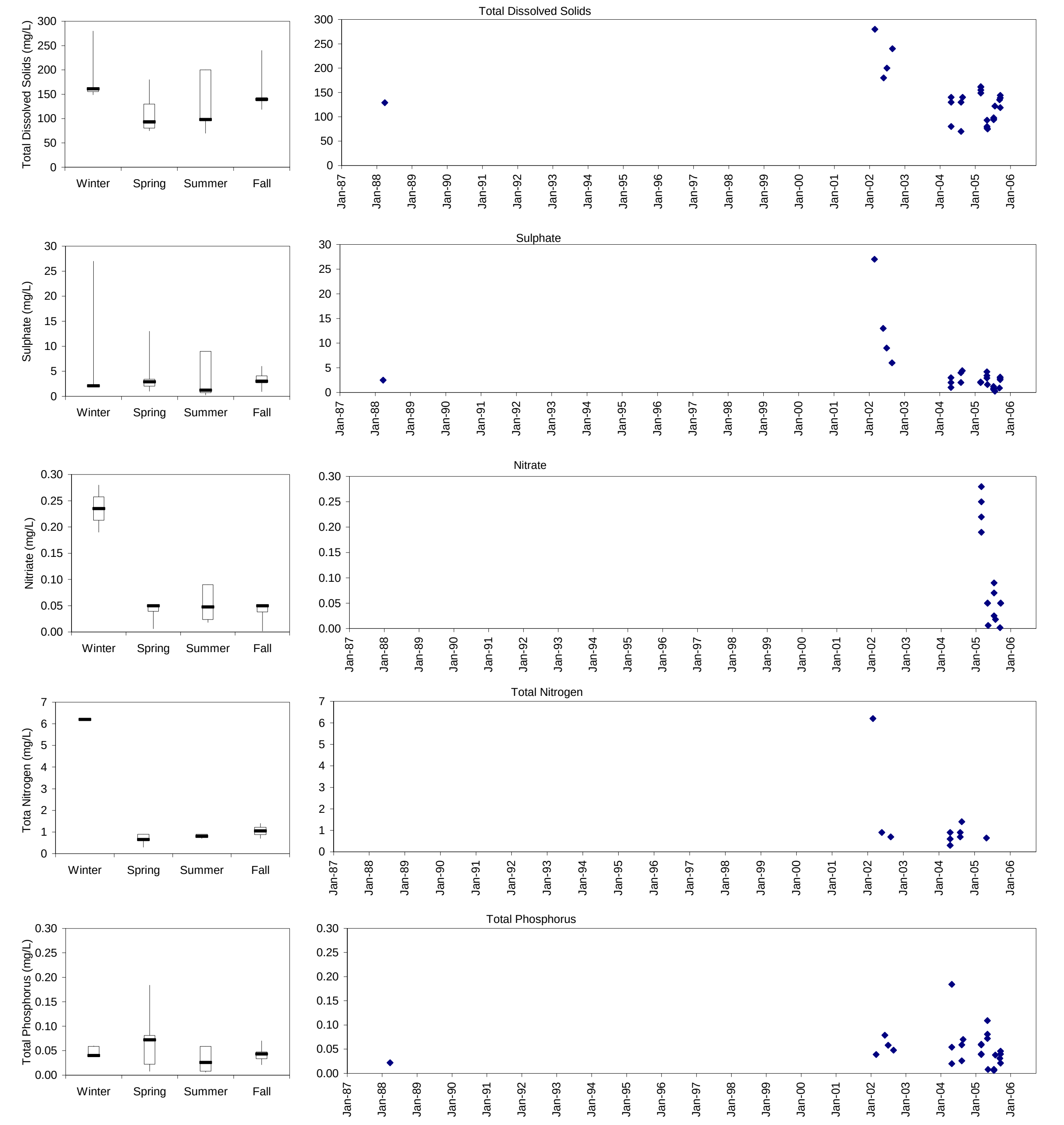
Box and Whisker Plots:

- Dark bar: median
- Upper and lower box limits: 75th and 25th percentiles
- High and low lines: data range

Title: Water Chemistry Indicators in Watercourses in the Mid-Christina River Basin	NORTH AMERICAN OIL SANDS CORPORATION
Approved:	Revision Date: April 1, 2007
File:	
Drawn by: DJ	Checked: LD
Fig. No.: 7.5-9a	



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Box and Whisker Plots:

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Upper and lower box limits: 75th and 25th percentiles

High and low lines: data range

Title:

Water Chemistry Indicators in Watercourses in the Mid-Christina River Basin

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date: April 1, 2007
File:	

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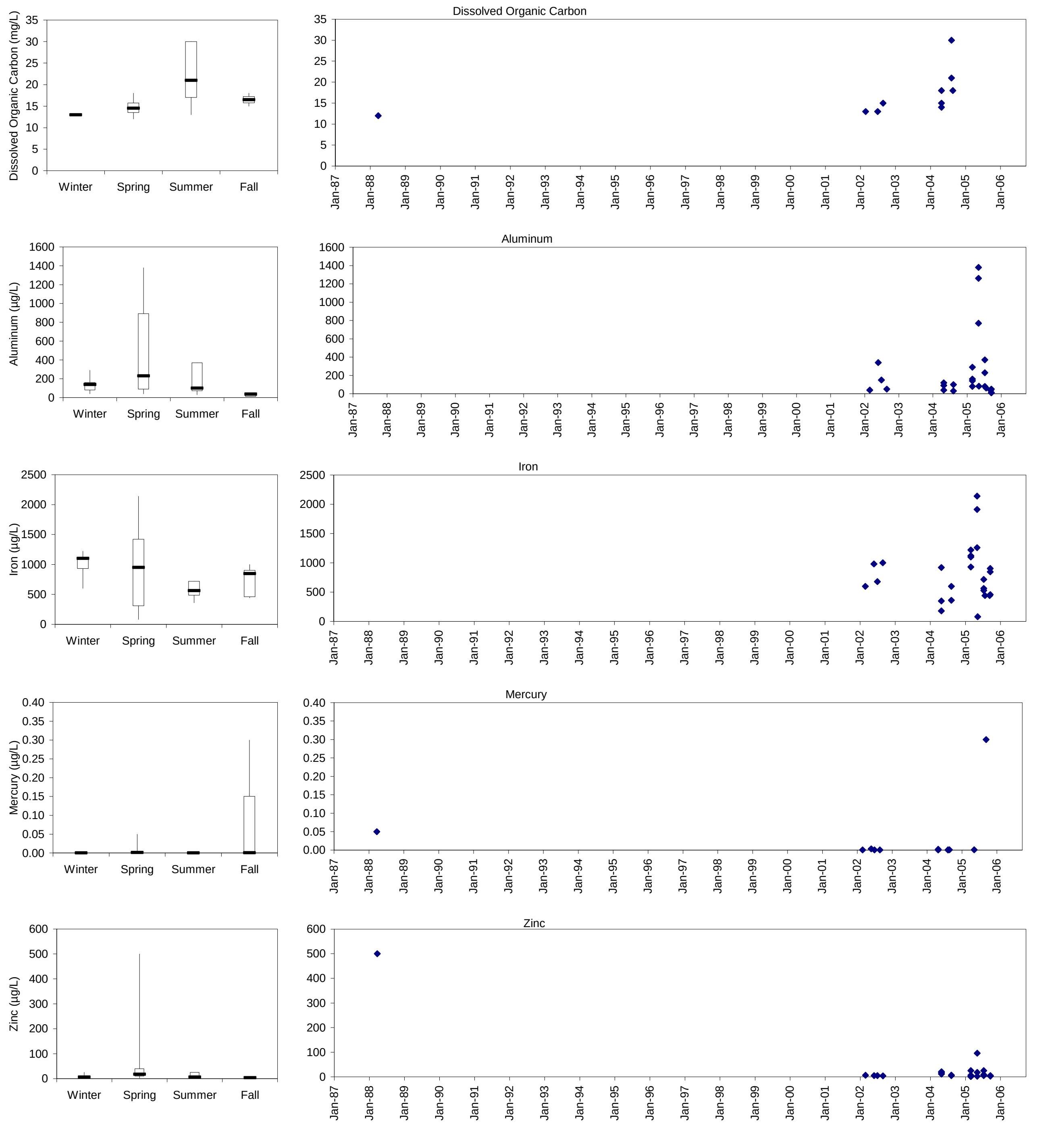

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High and low lines: data range

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Water Chemistry Indicators in Watercourses in the Mid-Christina River Basin

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date: April 1, 2007
File:	

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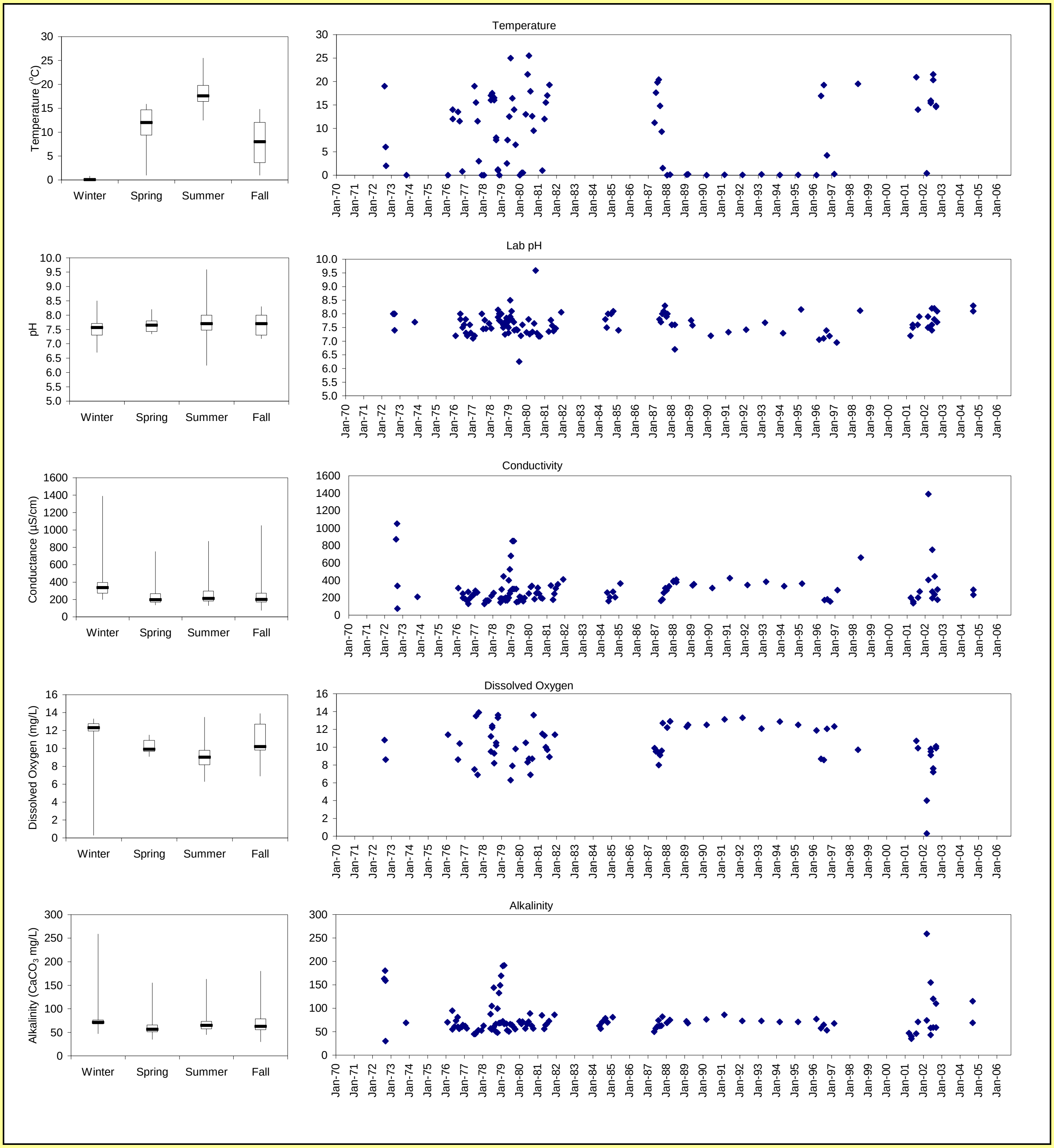

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Box and Whisker Plots:

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Upper and lower box limits: 75th and 25th percentiles

High and low lines: data range

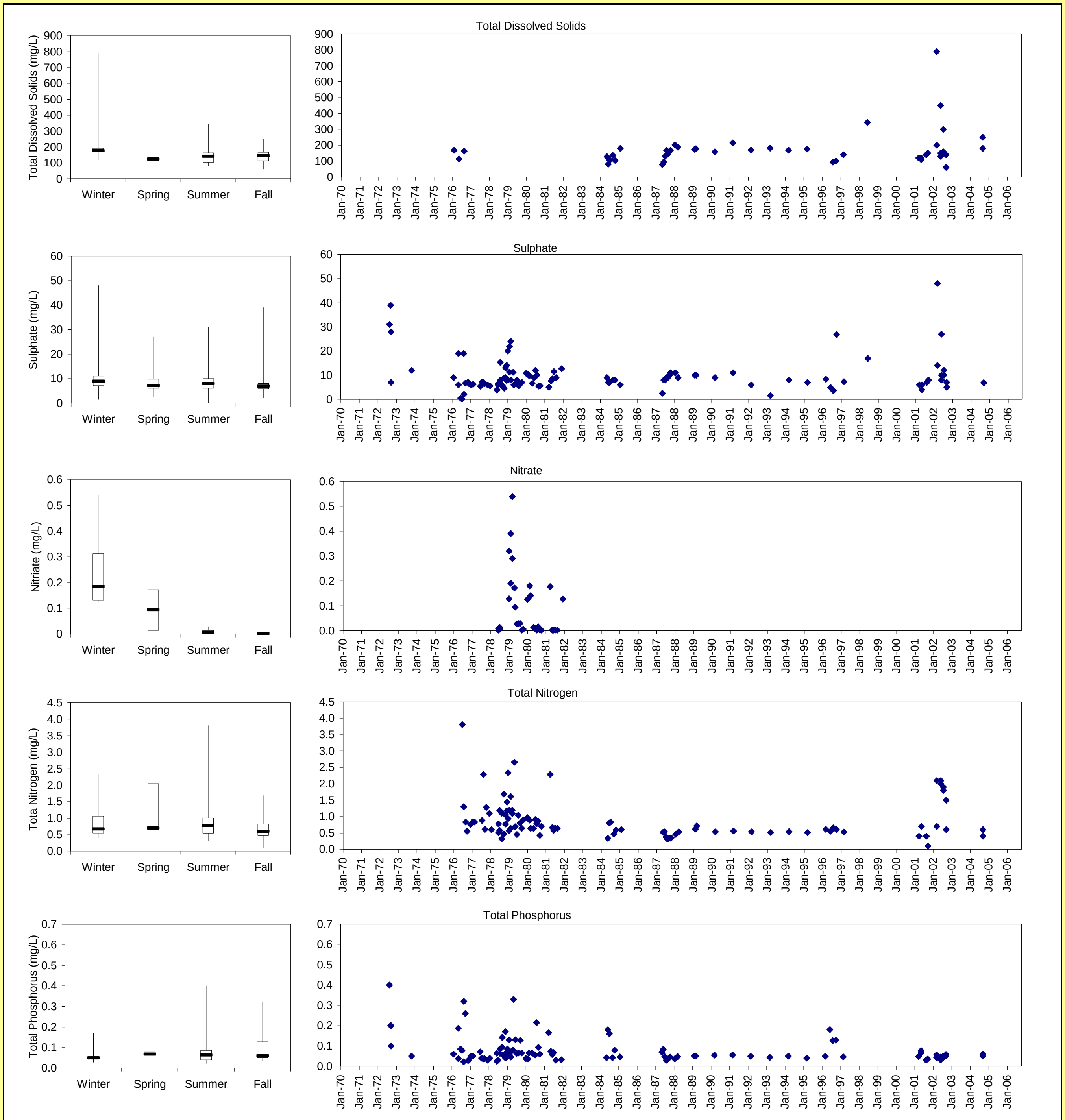
Title:

Water Chemistry Indicators in the Lower Christina and Clearwater Rivers

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date: April 1, 2007
File:	

Drawn by:	Checked:	Fig. No.:
DJ	LD	7.5-10a



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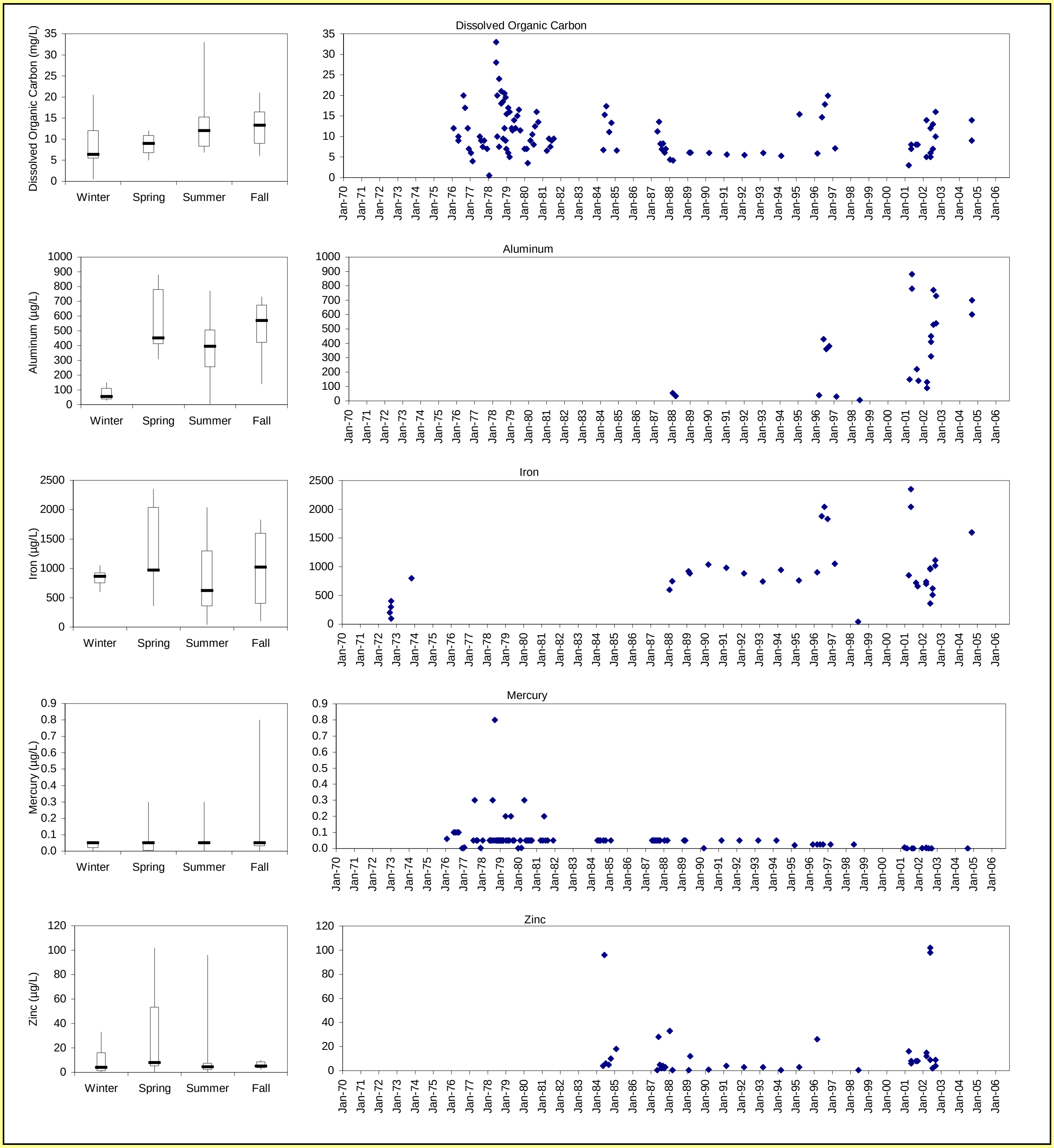
Box and Whisker Plots:

Dark bar: median

Upper and lower box limits: 75th and 25th percentiles

High and low lines: data range

Title: Water Chemistry Indicators in the Lower Christina and Clearwater Rivers	NORTH AMERICAN OIL SANDS CORPORATION	
	Approved:	Revision Date: April 1, 2007
	File:	
	Drawn by: DJ	Checked: LD	Fig. No.: 7.5-10b



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Box and Whisker Plots:

- Dark bar: median
- Upper and lower box limits: 75th and 25th percentiles
- High and low lines: data range

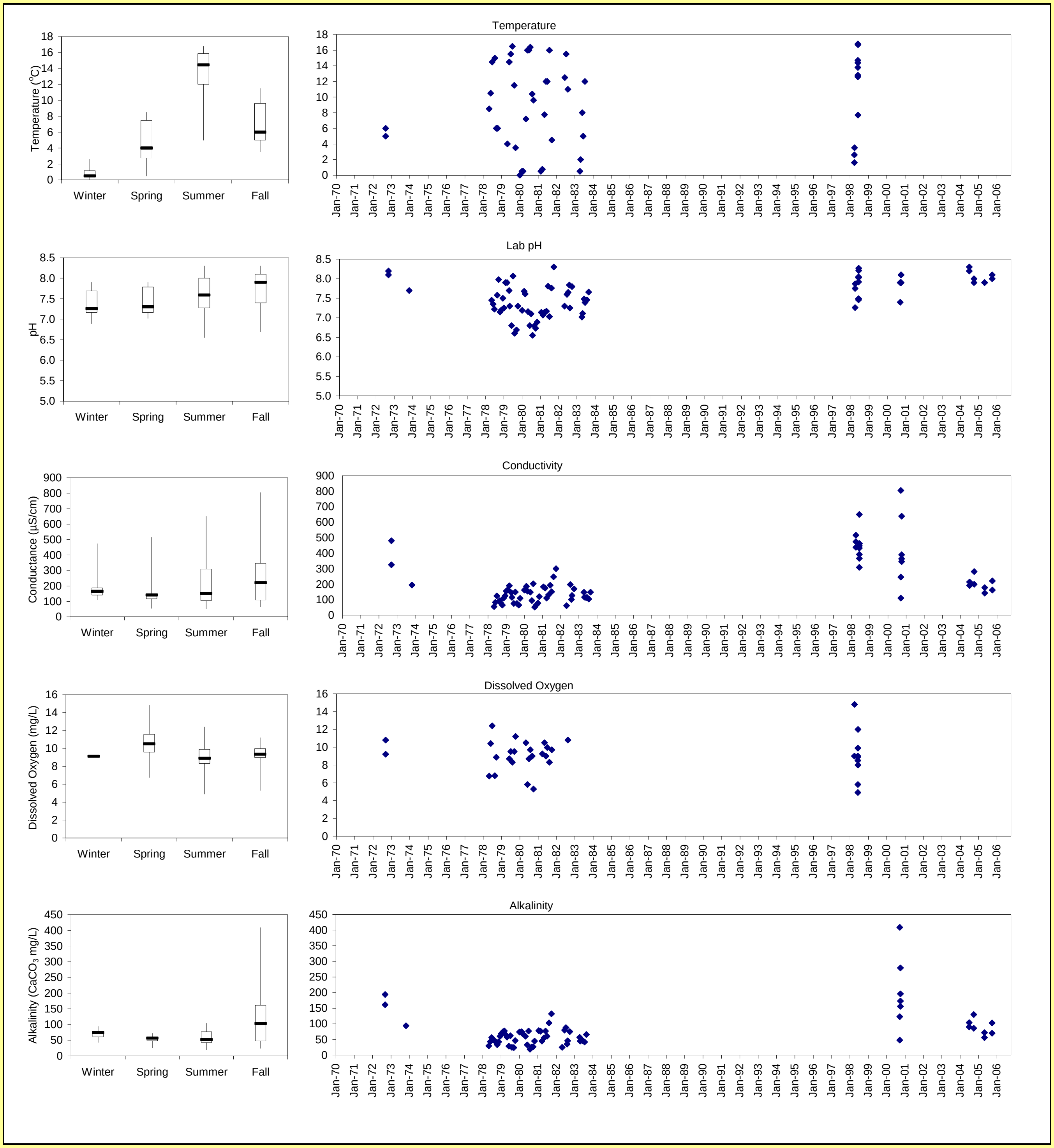
Title:

Water Chemistry Indicators in the Lower Christina and Clearwater Rivers

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date: April 1, 2007
File:	

Drawn by:	Checked:	Fig. No.:
DJ	LD	7.5-10c



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Box and Whisker Plots:

Dark bar: median

Upper and lower box limits: 75th and 25th percentiles

High and low lines: data range

Title:

Water Chemistry Indicators in Watercourses in Tributaries to the Lower Christina and Clearwater Rivers

NORTH AMERICAN OIL SANDS CORPORATION

Approved:

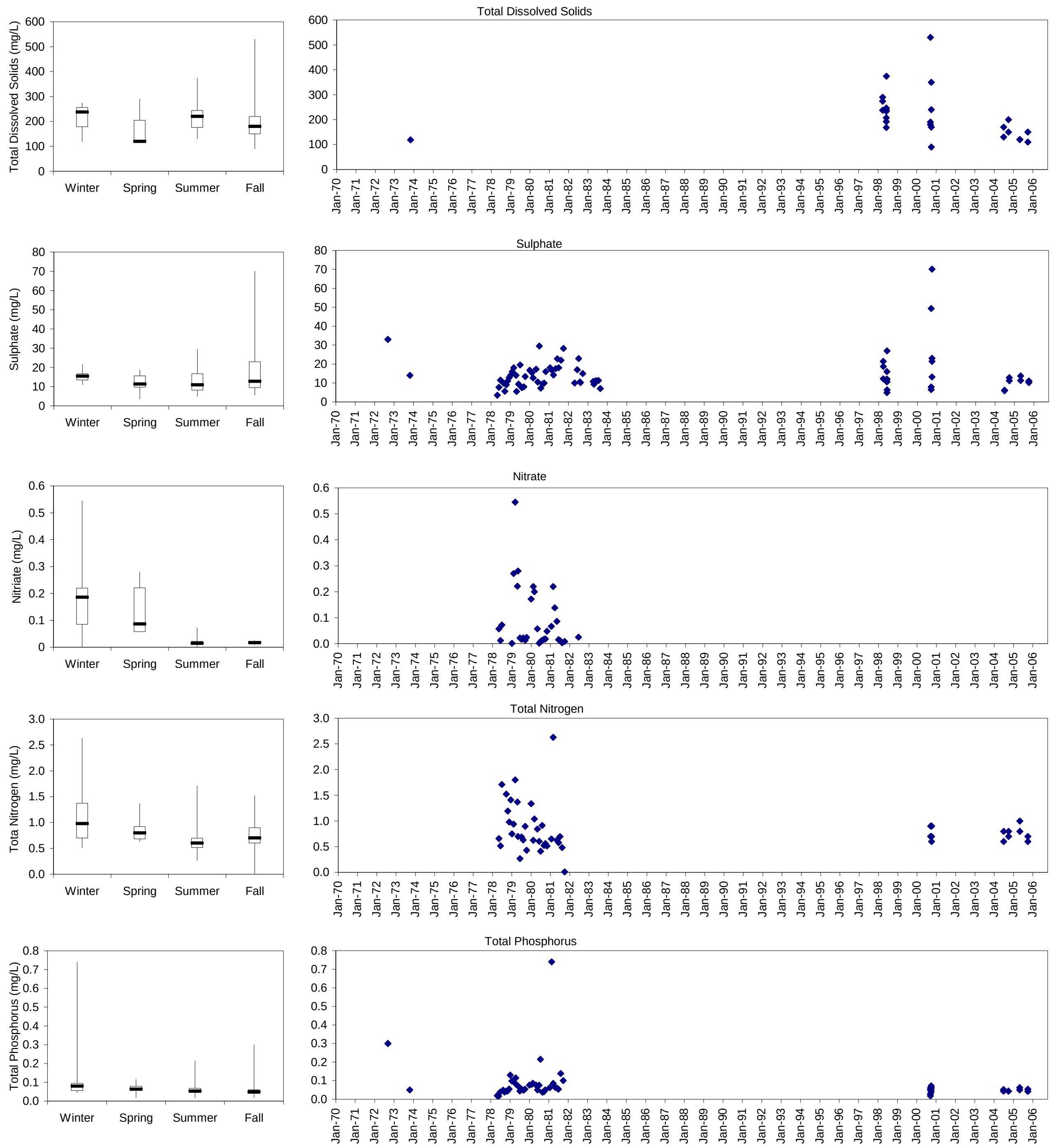
Revision Date: April 1, 2007

File:

Drawn by: DJ

Checked: LD

Fig. No.: 7.5-11a



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Box and Whisker Plots:

Dark bar: median

Upper and lower box limits: 75th and 25th percentiles

High and low lines: data range

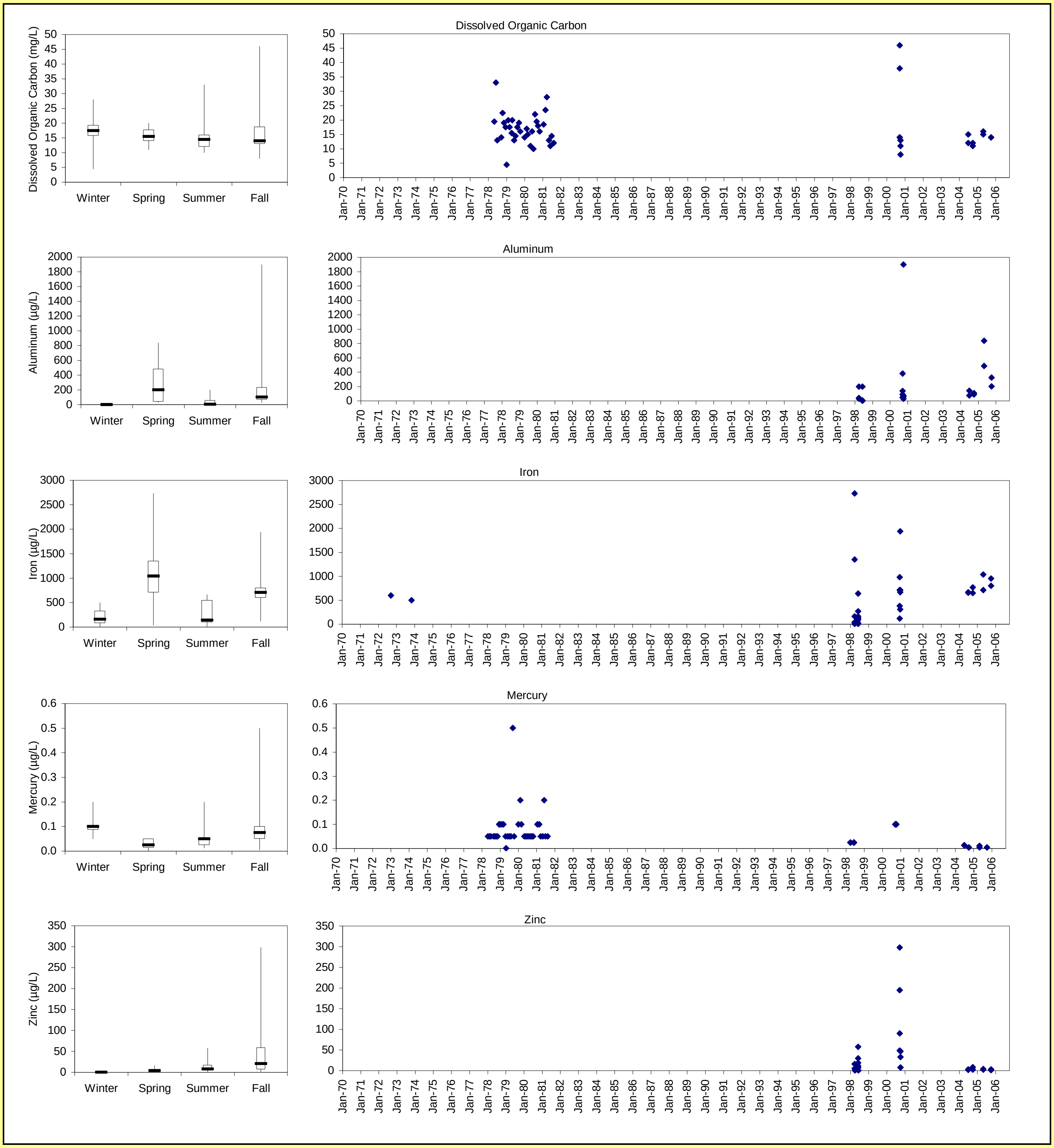
Title:

Water Chemistry Indicators in Watercourses in Tributaries to the Lower Christina and Clearwater Rivers

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date: April 1, 2007
File:	

Drawn by:	Checked:	Fig. No.:
DJ	LD	7.5-11b



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Box and Whisker Plots:

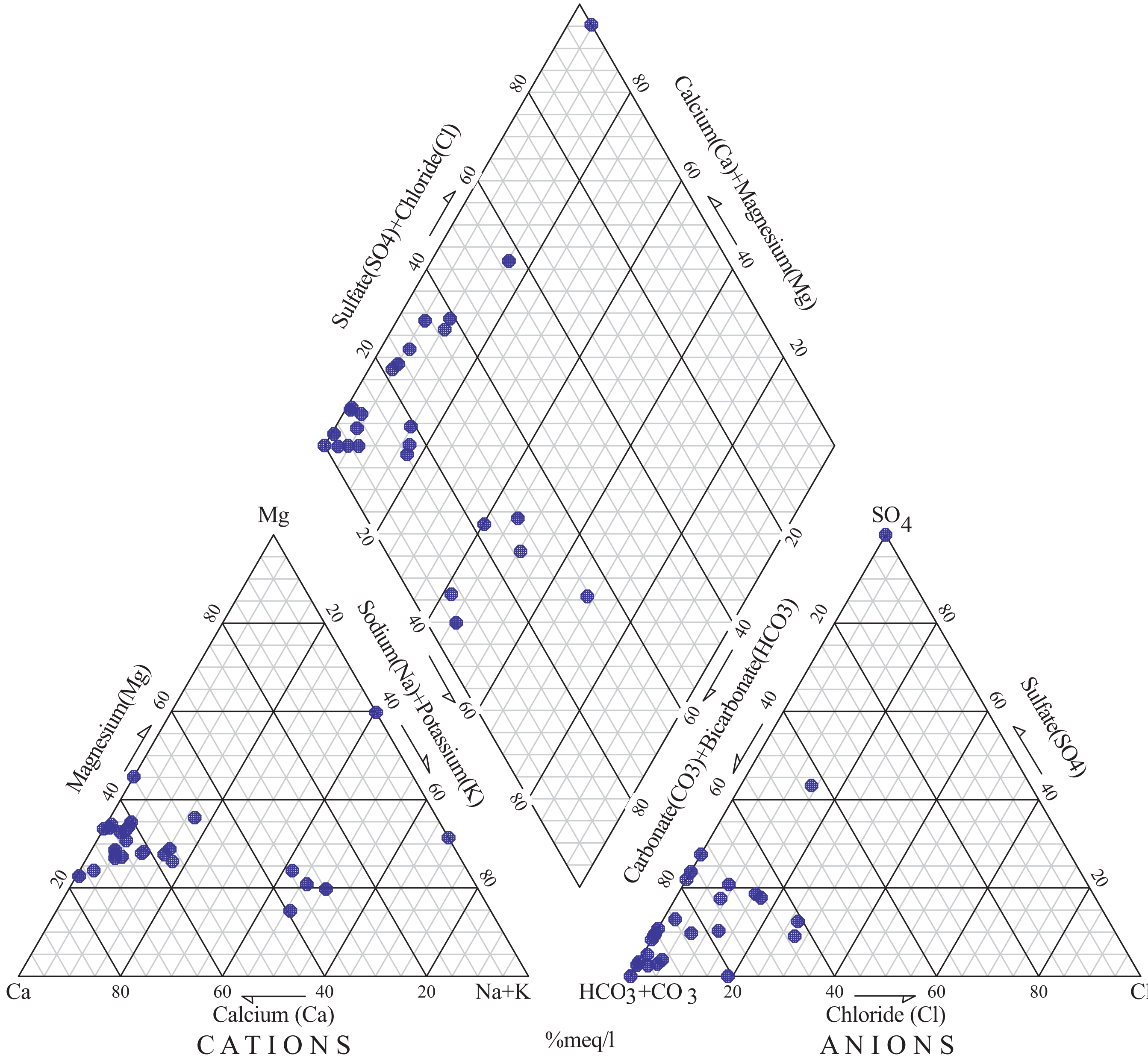
- Dark bar: median
- Upper and lower box limits: 75th and 25th percentiles
- High and low lines: data range

Title:

Water Chemistry Indicators in Watercourses in Tributaries to the Lower Christina and Clearwater Rivers

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date: April 1, 2007	
File:		
Drawn by: DJ	Checked: LD	Fig. No.: 7.5-11c



Legend

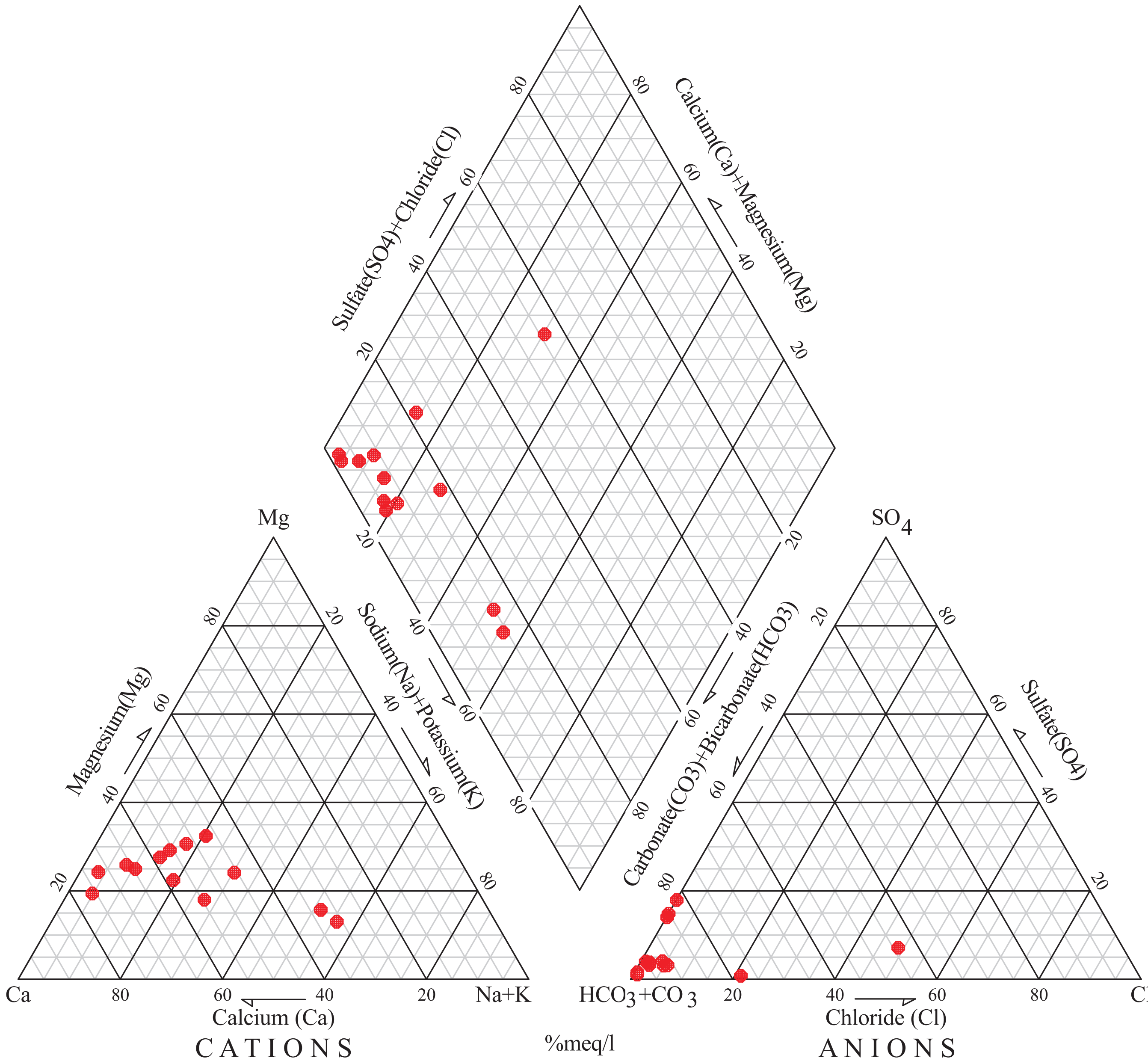
- points represent samples, not lakes
- data represents 12 lakes sampled over 4 seasons

Major ions present in waterbodies in the Horse and Hangingstone Basin

NORTH AMERICAN OIL SANDS CORPORATION

Approved: DJ	Revision Date: 07 05 15
File: 4455-PIPERS-07.CDR	

Drawn By:	Checked:	Fig. No.
BSW	DJ	7.5-12a



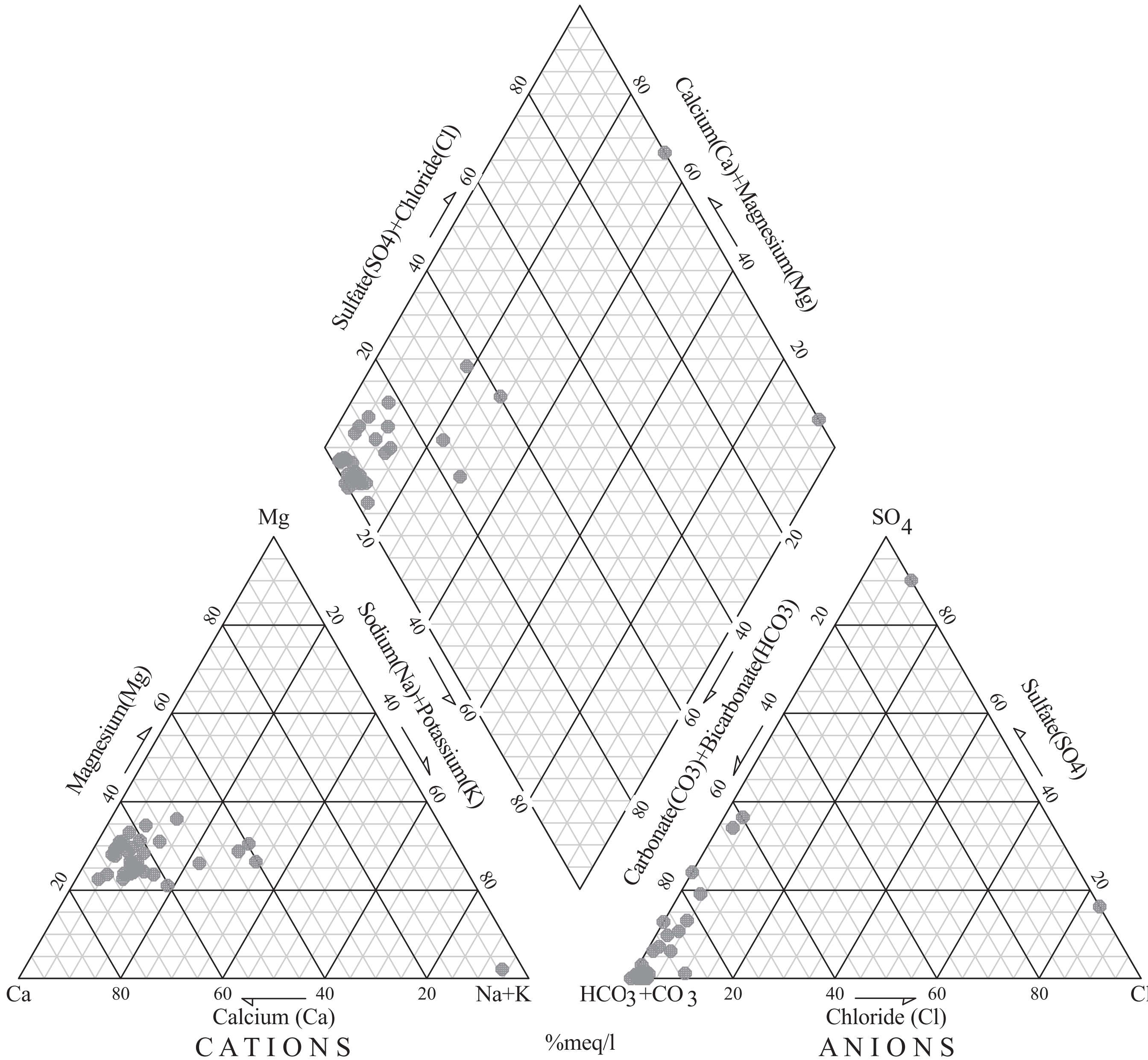
Legend

- points represent samples, not lakes
- data represents 13 lakes all sampled in the fall

Major ions present in waterbodies in the House River Basin

North American Oil Sands Corporation

Approved: DJ	Revision Date: 07 05 15	
File: 4455-PIPERS-07.CDR		
Drawn By: BSW	Checked: DJ	Fig. No. 7.5-12b



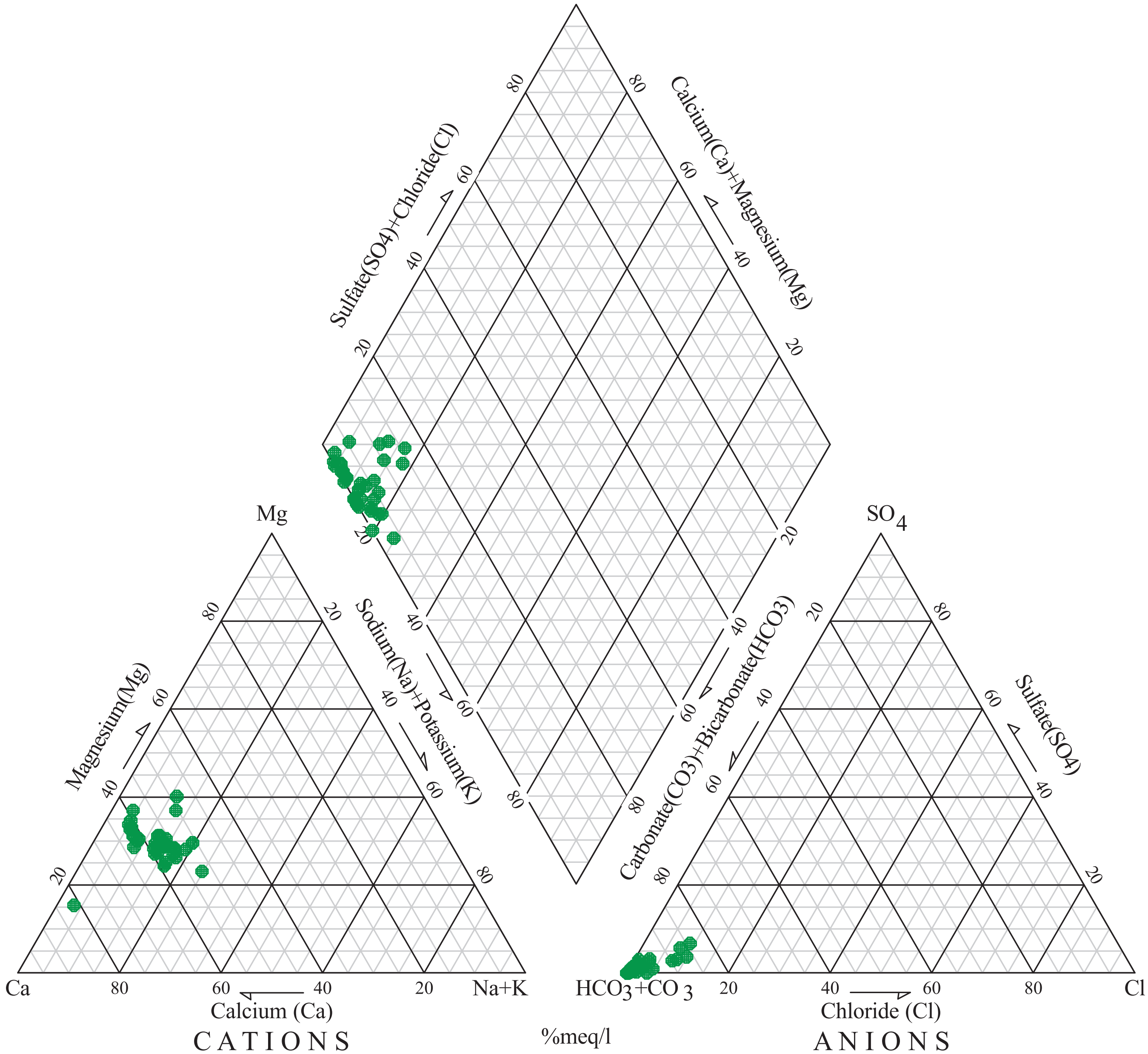
Legend

- points represent samples, not lakes
- data represents 24 lakes sampled in over seasons

Major ions present in the Upper Christina River Basin

NORTH AMERICAN OIL SANDS CORPORATION

Approved: DJ	Revision Date: 07 05 15	
File: 4455-PIPERS-07.CDR		
Drawn By: BSW	Checked: DJ	Fig. No. 7.5-12c



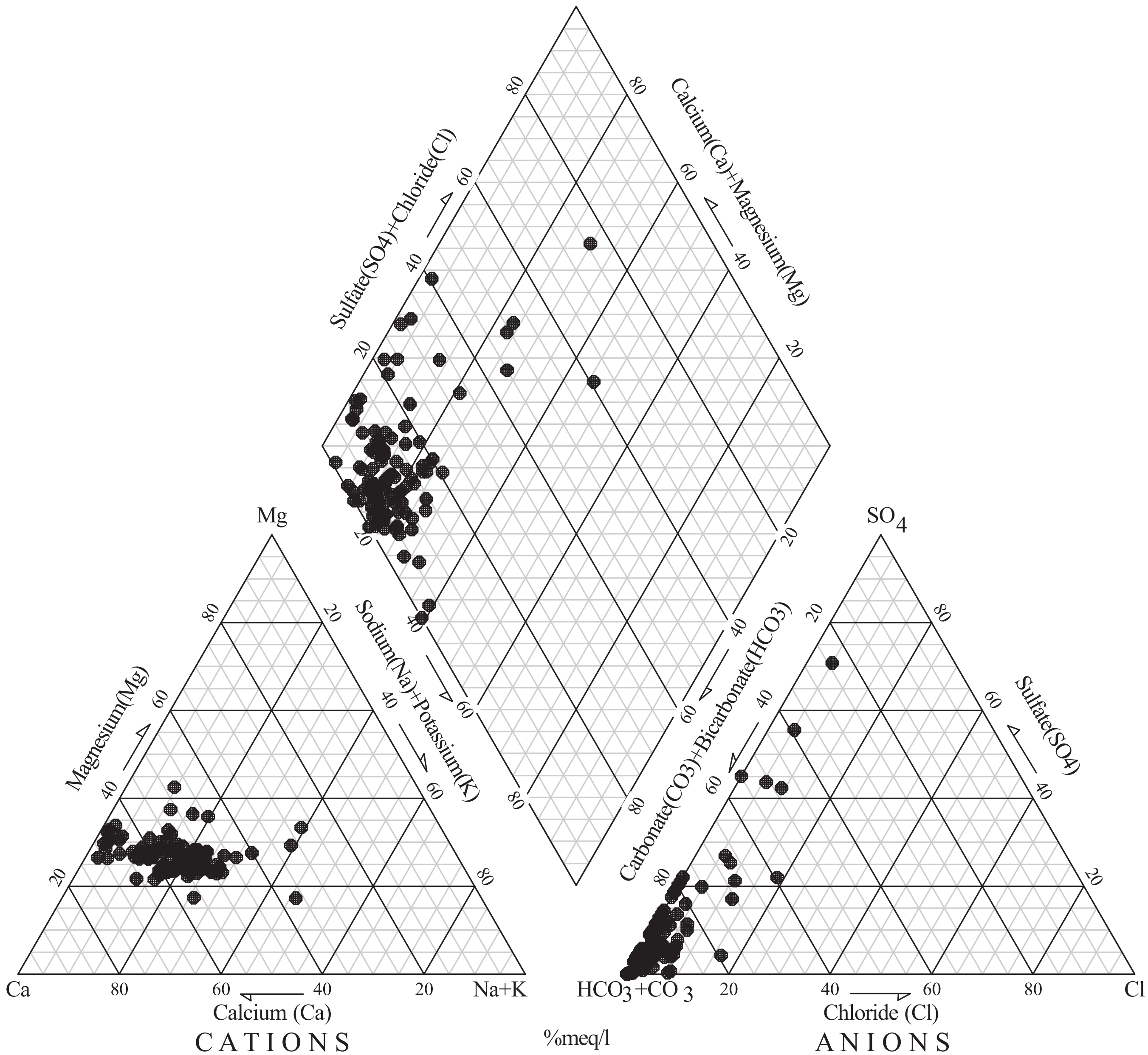
Legend

- points represent samples, not lakes
- data represents 27 lakes sampled over seasons

Major ions present in waterbodies in the Lower Mid-Christina River Basin

NORTH AMERICAN OIL SANDS CORPORATION

Approved: DJ	Revision Date: 07 05 15	
File: 4455-PIPERS-07.CDR		
Drawn By: BSW	Checked: DJ	Fig. No. 7.5-12d



Legend

- points represent samples, not lakes
- data represents 43 lakes sampled over 4 seasons

Major ions present in waterbodies in the Lower Christina River and Clearwater River Basin

NORTH AMERICAN OIL SANDS CORPORATION

Approved: DJ	Revision Date: 07 05 15	
File: 4455-PIPERS-07.CDR		
Drawn By: BSW	Checked: DJ	Fig. No. 7.5-12e

7.6 Impact Assessment and Mitigative Measures

The following includes a discussion of each potential impact issue with mitigative measures. Issues related to SAGD developments that have the potential to affect surface water quality have been identified based on public and regulatory consultation, professional experience and issues related to other similar developments in the oil sands area including:

- Potential water quality changes from the release of sediments during construction and operations (land-clearing, runoff, stream crossings, etc., assessed in Volume 3, Section 6);
- Potential water quality changes from the release of process-related chemicals (accidental spills or direct discharges);
- Potential water quality changes due to changes to surface water flows;
- Potential water quality changes due to reduced surface water levels (drawdown effects); and
- Potential changes in water quality due to deposition of acidifying emissions.

Conclusions include impact ratings for residual Project-related effects for the application case scenario. This scenario includes the water chemistry baseline condition (with existing projects in the area) and activities associated with the Project (i.e., construction, operation and reclamation). A project list for the application scenario is provided in Volume 2, Section 1.

7.6.1 Increases in Suspended Sediments

Turbidity in waterbodies and watercourses is the result of silt and clay particles that often originate in the terrestrial environment. Disturbed, exposed areas provide opportunities for surface water runoff to collect and transport sediments, which contribute to surface water sediment loading, and ultimately, increased turbidity. Disturbed substrates in watercourses and waterbodies from instream or near-stream construction also result in increased turbidity. Activities that may be associated with an increased potential for sediment loading include:

- Bridge and roadway development;
- Site clearing and facility construction; and
- Pipeline crossing construction and activities.

Increased sediment loading (e.g., suspended sediments or turbidity) may result in environmental changes that affect the health of aquatic life.

7.6.1.1 Potential Environmental Changes

Suspended particles including clays, silts, and aluminium and iron oxides comprise inorganic turbidity and are generally less than 2 um in diameter. Suspended sediments naturally occur in surface water and transport various water constituents important to water chemistry including organic matter, nutrients and metals. Suspended sediment levels are generally lowest during base flows and increase with runoff and during extreme weather events. Because suspended sediment naturally occurs to varying degrees, different jurisdictions set guidelines relative to background concentrations (e.g., not to increase more than 10 mg/L over background value; AENV, 1999).

Changes to water quality from increased suspended sediments are generally associated with decreased light penetration and impacts to aquatic habitat. Decreased light penetration affects light availability for photosynthesis and may result in a reduction in macrophytes and an increase in algae. Suspended sediments can reduce visibility affecting feeding behavior of fish; moreover they can clog gills and result in additional fish health problems. Effects on aquatic habitat, including the filling of interstitial spaces in gravel and cobble, impair habitat used by small bodied fish and benthic invertebrates. Spawning and some feeding habitat used by large bodied fish can be degraded by sediment deposition. Infilling of small lakes and reservoirs from increased sediment loading can reduce waterbody integrity.

7.6.1.2 Mitigation

Implementing best management practices and mitigation measures are intended to prevent increases in suspended sediments. Mitigation measures used for pipeline and road crossing construction in the LSA will be consistent with recommendations in the pipeline and road crossing codes of practice outlined below. Well pads will be located an appropriate distance back from waterbodies and watercourses. Natural surface drainage will be maintained. In instances where pads are placed near areas of natural surface water flow (e.g., during rain events or snow melt), steps will be taken to control water flows and protect water quality (Volume 3, Section 6). This will reduce the potential for overland flows from encountering exposed soils and transporting sediments to waterbodies or watercourses.

Site facilities, pipelines and associated roads will be constructed with methods consistent with pertinent regulatory guidelines and practices. Construction will include mitigation to ensure these activities have negligible effects on receiving streams, lakes, ponds and wetlands from suspended sediment concentrations. Therefore, sediment releases are not expected to have any effects on surface water. Where applicable, DFO operational statements will be observed (DFO, 2006a - e) and the Alberta codes of practice for pipeline (AENV, 2003a) and road crossings (AENV, 2003b), and Alberta Transportation and Utilities guidelines for stream crossings (AT&U, 2001) will be implemented during construction of watercourse crossings. General measures are outlined in Volume 3, Section 6 - Hydrology, and Volume 3, Section 8 - Fish and Fish Habitat.

7.6.1.3 Conclusion

Changes in suspended sediment concentrations are expected to be minimal (Volume 3, Section 6). Mitigation is intended to minimize effects and potential changes to water quality resulting from changes in suspended sediment loads. The direction of any changes is expected to be negative; however, the extent is predicted to be local and low in magnitude, of short term duration, occurring as isolated incidents and reversible in the short term. The confidence of these predictions is high based in the effectiveness of DFO Operational Statements and the Alberta Codes of Practice. The final impact rating is considered to be low impact.

7.6.2 Release of Process Related Chemicals

The release of process-related chemicals is not planned; however, to mitigate any accidental release North American will implement an Environmental Management Plan that will prevent or limit impacts to waterbodies in the Project area.

7.6.2.1 Potential Environmental Changes

Chemicals that have the potential to be released into the environment include constituents regularly used and produced in the oil and gas industry, including various hydrocarbons such as oil, grease and fuels, coolants such as glycol, and methanol. The main process related constituents include hydrocarbon condensate and salt water. All of the named constituents have the ability to affect water quality, and are potentially toxic to aquatic life.

Hydrocarbons are not water-soluble and, once released into an aquatic environment, generally form a visible sheen on the surface of a waterbody or accumulate in the organic component of sediment.

Some of the constituents may be observed naturally at low levels (e.g., chlorides and hydrocarbons in the form of PAHs); however, most are generally not detectable. Seasonal variation in surface water chemistry related to these chemicals is not likely to be observed. Spring thaws can lead to flushing of a contaminated area; however, increased surface flows will also contribute to dilution.

7.6.2.2 Mitigation

Spills are not anticipated at the CPF and well pad locations. The Project will be developed to include measures to minimize the occurrence of spills and upset conditions. Measures to prevent spilled materials from entering the aquatic environment include the following:

- Any spills from a pad facility would be collected into a bermed collection system for further handling;
- Any spilled produced water would be cleaned up as per the Project emergency response procedures;
- Vehicles, machinery, and facilities will be maintained in a manner that prevents the introduction of hydrocarbons or other deleterious substances into the environment (e.g., refuelling and maintenance should occur a reasonable distance from any waterbody); and
- In the event of a production oil spill, oil will be removed.

Surface water flows on pad and plant facilities will be collected in stormwater drainage ponds. Water will be tested and treated when necessary to meet water quality standards before being released into the environment.

Crews working on pipeline and road construction projects will implement the Project Environmental Management Plan to mitigate against the introduction of hydrocarbons and chemicals into watercourses, including on-site environmental monitoring, seasonal timing of construction near watercourses, and assigning setback distances from watercourses when fueling and maintaining equipment.

7.6.2.3 Conclusions

Any unanticipated spills or releases have the potential to influence water chemistry. However, in the event of an unanticipated spill, the recommended mitigation which includes following the Project Environmental Management Plan, is intended to prevent or minimize potential effects to surface water quality.

In the case where a spill may occur, the impact would be negative; however, with mitigation which includes following the Project Environmental Management Plan, the extent is expected to be sub-regional, low in magnitude, short term in duration, isolated short term in permanence. The prediction confidence is moderate based on the completeness of the Project Emergency Management Plan, and the difficulty in predicting the response of the environment to the chemical constituents. The final impact rating is considered to be low impact.

7.6.3 Changes to Surface Water Levels Associated with Drawdown

The necessary use of groundwater for Project activities has the potential to influence groundwater levels which may in turn affect surface water levels. Interactions between surface water and groundwater can influence the chemistry of waterbodies.

7.6.3.1 Potential Environmental Changes

Water quality parameters can be affected by changes in water levels. During the open water season, water temperature is a function of holding capacity; shallower waterbodies tend to warm faster than deeper waterbodies. Thus, changes in waterbody volume and depth can affect temperature. Reduced water levels can allow light to penetrate farther into the profundal zone (deeper parts of the lake). This effectively expands the littoral zone of a lake (area of plant growth). Increased light penetration will affect chemical and biological processes (e.g., photosynthesis and respiration) and may become more profound in lakes with reduced water levels. These processes can affect pH levels and the oxygen and carbon dioxide cycling.

Surface water chemistry can be strongly influenced by groundwater inputs. The basal flow of many watercourses is composed mainly of groundwater recharge, which is influenced by many hydrogeochemical processes. The amount of time groundwater resides in an aquifer influences its water chemistry (Holms, 2000; Pint et al., 2003; Walker et al., 2003).

The path that groundwater travels extends from the point where water percolates through the soil to the aquifer to where it resurfaces in a creek or waterbody (‘recharge’). Deeper flow paths are generally longer than near-surface or shallow groundwater paths and, therefore, contain older water. Shallow groundwater is generally younger than deeper water; consequently, the age of groundwater and its chemistry tends to change with depth (Stoner et al., 1997).

Aquifers near bedrock include the water the bedrock was formed in, often carbonate-rich water. In the case of the oil sands, bedrock was formed in shallow sea or near-shore water. Consequently, TDS generally increases with depth and water chemistry changes from $CaHCO_3$ to NaCl type water.

It is assumed that groundwater age increases with depth; however, complex interactions between various groundwater flow paths increase the difficulty of predicting how a decrease in the water table will affect surface water recharge chemistry. Under baseline conditions, several upper layers of water from the surficial aquifer may recharge a waterbody; thus, water of several ages may contribute to its recharge; this water mixes with surface water to influence the water chemistry of a waterbody. Under drawdown conditions, the water table drops to a lower position in the ground, thus effectively decreasing the thickness of the layer of water available for surface water recharge. The result is less of a range in age of water mixing in a waterbody. The water chemistry of this new recharge water may be different than the water chemistry that recharged the waterbody prior to drawdown because there is less contribution from the deeper (older) water layers.

Possible scenarios for groundwater surface water interaction may include the following:

- Increased influences from shallow groundwater with young residence time may dilute bicarbonates and Ca++ (Walker et al., 2003), consequently decreasing a waterbody's buffering capacity. Whereas, an increase in the proportion of very old water to surface water recharge may result in an increase in NaCl concentrations.

- A lower water table level has less contact with plant roots, consequently less uptake of nutrients by the plants. This may result in more nutrient-rich groundwater entering a waterbody.

- Dissolved organic material (including DOC) is commonly transported by surficial groundwater. If recharge levels drop, DOC concentrations may drop. This may contribute to an increase in water clarity, a decrease in water temperature, and decreased bacterial respiration which may increase available DO levels.

The loading capacity of a waterbody decreases with a decrease in its water level. Waterbodies with lower water levels may not have the volume to incorporate constituents from surface water runoff, groundwater, or internal cycling processes. These processes may contribute to higher levels of constituents than observed during baseline conditions. Situations where this may be observed may include the following:

- Suspended sediment from creeks, especially during high runoff events, may increase TSS concentrations in a waterbody.

- Groundwater inputs to a waterbody become proportionally higher when the volume of the waterbody decreases. During the winter when biological processes are dormant and waterbodies are covered in ice, TDS concentrations can become elevated.

- Interactions between sediments and lake water tend to be stronger in shallow lakes. A build-up of nutrients in pore-water and the subsequent release across the sediment/water interface may result in an increase in internal loading.

7.6.3.2 Mitigation

Management strategies to mitigate changing groundwater levels are addressed in Volume 3; Section 5.

7.6.3.3 Conclusion

Subsurface water levels are not predicted to be influenced by groundwater pumping (Volume 3; Section 5); therefore, water chemistry will not be influenced by changing water levels. The final impact rating is considered no impact.

7.6.4 Changes to Surface Water Flows

Surface water hydrology attributes, including water levels and stream flow, are important environmental characteristics that may affect the water quality.

7.6.4.1 Potential Environmental Changes

Development in the LSA has the potential to change downstream watercourse flow dynamics including stream flows, water velocity and hydraulic dynamics. Development in the Project area will increase the area of open space and bare ground. With less vegetation to capture and reduce overland movement of water, surface flows may increase and result in faster downgradient surface water movement than generally observed during baseline conditions. Creating drainage ditches, straightening existing channels and removing vegetation may also increase stream flows, which can lead to scouring of stream beds and increases in TSS concentrations.

Changes in surface flow are not always associated with development. Beaver activity in the area can influence local surface water flow dynamics. When watercourses associated with small lakes are influenced by beaver activity, changes in waterbody depth and locations can occur. These changes can confound predictions related to surface water flow dynamics. In addition, altered surface water flow patterns related to beaver activity can affect water quality. Impoundments can change stream habitat from lotic (moving water) to lentic (standing water), resulting in changes to temperature, mixing, TSS concentrations, and other chemical processes.

7.6.4.2 Mitigation

To mitigate surface water flows, facilities will be placed to minimize affects to surface watercourses. In cases where engineering conditions or resource extraction requires well pad placement that may affect surface water flows, water flows will be directed around the well pad to maintain down-gradient drainage patterns in a manner that protects water quality. Constructed channels designed to allow water movement around facilities and well pads will be built to maintain the free-flow of water, yet prevent erosion. Gravel and cobble will be used in the design of water channel beds and larger rocks may be strategically placed to slow moving water and prevent erosion. Additionally, channels will be designed with bank vegetation to increase stability and reduce erosion.

Road crossings will be designed and constructed to minimize flow restrictions and potential erosion. Recommended mitigation strategies include using AENV (2003a) Code of Practice, AT&U (2001) and DFO (2006 a - e) Operational Statements which are covered in Volume 3, Section 6.

7.6.4.3 Conclusion

The recommended mitigation techniques for managing surface water flows will maintain flow patterns in the LSA for the duration of the Project through reclamation of facilities. Any changes are predicted to be neutral in direction, local in extent, negligible in magnitude, short term in duration, isolated in frequency and reversible in the short term. The confidence of predictions associated with changes to surface water flow is based on the effectiveness of Project surface water hydrologic engineering and the AENV Code of Practice and DFO Operational Statements, all of which are considered high when used appropriately. Therefore the final impact rating is considered no impact.

7.6.5 Deposition of Acidifying Emissions

7.6.5.1 Potential Environmental Changes

Deposition of aerial emissions from industrial activities has the potential to alter the chemistry of surface waters. The primary pollutants (NOx and SOx, SO_2) which react with atmospheric water to produce nitric and sulphuric acid, the main constituents contributing to potential acid input (PAI). Over time, PAI modelling results indicate the potential to acidify land and waterbodies.

Acidification of waterbodies can have a negative effect on aquatic life. Many organisms cannot tolerate pH below 5.7 (Mitchell and Prepas, 1990). Indirect effects of acidification are a result of how metals react to pH changes. Inorganic aluminium in soils is mobilized with an increase in acidity. Through acidification $Al(OH)_3$ dissociates to Al^{3+} and H_2O. The aluminum +3 ion (Al^{3+}) is mobile and is leached from soil into surface waterbodies (Langmuir, 1997). At elevated concentrations, Al^{3+} is toxic to most aquatic life.

At higher pH levels (pH between 5 and 6), aluminium exists as a hydroxide ($Al(OH)_3$) where it forms polymers and begins to precipitate. Where concentrations are high enough, aluminium hydroxides form precipitates on the gills of fish thus creating a polymerization site that results in further aluminium precipitation (Sullivan, 2000). The consequence is irritation to the gills and secretion of mucus which interferes with the fish's ability to obtain oxygen. The result is hypoxia (lack of oxygen) and fish death.

Seasonal changes in pH are typically driven by two factors. During spring snowmelt, runoff can dilute waterbody alkalinity resulting in short term lower pH levels (Wetzel, 2001). Plant material decomposition can result in increased CO_2 from bacterial respiration in the late fall and winter. An increase in CO_2 can result in a decrease in pH (Wetzel, 2001). If acidifying emissions result in acidification, seasonal changes in pH may exceed natural variability.

7.6.5.2 Mitigation

Under normal operating conditions, acidification from aerial deposition is not expected to occur. Low NOx technology is planned for the steam generators, which may aid in reducing potential acidifying emissions. Monitoring of waterbodies in the area for potential acidification will be included in any post approval monitoring program. Any changes to water pH level resulting from aerial deposition will be considered a potential impact to water quality.

7.6.5.3 Conclusions

Waters with alkalinity less than 20 mg/L $CaCO_3$ are generally considered to have a low acid neutralizing capacity and may be susceptible to the effects of acidification (Saffran and Trew, 1996). Waters with alkalinities greater than 40 mg/L are considered to be well buffered from the effects of acidification.

Many of the lakes located in the Project area are not considered sensitive to acid deposition. Alkalinities are generally greater than 40 mg/L and pH levels greater than 7.5 (Saffran and Trew, 1996). Historically most of the waterbodies in the RSA appear to be well buffered. Concentrations of $CaCO_3$ alkalinity have generally been greater than 100 mg/L for much of the RSA. Values for pH were variable, however, and did not indicate problems with acidity. In the northern part of the RSA, waterbodies in the upper Hangingstone and Surmont Creek watersheds (the Stony mountain area) had low alkalinities and occasionally low pH levels (Appendix 7C, Figures 7.5-1, 7.5-5) (also OPTI, 2000; Petro-Canada, 2001). Alkalinity levels from samples analysed in the 2005 and 2006 sampling were variable. Alkalinity levels of less than 10 mg/L were consistently reported in two waterbodies in the LSA; these included waterbodies LH1 and LH3 in the Hangingstone watershed. Waterbodies LC1 and LC2 located in the upper Christina watershed had late summer alkalinities of 27 mg/L and 31 mg/L, respectively. Waterbodies LL2, LL3, LL4 and LL5 were considered not sensitive with alkalinities greater than 40 mg/L.

Critical load limits were evaluated for 86 waterbodies in the RSA. Baseline PAI was greater than critical load limits at 12 of these waterbodies (Table 7.5-4; Figure 7.2-7). No additional waterbodies are expected to receive PAI greater than critical loads under the application predictions.

Most of the waterbodies in the RSA are well buffered and are not likely to show any effects of acidification from aerial deposition. Eleven of the twelve waterbodies identified to receive acid inputs greater than their critical loading limits are in an upland area that includes the Stony Mountains and the headwaters of the Hangingstone River. One additional waterbody located in the vicinity of a current SAGD development was identified to have the potential to be sensitive to acidification.

If changes to surface water chemistry from aerial deposition associated with the Project (i.e., acidification) occur, changes would likely be considered sub-regional in extent and limited to the eleven waterbodies identified above. Changes to water chemistry in these lakes would be negative in direction, with a medium magnitude and long term in duration. The frequency would be isolated to the above named lakes and permanence would be long term.

The final impact rating is moderate impact for waterbodies in the upland area in the Stony Mountains and the headwaters of the Hangingstone River. A final impact of no impact is predicted for the waterbodies in the rest of the RSA. The prediction confidence is considered moderate. The critical load calculations only indicate which waterbodies have to potential to be sensitive to acidification. The likelihood of acidification is not a certainty. However, the potentially sensitive waterbodies do appear to have low buffering capacity and long term aerial deposition may alter their water chemistry.

7.7 Cumulative Effects Assessment

Additional projects in the area that may potentially contribute to water quality changes beyond the baseline and application scenarios are summarized in the Project inclusion list (Volume 2, Section 1).

Changes to water quality associated with increases in suspended sediment concentrations and modifications to surface water flows are not likely to occur. Any new projects will have to consider AENV (2003a) Code of Practice, and AT&U (2001) and DFO (2006a-e) Operational Statements during development. As in the Project, these mitigation practices are intended to ensure that any changes to water quality will be highly localized and with no impact.

Table 7.7-1 Potential Impacts Associated with the Kai Kos Dehseh Project Based on the Assessment Criteria

Environmental Impact Associated with Water Quality	Direction	Extent	Magnitude	Duration	Frequency	Permanence	Confidence	Environmental Impact
Increases in Suspended Sediments	negative	local	low	short term	isolated	short term	high	low impact
Release of Process Related Chemicals	negative	sub-regional	low	short term	isolated	short term	moderate	low impact
Water Level Drawdown	neutral	local	negligible	short term	isolated	short term	high	no impact
Changes to Surface Water Flows	neutral	local	negligible	short term	isolated	short term	high	no impact
Acidifying Emissions on 12 Potentially Sensitive Waterbodies with PAI Exceedances	negative	sub-regional	medium	long term	isolated	long term	moderate	moderate impact

Environmental Impact Associated with Water Quality	Direction	Extent	Magnitude	Duration	Frequency	Permanence	Confidence	Environmental Impact
Acidifying Emissions on Waterbodies Not Considered Acid Sensitive	neutral	local	negligible	short term	isolated	short term	moderate	no impact

The Project does not plan to discharge water into the aquatic environment; therefore, the Project will not contribute to cumulative changes in water quality via discharges. Any releases from stormwater runoff ponds will be compliant with water quality guidelines. Other developments are likely to have stormwater management plans that will be compatible with this Project. The three additional SAGD developments in the cumulative assessment scenario are located such that any stormwater releases are not likely to interact with stormwater releases from the Project. Likewise, the three developments will have emergency management plans in place to deal with unanticipated spills or releases in a similar fashion as the project. Cumulative effects to surface water associated with unanticipated spills and releases are expected to be no impact.

The level of uncertainty in each of these cases is relative to the ability of other developments in the area to follow surface water hydrology engineering recommendations, the AENV Code of Practice and DFO Operational Statements.

Groundwater withdrawals associated with the Project and the three other SAGD projects in the project inclusion list are not anticipated to result in measurable changes to surface water levels (Volume 3, Section 5). Consequently, changes to water quality are not anticipated. Therefore, final cumulative impact rating is no impact.

The cumulative effect of PAI on waterbodies in the RSA is likely to have a low impact on water chemistry. Cumulative PAI was predicted to increase to greater than the critical load limit in one waterbody out of 86 that were assessed (Table 7.5-4; Figure 7.2-7).

7.8 Follow-up and Monitoring

The Project will adhere to post construction surface water quality monitoring (e.g., road/bridge stream crossings) where required by DFO and AENV regulations. The surface water quality program design was intended to characterize water quality in the LSA. Site specific water chemistry at development areas (e.g., CPF locations) may require additional sampling to ensure local water chemistry is consistent with the baseline report.

North American will develop, if necessary, a lake monitoring program to determine the potential effects of increased acidic deposition on lakes within the RSA.

7.9 Summary

Potential changes to water quality associated with any unanticipated release of process related chemicals will be largely mitigated through implementation of spill management and the environmental management plans. Any potential effects would be localized and isolated with a predicted environmental impact of low impact (Table 7.9-1).

Changes to water quality associated with increases in suspended sediment concentrations and modifications to surface water flows is not likely to occur. Adherence to the AENV (2003a) Code of Practice, and AT&U (2001) and DFO (2006 a - e) Operational Statements are intended to prevent and mitigate these effects. Any potential effects would be localized, isolated and low in magnitude. Environmental effects associated with suspended sediments are expected to be low impact and impacts associated with changes to surface water flows are no impact.

Groundwater withdrawals associated with the Project are not anticipated to result in measurable changes to surface water levels (Volume 3, Section 5). Consequently, changes to water quality are not anticipated and predicted to be no impact.

Baseline PAI was greater than critical load limits at twelve waterbodies in the RSA (Table 7.5-4). No additional waterbodies are expected to receive PAI greater than critical loads under the application predictions; however, one additional waterbody was predicted to have PAI greater than its critical load under cumulative effects.

Table 7.9-1 Potential Cumulative Impacts Based on the Assessment Criteria

Environmental Impact Associated with Water Quality	Direction	Extent	Magnitude	Duration	Frequency	Permanence	Confidence	Cumulative Impact
Acidifying Emissions of one waterbody predicted to have PAI under the CEA	negative	localized	medium	long term	isolated	long term	moderate	low impact

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TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

8 FISH AND FISH HABITAT

8.1 Introduction

This section provides a description of the existing (baseline) condition of the aquatic resources (i.e., fish and fish habitat and benthic invertebrates) present within the Project area. The information presented has been compiled in support of an EIA associated with the Project.

The fish and fish habitat section provides a general assessment of aquatic resources in the Project's development area as well as the local study areas directly related to Project development plans. To support the EIA, the aquatics study focused on North American's Hangingstone, Corner, Thornbury, Leismer, South Leismer and Northwest Leismer lease areas. Field assessments were completed to determine presence or absence of fish species in the region and the quality and availability of fish habitat (including the benthic invertebrate community). As a result of the large geographic area encompassed by the Project, a representative selection of waterbodies and watercourses in the Project area were assessed using information that reflected the diversity of habitat for local fish species in various life cycles. For the Project, watercourses and waterbodies are defined as per AENV,

> "Any permanent or intermittent surface water body supporting an aquatic and terrestrial environment (including soil types, plant and animal species) (e.g. slough/marsh wetlands, alkali sloughs, prairie potholes, shallow open water, ephemeral wetlands, bogs, fens, lakes, peat lands, oxbows, swamps, muskeg, water courses) and a water body created solely as a compensatory wetland as a mitigative measure due to the loss or destruction of a previous natural surface water body, or a wetland control project (AENV, 2001)."

For the purposes of the fish and fish habitat assessment, bogs and fens were excluded as they are not considered viable fish habitat.

In addition to conducting detailed field assessments related to the Project, a review of existing historic data was also completed. The historic data were compiled and used to aid in the determination of fish habitat and fish species observed in the RSA.

The impact assessment was based upon measured, predicted, or reasonably expected changes in identifiable attributes of indicator species. More detail regarding impact assessment methodology criteria is provided in Volume 2, Section 1. Indicators (i.e., sport fish, benthic invertebrates) were chosen to represent important components of fish and fish habitat. Predicted responses of the indicator resources were used to ascertain the level of effects to fish and fish habitat in relation to the Project.

A final qualitative impact rating provided guidance whether further measures should be considered. Measures including mitigation, monitoring and other means of preventing habitat loss are discussed in detail and relate to potential project activities.

8.2 Study Areas

For the purpose of conducting the assessment of the aquatic resources in relation to the Project, a local study area (LSA) and a regional study area (RSA) were delineated (Figure 8.2-1). The LSA was chosen based on North American's lease areas, the watershed boundaries in the vicinity of the leases and Project development. The RSA includes areas outside of the LSA where aquatic resources may be indirectly (e.g., by the cumulative effects from the Project and other projects nearby) affected by activities associated with the Project. Because the condition of fish and fish habitat is closely tied to surface water quantity and quality, potential impacts to hydrology (Volume 3, Section 6) and surface water quality (Volume 3, Section 7) were considered when study area boundaries were established.

8.2.1 Local Study Area

The fish and fish habitat LSA was established to assess the potential for localized effects on water quality, hydrology and fish and fish habitat. Delineated based on the criteria listed above, the LSA includes waterbodies and watercourses that may be directly or indirectly affected by the Project. To aid in the discussion of fish and fish habitat in relation to the Project, the LSA was further divided into three distinct study areas, namely the Hangingstone study area, the Corner study area and the Leismer study area (including the Thornbury, Leismer, Northwest Leismer and South Leismer lease areas)(Figure 8.2-2). Detailed studies were conducted within these study areas and the information collected is being used to provide a general overview of the waterbodies and watercourses in the LSA.

8.2.1.1 Hangingstone Study Area

The Hangingstone study area is delineated by watershed boundaries for the upper Hangingstone River and several tributaries and lakes associated with the upper Christina River watershed. Waterbodies within the Hangingstone study area ranged from small, shallow unnamed waterbodies to medium sized unnamed lakes. Watercourses within the study area ranged from shallow, poorly defined unnamed channels to well defined named streams (e.g., Hangingstone River). A total of six watercourse sites (four unnamed and two Hangingstone River reaches) and three waterbodies (two unnamed and Soho (Owl) Lake) were visited in the 2005 and 2006 field surveys.

8.2.1.2 Corner Study Area

The Corner study area is delineated by watershed boundaries within the Christina River, and several tributaries and lakes associated with the upper Christina River watershed. Waterbodies ranged from small, shallow, unnamed waterbodies to medium sized unnamed lakes. Watercourses within the Corner study area ranged from shallow, poorly defined unnamed channels to well defined named streams (e.g., Christina River). A total of three unnamed watercourse sites and two waterbodies (one unnamed and Egg Lake) were visited in the 2005 and 2006 field surveys.

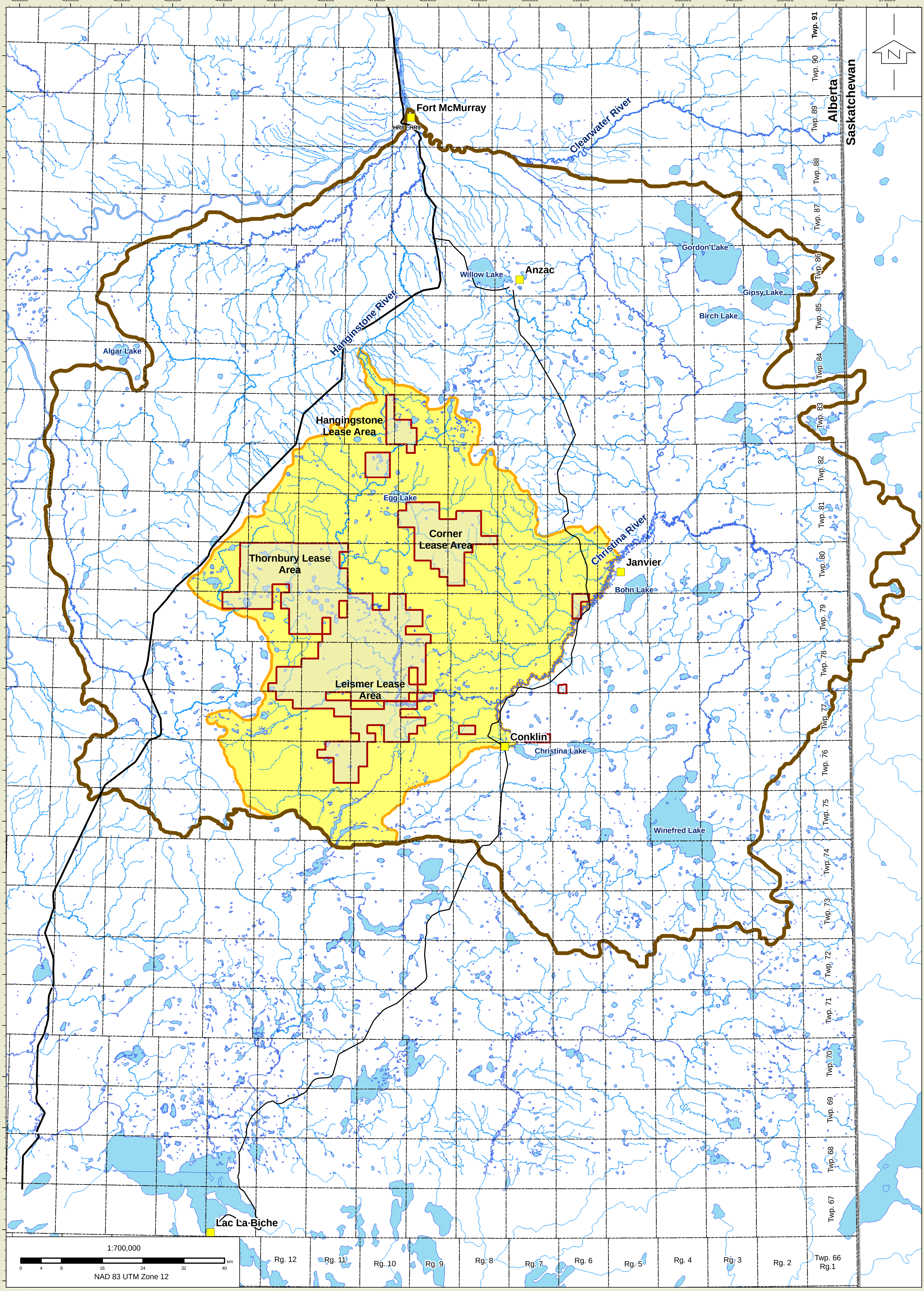
8.2.1.3 Leismer Study Area

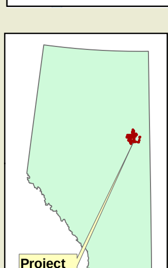
The Leismer study area is delineated by watershed boundaries within the Christina River, and several tributaries and lakes associated with the upper Christina River watershed. Additionally, the eastern portion of the Leismer study area contains watercourses that are part of the House River watershed. Waterbodies within the Leismer study area ranged from small, shallow unnamed waterbodies to medium sized unnamed lakes. Watercourses within the study area ranged from shallow, poorly defined unnamed channels to well defined named streams (e.g., Christina River). A total of fifteen watercourse sites (six unnamed, seven Christina River, one May River and one Waddell Creek) and five unnamed waterbodies were visited in the 2005 and 2006 field surveys.

8.2.2 Regional Study Area

The RSA was established to encompass all areas where aquatic resources may be potentially impacted by Project activities. Consideration was given to flows and levels in regional rivers, lakes and streams, as well as areas where potential exists for surface water/groundwater interaction. The RSA defines the areal extent upon which potential cumulative effects of the Project will be assessed. Beyond this boundary, there is expected to be negligible impact to aquatic resources attributable to the Project.

The Christina River watershed forms the south and east borders of the RSA boundary, the House River watershed defines the southwest boundary, the Horse River watershed defines the west and northwest limits, and the Clearwater River marks the northeast border.





Legend

- North American Leases
- Regional Study Area
- Local Study Area
- Lake
- Stream
- Town
- Highway (63, 881)

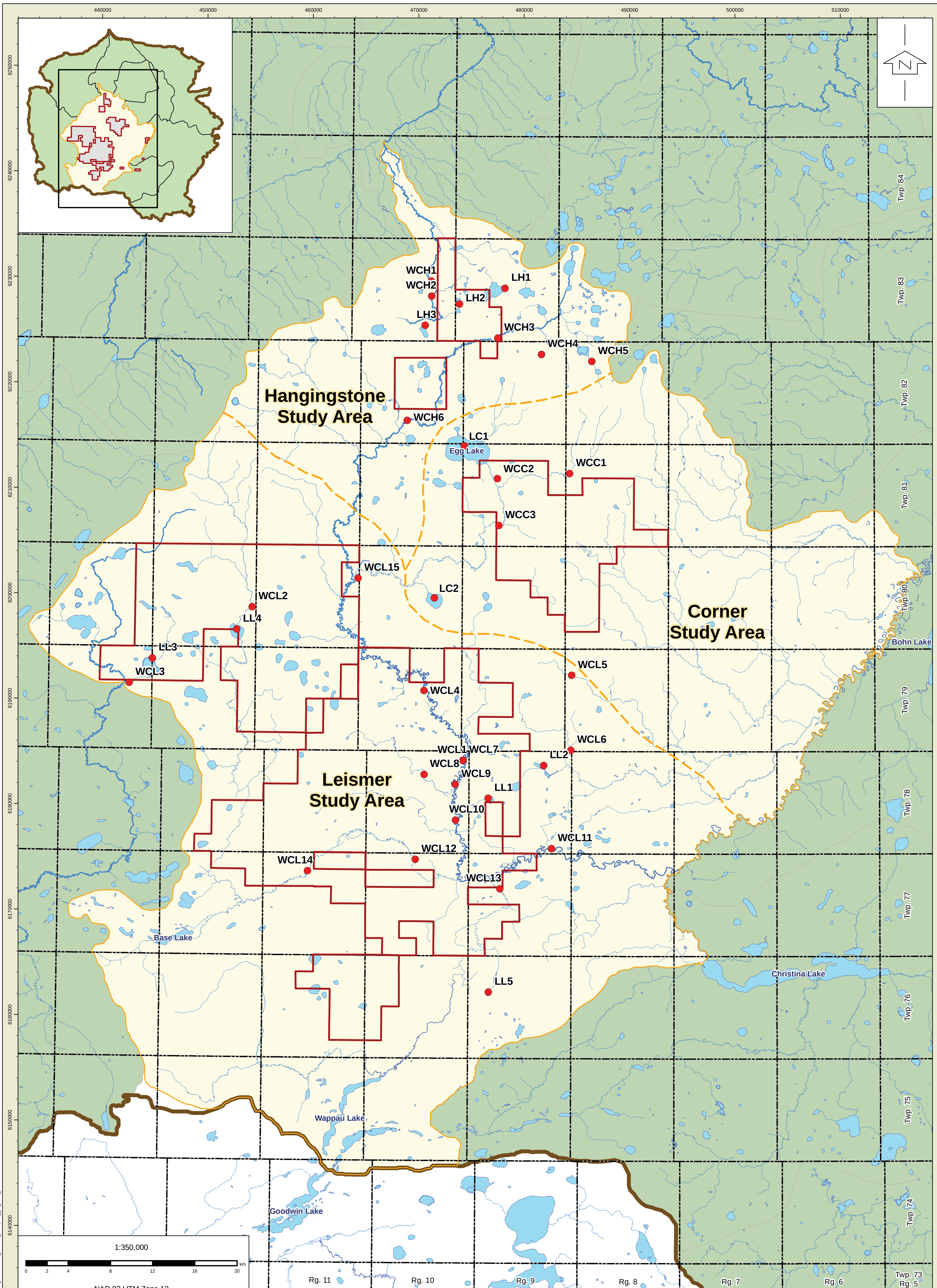
Title:

FISH & FISH HABITAT RSA, LSA AND NORTH AMERICAN LEASE AREAS

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:	
DJ	June 15, 2007	
File: Fig. 8.2-1 Fish and Fish Habitat RSA LSA and North American Lease Areas_20070615.mxd		
Drawn by: JC	Checked: LZ	Fig. No.: 8.2-1

I:\4455-514_NAOSC\NAOSC_Maps\Maps_Historical_Fish_Data\FINAL\Fig. 8.2-1 Fish and Fish Habitat RSA LSA and North American Lease Areas_20070615.mxd



Project Location

Legend

- North American Lease Boundary
- Regional Study Area
- Local Study Area
- Regional Study Area
- Lake
- Stream
- Fish & Fish Habitat Samplig Sites

Title:

FISH & FISH HABITAT STUDY AREAS AND SAMPLING LOCATIONS IN THE LSA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: DJ	Revision Date: June 11, 2007
File: Fig. 8.2-2 Fish_Habitat_Sampling_in_LSA_20070611.mxd	

Drawn by: TR	Checked: LZ	Fig. No.: 8.2-2

I:\4455-514_NAOSC\NAOSC_Maps\Maps_Historical_Fish_Data\FINAL\Fig. 8.2-2 Fish_Habitat_Sampling_in_LSA_20070611.mxd

8.3 Issues and Assessment Criteria

Activities associated with the Project, including construction, operation and reclamation, have the potential to affect fish and fish habitat in watercourses and waterbodies within the study areas. The fish and fish habitat assessment considered Project activities that might cause direct physical impacts to fish and fish habitat and indirect effects associated with changes in surface water quality and hydrology.

The following key issues for aquatic resources have been identified. They are based on public and regulatory consultations, professional experience and the issues identified with other developments in the oil sands area.

The Project could potentially impact the aquatic resources within the study area in the following ways:

- Riparian and instream fish habitat alteration:
    - Sedimentation,
    - Changes to water flows and levels,
    - Riparian habitat degradation, and
    - Changes in benthic invertebrate abundance and composition.
- Combined industrial disturbance on fish habitat:
    - Spills and discharges,
    - Changes in surface water pH, and
    - Increased access.

These potential effects on fish and fish habitat could ultimately influence fish health and/or fish abundance.

The assessment criteria (Volume 2, Section 1) provide a framework to predict or measure environmental effects due to activities associated with the Project. Changes in fish and fish habitat that may occur from the identified issues are assessed according to each criterion.

Consistent with guidelines in the *Canadian Environmental Assessment Act* Responsible Authorities Guide (FEARO, 1994), Project-specific effects and cumulative effects were assessed using the following seven criteria:

- Direction
- Extent
- Magnitude
- Duration
- Frequency of Occurrence
- Permanence
- Prediction Confidence

One component of the criteria was slightly modified, as was done in the surface water quality assessment (Volume 3, Section 7), to address unique fish and fish habitat characteristics and is further defined as follows:

- **Extent** describes the area within which the effect occurs. It is classified as local (within a localized area of the watershed such as a stream reach or individual waterbody), sub-regional (within a given sub-basin), regional (within the RSA), or extra-regional (effect extends beyond the RSA) effect.

8.4 Methods

The methods used for the fish and fish habitat assessment of watercourses and waterbodies included an historic review of existing fisheries data and field assessments to evaluate the current baseline conditions of fish habitat and fish community structure that may be affected directly or indirectly by the Project. During field assessments, data were collected using recognized operating procedures and verified through quality assurance reviews. Results were then analyzed and summarized.

8.4.1 Historic Resources

A review of existing information was conducted to aid in the development of the baseline scenario related to the Project area. The information was collected from a number of sources including existing baseline reports prepared for similar projects in the area, regional aquatic studies, government databases and information contained in current regulatory publications.

Characterization of the watercourses and waterbodies in the area was aided by the use of existing data contained in studies previously conducted in the region. Several projects in the area have assessed and characterized watercourses and waterbodies with similar attributes as those within the Project area. Additionally, many of the watercourses located within the Project area are located within other project areas. Therefore, the information collected for other projects may be relevant and useful when looking at the watercourses and waterbodies in the Project area.

Data collected for the Regional Aquatics Monitoring Program (RAMP) study were incorporated into the historic information search. The information from RAMP is limited as it relates to the Project. However, it does capture data points that will be monitored over time.

Historic information on the fish community associated with the Project area was also acquired from the AENV Fisheries Management Information System (FMIS) during consultation with representatives of AENV. Sites included in the search consisted of watercourses and waterbodies visited during the sampling program associated with the Project (WCL1 to LL3) and waterbodies on or within close proximity to the lease areas (L11 to L42) (Table 8.4-1).

Additional information related to fish species presence in the area was attained through various sources including the Alberta Guide to Sportfishing Regulations.

Throughout this section, the following nomenclature is used:

- WCL – a watercourse in the Leismer study area
- WCC – a watercourse in the Corner study area
- WCH – a watercourse in the Hangingstone study area
- LL – a waterbody in the Leismer study area

- LC – a waterbody in the Corner study area
- LH – a waterbody in the Hangingstone study area
- L – a waterbody in the RSA queried through the AENV FMIS database to determine whether historic information was available; these lakes were not sampled for the Project

Table 8.4-1 Waterbodies and Watercourses Included in a Search of Alberta Environment's Fisheries Management Information System

Site ID	Aquatic Type	LSD	Section	Township	Range	Meridian
WCL1 Christina River	Watercourse	7	36	82	10	4
WCL2	Watercourse	8	13	80	12	4
WCL3	Watercourse	9	23	79	13	4
WCL4 Christina River	Watercourse	8	22	79	10	4
WCL5	Watercourse	6	30	79	8	4
WCL6	Watercourse	3	6	79	8	4
WCL7 Christina River	Watercourse	7	36	78	10	4
WCL8	Watercourse	11	27	78	10	4
WCL9 Christina River	Watercourse	3	25	78	10	4
WCL10 Christina River	Watercourse	14	12	78	10	4
WCL11 Christina River	Watercourse	1	2	78	9	4
WCL12	Watercourse	6	33	77	10	4
WCL13 May River	Watercourse	16	20	77	9	4
WCL14	Watercourse	15	28	77	11	4
WCL15 Christina River	Watercourse	1	25	80	11	4
WCC1	Watercourse	2	30	81	8	4
WCC2	Watercourse	2	29	81	9	4
WCC3	Watercourse	3	9	81	9	4
WCH1	Watercourse	10	23	83	10	4
WCH2	Watercourse	16	11	83	10	4
WCH3	Watercourse	2	4	83	9	4
WCH4	Watercourse	16	35	82	9	4
WCH5	Watercourse	15	29	82	8	4
WCH6	Watercourse	8	9	82	10	4
LL1	Waterbody	3	20	78	9	4
LL2	Waterbody	3	35	78	9	4
LL3	Waterbody	16	25	79	13	4
LL4	Waterbody	13	1	80	12	4
LL5	Waterbody	11	20	76	9	4
LC1 (Egg Lake)	Waterbody	4	36	81	9	4
LC2	Waterbody	10	14	80	10	4

Site ID	Aquatic Type	LSD	Section	Township	Range	Meridian
LH1	Waterbody	13	16	83	9	4
LH2	Waterbody	3	18	83	9	4
LH3	Waterbody	11	2	83	10	4
Christina River	Watercourse	16	9	79	6	4
L11	Waterbody	8	36	83	10	4
L12	Waterbody	13	28	79	11	4
L13	Waterbody	6	32	79	11	4
L14	Waterbody	4	6	80	11	4
L15	Waterbody	6	5	80	11	4
L16	Waterbody	16	8	80	11	4
L17	Waterbody	11	4	80	11	4
L18	Waterbody	1	28	79	11	4
L19	Waterbody	15	14	79	11	4
L20	Waterbody	13	27	79	14	4
L21	Waterbody	6	15	79	11	4
L22	Waterbody	12	23	79	11	4
L23	Waterbody	5	26	79	11	4
L24	Waterbody	7	3	80	12	4
L25	Waterbody	12	4	80	12	4
L26	Waterbody	2	21	79	12	4
L27	Waterbody	11	28	80	12	4
L28	Waterbody	14	17	79	10	4
L29	Waterbody	8	33	80	11	4
L30	Waterbody	11	20	80	11	4
L31	Waterbody	1	36	80	9	4
L32	Waterbody	6	4	79	9	4
L33	Waterbody	16	21	78	9	4
L34	Waterbody	11	7	78	9	4
L35	Waterbody	6	31	77	9	4
L36	Waterbody	3	2	78	10	4
L37	Waterbody	5	27	82	10	4
L38	Waterbody	8	27	82	10	4
L39	Waterbody	16	25	79	13	4
L40	Waterbody	8	13	80	13	4
L41	Waterbody	12	14	78	12	4
L42	Waterbody	7	4	78	12	4

8.4.2 Species of Special Concern

A search of existing databases was conducted to determine the presence of Species at Risk and Species of Special Concern within the vicinity of the Project area. Database inquiries included a search of the Alberta Species at Risk listings as well as the lists generated by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Information from these lists was cross referenced with lists of fish species known to exist in the vicinity of the Project area.

8.4.3 Fish and Fish Habitat Surveys

8.4.3.1 Scope, Timing and Locations of Work

Field surveys were conducted at different times of the year in order to assess the seasonal use of area watercourses and waterbodies by fish species in various life stages. For the purpose of this survey, data were collected from selected study sites within the LSA during summer and fall of 2005 and winter and spring of 2006. Representative sites were selected based on probability of providing fish habitat and potential to support fish communities (Figure 8.2-2 and Table 8.4-2).

Ten waterbodies within the LSA were sampled. Outlets of selected waterbodies contribute to Surmont Creek, Waddell Creek, House River, Hangingstone River, Christina River and May River. Representative waterbodies ranged from shallow, isolated pockets of water to deep, named lakes with one or more inlets and/or outlets. Seasonal field studies were conducted at each waterbody to provide baseline data pertaining to the habitat use potential and the fish communities present.

Twenty-four watercourse sampling sites were assessed for fish and fish habitat potential. Of the 24 sites, 20 were located on tributaries and the mainstem of the Christina River, 3 were on tributaries to the Hangingstone River and 1 site was on the House River. Seasonal field studies were conducted on watercourses to provide baseline data pertaining to the habitat use potential.

8.4.3.2 Field Sampling Methods

Various field sampling techniques were used to assess fish communities and fish habitat in the selected watercourses and waterbodies. Sampling methods were selected for each site based on the most appropriate method for the season and site conditions.

The seasonal baseline field assessments for watercourses included, as appropriate:

- Habitat mapping of all relevant instream and bank habitat characteristics to provide an inventory of available spawning, rearing, feeding and overwintering habitats;
- Measurement of average channel dimensions;
- Identification of features that may affect fish movement and fish migration potential;
- Measurement of stream discharge to help evaluate habitat use potential;
- Measurement of water quality parameters (i.e., pH, conductivity, temperature and dissolved oxygen [DO]);
- Description of riparian vegetation;
- Investigation of under-ice habitat and overwintering potential;
- Fish inventory to determine the fish community presence; and
- Photographs documenting available habitat types and general stream morphology.

The seasonal baseline field assessment of waterbody sites included, as appropriate:

- Habitat mapping of the waterbody basin and shoreline characteristics (including distribution of aquatic macrophytes);
- Confirmation of basin dimensions and depths;
- Examination of inlet and outlet channels to evaluate fish passage potential;
- Measurement of water quality parameters (i.e., pH, conductivity, temperature and DO) along a vertical profile or series of profiles at various depths;
- Description of riparian vegetation;
- Investigation of under-ice habitat and overwintering habitat potential;
- Fish inventory to determine the fish community presence; and
- Photographs documenting available habitat types and general basin morphology.

Details of the various field sampling activities for habitat evaluation and fish sampling techniques follow.

8.4.3.3 Habitat Mapping

Habitat mapping was used to provide an inventory (location and extent) of aquatic habitat types available in the Project area. The habitat classification system is intended to be ecologically significant by focusing on habitat features required by fish species in various life stages (i.e., spawning, incubation, nursery, rearing, summer feeding, holding, overwintering and migration). To a lesser extent, the habitat requirements of the benthic invertebrate community were considered when evaluating fish habitat at a given sampling location. Detailed habitat maps were generated for each sampling site, where possible. The location and timing of watercourse and waterbody sampling are detailed in Table 8.4-2.

Table 8.4-2 Sampling Site Locations and Seasonal Field Survey Dates

Watercourse Study Site ID	Sampling Date	UTM (NAD 83-Zone 12)		Waterbody Study Site ID	Sampling Date	UTM (NAD 83-Zone 12)	
		Easting	Northing			Easting	Northing
Hangingstone							
WCH1 Hangingstone River	07-Aug-05	471202	6229541	LH1	07-Aug-05	478188	6228862
	01-Oct-05				01-Oct-05		
	04-May-06				07-Feb-06		
WCH2 Hangingstone River	07-Aug-05	471238	6228115		05-May-06		
	01-Oct-05			LH2	07-Aug-05	473870	6227359
	07-Feb-06				04-May-06		
	04-May-06			LH3 Soho (Owl) Lake	07-Aug-05	470619	6225356
WCH3	30-Sep-05	477503	6224132		03-Oct-05		
	09-Feb-06				08-Feb-06		
	04-May-06				04-May-06		
WCH4	06-Aug-05	481644	6222589				
	03-Oct-05						
	06-Aug-06						
WCH5	06-Aug-05	486419	6221932				
	05-May-06						

Watercourse Study Site ID	Sampling Date	UTM (NAD 83-Zone 12)		Waterbody Study Site ID	Sampling Date	UTM (NAD 83-Zone 12)	
		Easting	Northing			Easting	Northing
WCH6	06-Aug-05	468913	6216336				
	29-Sep-05						
	05-May-06						
Corner							
WCC1	06-Aug-05	484319	6211287	LC1 Egg Lake	06-Aug-05	474318	6213929
	29-Sep-05				01-Oct-05		
	05-May-06				10-Feb-06		
WCC2	06-Aug-05	477451	6210807		05-May-06		
	29-Sep-05			LC2	06-Aug-05	471488	6199513
	05-May-06				03-Oct-05		
WCC3	05-Aug-05	477612	6206365		07-May-06		
	29-Sep-05						
	09-Feb-06						
	05-May-06						
Leismer							
WCL1 Christina River	05-Aug-05	474208	6184090	LL1	05-Aug-05	476587	6180510
	30-Sep-05				10-May-06		
WCL2	08-Aug-05	454200	6198681	LL2	04-Aug-05	481855	6183602
	28-Sep-05				04-Oct-05		
	08-Feb-06				10-Feb-06		
	06-May-06				07-May-06		
WCL3	10-May-06	442515	6191507	LL3	10-May-06	444725	6193800
WCL4 Christina River	05-Aug-05	470497	6190716	LL4	08-Aug-05	452729	6196552
	29-Sep-05				04-Oct-05		
	09-Feb-06				10-Feb-06		
	06-May-06				07-May-06		
WCL5	06-Aug-05	484506	6192154	LL5	04-Aug-05	476598	6162118
	28-Sep-05				04-Oct-05		
	08-Feb-06				10-Feb-06		
	06-May-06				10-May-06		
WCL6	06-Aug-05	484436	6185056				
	28-Sep-05						
	08-Feb-06						
	06-May-06						
WCL7 Christina River	05-Aug-05	474185	6184109				
	29-Sep-05						
	07-May-06						
WCL8	05-Aug-05	470508	6182759				
	28-Sep-05						
	06-May-06						
	20-Aug-06						
WCL9 Christina River	04-Aug-05	473462	6181836				
	28-Sep-05						
	10-Feb-06						
	07-May-06						
WCL10 Christina River	04-Aug-05	473481	6178442				
	28-Sep-05						
	07-May-06						
WCL11 Christina River	03-Aug-05	482594	6175720				
	27-Sep-05						
	07-Feb-06						
	03-May-06						

Watercourse Study Site ID	Sampling Date	UTM (NAD 83-Zone 12)		Waterbody Study Site ID	Sampling Date	UTM (NAD 83-Zone 12)	
		Easting	Northing			Easting	Northing
WCL12	04-Aug-05 28-Sep-05 11-Feb-06 07-May-06	469659	6174720				
WCL13 May River	07-Feb-06 03-May-06	477695	6171918				
WCL14	08-Aug-05 07-May-06	459444	6173637				
WCL15 Christina River	10-May-06	464237	6201373				

Waterbodies

Ten waterbodies within the three study areas were selected, based on their probability of providing fish habitat and supporting fish communities. In the Hangingstone study area, Soho (Owl) Lake and two unnamed lakes were sampled. In the Corner study area, Egg Lake and one unnamed waterbody were sampled, and in the Leismer study area, sampling sites were selected at five unnamed waterbody locations. Representative waterbodies ranged from shallow, isolated pockets of water to deep, named lakes with one or more inlets and/or outlets. Seasonal field studies were conducted at each waterbody to provide baseline data pertaining to the habitat use potential and the fish communities present.

Waterbodies were mapped during open water season, namely spring or summer, when habitat features were most visible. Bathymetric surveys were conducted to determine the extent of the habitat types and to identify shallow littoral zones and deep pelagic zones. Habitat maps were developed to show the location of shoreline characteristics and the distribution of aquatic vegetation.

The physical characteristics recorded for each waterbody included:

- Water depths;
- Distribution of aquatic macrophytes (submergent, emergent and floating-leaved vegetation);
- Shoreline slope and stability; and
- Riparian vegetation.

The habitat use potential for each waterbody was evaluated based on habitat characteristics, such as the proportions of the available habitat types, water depths, substrate material, vegetation distribution and shoreline development using the Fish Habitat Manual (Alberta Transportation and Utilities, 2001). Analysis of these types of habitat parameters provides an indication of the potential suitability of the habitats for use by fish species in various stages of life.

Watercourses

A total of 24 watercourse sampling locations were assessed in the three study areas for fish and fish habitat potential. In the Hangingstone study area, sampling sites were selected on four unnamed tributaries, and on the mainstem of the Hangingstone River at two locations. In the Corner study area, sampling sites were selected on three unnamed watercourses. In the Leismer study area, sampling sites were selected at 15 locations, including 10 unnamed watercourses, 4 Christina River sites and 1 location on the May River.

Representative locations were used to determine typical baseline habitat conditions, fish community structure and fish habitat usage. Watercourses were mapped during open water season, namely spring or summer, when habitat features were most visible. The location and extent of all instream habitat types and bank characteristics of each watercourse sampling site were mapped to provide an inventory of available habitats. Typical habitat units include riffle, run and pool type habitats.

The physical characteristics recorded for each sampling site included:

- Channel unit type;
- Maximum water depth;
- Dominant substrate type and size classification;
- Channel dimensions, including mean channel width and wetted width;
- Debris piles (small and large woody debris);
- Cover for fish, including both instream (velocity shelter) and overhead (visual isolation) cover;
- Aquatic vegetation;
- Beaver dams and other features that might impede fish movements;
- Bank features, including areas of unstable bank and areas of overhanging vegetation or undercut banks; and
- Riparian plant community composition.

At each sampling site, representative photographs were taken to illustrate physical characteristics such as bank conditions, bank profiles, riparian areas, channel characteristics and general terrain layout.

The habitat use potential for study sites was evaluated relative to the habitat requirements of the local fish species and life stages (e.g., spawning, rearing, and feeding), the types and proportions of the available channel units, average water depths and substrate material.

Discharge Measurements

Stream discharges were measured at study sites during seasonal sampling activities. Discharge measurements were conducted according to recognized industry protocol. Measurements were conducted using a calibrated tagline to determine horizontal stations and a Pygmy Water Velocity Meter and top setting-wading rod to measure water depth and velocity. The horizontal station distance, water depth and water velocity data were used to calculate the total stream discharge. Measurement of discharge was not possible at some locations due to safety concerns, the lack of measurable flow or the lack of a defined channel.

Field Water Quality Parameters

Field water quality parameters (i.e., water temperature, dissolved oxygen, pH and conductivity) were measured at study sites during seasonal sampling activities. In watercourses and waterbodies, water quality parameters were measured at one or more locations along a vertical profile. Surface water quality and water quality profiles were measured using a YSI 556 multi-parameter handheld water quality meter equipped with a 30 m cable.

Overwintering Habitat Assessment

Overwintering habitat assessments evaluated the potential for watercourses and waterbodies to provide habitat for fish throughout the winter season. The assessment was conducted in winter to accurately represent limiting conditions for fish potentially overwintering in these habitats.

The winter field assessment of watercourse sites included the following:

- Measurement of ice thickness and under-ice water depth;
- Measurement of water depth and velocity along a transect to determine average depth and velocity;
- Measurement of stream discharge, if possible;
- Measurement of water quality parameters (i.e., water temperature, dissolved oxygen, pH and conductivity); and
- Fisheries inventory to determine fish presence.

The winter field assessment of waterbody sites included the following:

- Measurement of ice thickness and under-ice water depth;
- Measurement of water quality field parameter profiles (i.e., water temperature, dissolved oxygen, pH and conductivity); and
- Fisheries inventory to determine fish presence.

Fish Inventory

Fish sampling was conducted at each watercourse and waterbody sampling site to determine the fish communities present. A variety of sampling techniques were used to determine the species and life stages of the fish that use these systems.

Fish sampling techniques employed during field investigations included:

- Electrofishing (backpack electrofishing in wadeable watercourses);
- Aqua-Vu underwater observations;
- Baited minnow traps; and
- Test netting (gill netting).

Site specific conditions dictated fish sampling methods used. The sampling methods used at each site are provided in Figures 8.5-9 to 8.5-42.

8.4.3.4 Seasonal Sampling

Seasonal sampling of study sites was conducted in an attempt to gather data on fish presence and fish habitat utilization at various times of the year. Some fish species may require different habitat types at different stages of their life cycle. Seasonal habitat assessments provide a representative view of habitat utilization by fish species at various stages in their life cycle. Where conditions permitted, sampling of aquatic environments included minnow trapping and electrofishing.

Spring, Summer and Fall Sampling

Minnow trapping, backpack electrofishing and Aqua-Vu observations were used on watercourses to assess fish populations and habitat conditions during open water seasons. Large multi-panel gill nets were used to sample waterbodies and suitable watercourse locations.

Standard Gee type minnow traps were used to sample for forage fish and juvenile sportfish species. The minnow traps were baited to attract fish and placed in locations suitable for small-bodied species. The traps were set at study sites with sufficient water depths (generally 0.4 m or more) for effective minnow trap sampling to occur.

A Smith-Root Model 12-B backpack electrofishing unit was used during spring sampling at watercourse sites where conditions permitted. Backpack electrofishing was not conducted at sites where water depth, soft silt substrates or other unsafe conditions existed.

The gill nets utilized for sampling smaller waterbodies consisted of a two panel 15 m net; each panel was 7.6 m in length, 1.8 m in depth and the panel mesh size ranged from 38 mm to 51 mm. The gill nets utilized for sampling larger waterbodies consisted of a seven panel 50 m net; each panel was 7.6 m in length, 1.8 m in depth and the panel mesh size ranged from 25 mm to 152 mm.

Gill net sets were typically set up by placing the gill net perpendicular to the direction of flow, while anchoring the bottom of the net to the substrate. Placing the gill net in this configuration increases the opportunity to capture fish species during daily movement between habitats and also during seasonal migration. Orientation also included anchoring the small mesh end of the gill net to one bank of the watercourse and extending the gill net toward the centre of channel, at an obscure angle. A gill net set at an obscure angle to the direction of flow may also act as a weir to trap migrating fish species that are larger than the sampling range of the gill net.

Fish captured were identified and enumerated by species and life stage, where possible. Fork length (mm) and body weight (g) were measured for all large species and for a representative sub-sample of small species. If discernable from external examination, sex and state of maturity of captured fish were also recorded.

Winter Sampling

Fish sampling in winter was conducted at watercourse and waterbody sites as conditions permitted. Observations recorded include ice depth, water depth, water quality and under-ice conditions. Baited minnow traps and gill netting were used to determine fish presence and assess potential overwintering habitat conditions and were deployed at study sites with sufficient water depths (generally 0.4 m or more). Insufficient water depth did not allow for proper deployment of gill nets at some locations.

8.4.3.5 Habitat Assessments

Fisheries and Oceans Canada (DFO) defines fish habitat as those parts of the environment "on which fish depend, directly or indirectly, in order to carry out their life processes". Therefore, fish habitat includes the water, water quality and aquatic life in rivers, lakes, canals, streams and oceans, as well as the surrounding environment, including plants and other life forms that interact to make fish life possible. Small streams, ponds, reservoirs, marshes, wetlands, canals, drains and sometimes even flooded meadows can provide important habitat for fish, if only on a seasonal basis.

Fish habitat assessments consider potential migratory corridors and spawning, rearing, feeding and overwintering habitat for fish species that have the potential to exist within the RSA.

Fish exist in a wide variety of habitat conditions on a year-round or seasonal basis. Typical fish habitat requirements include aspects such as spawning substrates, physical features providing food, refuge areas providing cover from water flow or predation and migratory corridors to and from overwintering or spawning areas.

Once the presence of fish habitat has been determined, the habitat can then be further characterized according to large bodied/sport fish and forage fish life cycle habitat requirements. The rating of potential habitat is a subjective interpretation of a variety of habitat characteristics based on physical and visual estimates. The habitat rating system is designed to provide a description of existing fish habitat and an indication of potential habitat use.

Physical, chemical and biological characteristics were assessed on a seasonal basis to evaluate the presence of seasonal fish habitat. Habitat characteristics assessed in seasonal surveys included:

- Water quality: pH, conductivity (uS/cm), DO (mg/L) and turbidity;
- Substrate composition: particle sizes and embeddedness, determined via visual estimation or pebble counts;
- Barriers to fish movement: beaver dams, falls, high velocity chutes, perched culverts intermittent flows or very low flow;
- Available instream cover habitats: large organic debris, boulders, instream vegetation, turbidity, deep pools and surface turbulence;
- Available overhead cover habitats: large organic debris, undercut banks and overhanging trees, shrubs or grasses;
- Bank and shoreline characteristics: height, slope, riparian vegetation, percent coverage, percent of bank that is undercut, erosion potential, presence of riprap, crib walls or other erosion control measures;
- Physical structure: mean wetted width, mean wetted depth, mean channel width and mean channel depth;
- Hydrologic condition: discharge (m^3/s), turbulence, watercourse stage (dry, pooled, low, moderate, high, flood);
- Biological processes present (food, cover or reproduction); and

- Habitat quantity: a specific habitat condition may be present, but may not be significantly represented within the study area.

8.4.3.6 Habitat Rating

Rating fish habitat requires the assessment of a broad spectrum of fish habitat conditions. These include water quality, hydraulics, geographic location, and physical attributes of the watercourse or waterbody. Habitat characteristics and an in-depth knowledge of fish life cycle habitat requirements were used to determine the habitat rating.

Essential habitat requirements of a given fish species can vary between life cycle stages and/or seasonal temperature ranges. Therefore, fish will thrive in different habitats depending upon life cycle or seasonal temperature regime.

Fish habitats consist of the areas within a watercourse or waterbody that fish need to successfully carry out one or all of their life processes. The potential utilization of fish habitat can be further described by fish life cycle stage and/or how the fish utilize the existing habitat.

Fish sampling techniques were employed to verify the existence of fish habitat. Fish capture data identified both species present and the life cycle stage that the assessment area provided for habitat. An historic record of fish habitat utilization, an assessment of existing habitat characteristics and habitat suitability indices were used to determine the habitat potential.

Fish require specific habitat conditions to successfully complete critical life cycle stages, such as spawning, rearing, feeding and migration to spawning or overwintering areas. Spawning habitats are areas of a watercourse or waterbody where fish congregate in order to seek out a mate, nest and reproduce. Rearing habitat refers to the areas that provide young fish the opportunity to hatch, feed and grow into adults. Migratory corridors are the areas through which fish will move to reach the habitats they require to carry out subsequent life processes. Overwintering habitats consist of areas that provide adequate water quality, habitat features and physical space for fish species to survive for months at a time without overcrowding. Overcrowding is a concern because available oxygen may not be sufficient to sustain the fish population in a given waterbody or watercourse.

The degree of potential habitat utilization associated with a specific fish life stage may be further characterized as nil, low, medium, or high.

A nil habitat rating would characterize an area that does not provide any significant habitat for a specific life cycle stage of a give fish species. A nil rating describes an area where habitat characteristics, such as water quality, were considered inadequate to support aquatic life (CCME, 1999), and/or physical attributes of the area were insufficient to provide for the life cycle requirements of fish species that may exist within the RSA. Nil habitat characteristics would include:

- Dry and/or undefined channel;
- No suitable habitat for overwintering, spawning, migration or rearing; and
- Not suitable for use as a migratory corridor.

A low habitat rating would indicate an area that provides limited habitat potential for fish life cycle requirements, due to the existence of sub-optimal water quality, hydrological or physical conditions limiting the habitat potential. ‘Low’ habitat characteristics would include:

- Unstable banks are present and abundant;
- High - Moderate scour potential;
- Deep pools or evidence of groundwater seepage are non-existent or are limited in abundance;
- Flow and depths are not generally suited for overwintering habitat;
- Size of substrates and cover is limiting for rearing activities;
- Substrate or macrophytes are not suitable for spawning or not abundant;
- Flows or water depth are not favourable for spawning;
- Flow and depths meet minimal requirements for rearing but are limiting in area;
- Flows, water depth and cover habitats are not typically suitable for adult holding or feeding; and
- Barriers to upstream movement such as seasonal flow, beaver dams, waterfalls or perched culverts exist within the survey area.

A medium habitat rating would characterize habitat conditions that are considered adequate for supporting a given life cycle stage. This rating would include areas that provide sufficient habitat characteristics to satisfy life history requirements. This area would also be considered large enough to accommodate multiple individuals. Medium habitat characteristics would include:

- Moderately stable banks are present;
- Moderate - Low scour potential;
- Deep pools, riffles, vegetation, evidence of groundwater seepage and suitable flows are observed in moderate abundance;
- Size of substrate or macrophytes, flows or water depth are suitable for spawning activities;
- Water depths, flows, size of substrate, and instream or overhead cover are adequately suitable for rearing; and
- Barriers to upstream migration such as low seasonal flow, beaver dams, waterfalls or perched culverts are not observed in the immediate vicinity of the study area or are not considered a barrier.

A high habitat rating describes habitat conditions considered optimal for one or more stages of a fish life cycle. Habitat characteristics that are rated high would provide ample physical space with optimal habitat condition to satisfy the life history requirements for fish species. This area would not be limiting due to available habitat and physical, chemical or biological characteristics. A high habitat potential area would include:

- Stable banks are abundant;

- Low scour potential;
- Deep pools, riffles, vegetation or evidence of groundwater seepage are optimal for spawning activities;
- Watercourse structure, overhead cover, flow velocities, water depths, size of substrates, instream cover and water quality are considered optimal for spawning, rearing, overwintering or migration activities; and
- Barriers to upstream migration such as low seasonal flow, beaver dams, waterfalls or perched culverts are not observed in the immediate vicinity of the study area or are not considered a barrier.

Fish habitat requirements at a given life cycle stage can vary from species to species, and are best summarized by delineating large bodied/sport fish species from small bodied forage fish species.

8.4.4 Benthic Invertebrates

Benthic invertebrate samples were collected in the fall of 2005 (September 27 to October 4). Sampling sites were located in five watercourses (WCH3, WCL1, WCL4, WCL6 and WCL11) and two waterbodies (LH1 and LL4) in the LSA. Watercourses were sampled in depositional habitat. Waterbody samples were collected from soft bottom sediment. The objective of collecting benthic invertebrate samples was to characterize the benthic invertebrate community in representative habitat areas. The data were used to describe baseline conditions of the availability of food resources for fish and the health of the aquatic ecosystem. Benthic invertebrate community data are also useful for monitoring environmental change in aquatic habitats.

A literature review of historic data was completed to obtain background benthic invertebrate data for the study areas. Many previously documented studies including industry and government reports, EIAs and the RAMP were compiled in the “Review of Historical Benthic Invertebrate Data for Rivers and Streams in the Oil Sands Region” (Golder, 2003). Other documents (including the MEG Energy, 2005; Nexen/OPTI, 2006; Rio Alto, 2002) were reviewed to augment an historic benthic invertebrate database.

Benthic invertebrate abundances were summarized as the number of organisms per square metre. The number of benthic invertebrate taxa (identified to the lowest practical level) was termed taxonomic richness.

The benthic invertebrate community was characterized using community variables, including abundance (number of organisms per square metre), taxonomic richness, dominance and community composition. Richness was presented as the total number of taxa (identified to the lowest practical level) and/or the number of families among replicates at a given site. The abundance data among sites were presented graphically. Common invertebrates (invertebrates comprising more than one percent of the total abundance) were presented in tabular format. Major groups of invertebrates were presented in stacked bar graphs to show differences in community composition (Figure 8A-3, Appendix 8A).

Project benthic invertebrate data and any suitable historic data were summarized in terms of principal components to identify variability in the benthic invertebrate community residing in the LSA. Principal components analysis (PCA) can be used to incorporate large amounts of data (e.g., benthic invertebrate abundances for each family present) into a few workable variables, termed factors. The most important factors (i.e., the principal components that explain the greatest percentage of the variance) are used to build a two-dimensional ordination plot to investigate affiliations among samples (Figure 8A-4, Appendix 8A).

8.5 Existing Conditions

The existing conditions data related to fish and fish habitat within the Project area were collected during a series of background data searches, in addition to the seasonal field programs. Twenty-five fish species were identified to occur in the RSA, upon review of available information. Table 8.5-1 summarizes reported fish presence in the LSA and RSA.

Table 8.5-1 Fish Species Documented During the Present and Previous Studies in the North American Kai Kos Dehseh Project LSA and RSA

Common Name	Scientific Name	Species Code	Occurrence Reported In		Found in Current Study
			LSA	RSA	
longnose sucker	*Catostomus catostomus*	LNSC	√	√	√
white sucker	*Catostomus commersoni*	WHSC	√	√	√
spoonhead sculpin	*Cottus ricei*	SPSC		√	
slimy sculpin	*Cottus cognatus*	SLSC	√	√	
longnose dace	*Rhinichthys cataractae*	LNDC		√	
flathead chub	*Platygobio gracilis*	FLCH		√	
lake chub	*Couesius plumbeus*	LKCH	√	√	√
pearl dace	*Semotilus margarita*	PRDC	√	√	√
finescale dace	*Phoxinus neogaeus*	FNDC		√	
spottail shiner	*Notropis hudsonius*	SPSH	√	√	√
fathead minnow	*Pimephales promelas*	FTMN		√	√
emerald shiner	*Notropis atherinoides*	EMSH		√	
northern pike	*Esox lucius*	NRPK	√	√	√
burbot	*Lola lota*	BURB		√	√
brook stickleback	*Culea inconstans*	BRST	√	√	√
goldeye	*Hiodon alosoides*	GOLD		√	√
walleye	*Stizostedion vitreum*	WALL	√	√	
yellow perch	*Perca flavescens*	YLPR		√	
trout-perch	*Percopsis omiscomaycus*	TRPR		√	√
Arctic grayling	*Thymallus arcticus*	ARGR	√	√	√
cisco, lake herring	*Coregenus artedii*	CISC		√	
lake whitefish	*Coregonus clupeaformis*	LKWH		√	
mountain whitefish	*Prosopium williamsoni*	MNWH		√	
lake trout	*Salvelinus namaycush*	LKTR		√	
rainbow trout	*Oncorhynchus mykiss*	RNTR		√	

Source(s): MEG Energy Corp. (2005), Devon (2003), Gulf Canada (2001), RAMP (2005), JACOS (2002), OPTI (2000), Nexen/OPTI (2006), Petro-Canada (2001), FMIS (Fisheries Management Information System) database, as of November 16, 2006 (pers. com. L. Rhude, Alberta Sustainable Resource Development).

The existing or potential use of fish resources by Aboriginal, sport or commercial fisheries is governed within the RSA by both federal and provincial regulations. Aboriginal and commercial sport fisheries in the LSA are limited by both access and the existing fish habitat potential in the area. Further information relating to sport fishing activities in the region is presented in Volume 5, Section 13.

8.5.1 Historic Information

Several assessments of fish habitat and fish species were conducted within the RSA (MEG Energy Corp. 2005; Devon, 2003; Gulf Canada, 2001; RAMP, 2005, JACOS 2002; OPTI, 2000; Nexen/OPTI, 2006; Petro-Canada 2001). These studies, along with an historic data search in AENV's FMIS, provide a summary of the fish species and habitat in the Christina River, Hangingstone River, Horse River, House River and Saprae Creek watersheds. The presence and availability of historic fish and fish habitat data from waterbodies and watercourses dictated how the RSA was organized into drainage basins (Figure 8.5-1). Where available within data sources, overwintering habitat potential is included.

8.5.1.1 Clearwater River and Hangingstone River/Saprae Creek Basins

Clearwater River

RR1 (Clearwater River) (Figure 8.5-2) – The Clearwater River was sampled in spring and fall of 2004 by RAMP to collect on-going data on geographic and temporal variations in fish species composition, relative abundance, size and condition (RAMP, 2004). A total of 13 species were captured during sampling. These include Arctic grayling, fathead minnow, goldeye, lake chub, lake whitefish, longnose sucker, mountain whitefish, northern pike, slimy sculpin, spottail shiner, trout-perch, walleye and white sucker. White sucker was the most abundant species captured during both spring and fall sampling.

RR3 (Clearwater River) (Figure 8.5-2) – The Clearwater River was sampled in spring and fall of 2005 by RAMP to augment existing fish presence and abundance data for key indicator species in the region (RAMP, 2005). A total of 14 species were captured during sampling. These include Arctic grayling, brook stickleback, goldeye, lake whitefish, longnose sucker, mountain whitefish, flathead chub, northern pike, spottail shiner, trout-perch, burbot, pearl dace, walleye and white sucker. Pearl dace was the most abundant species captured in the spring; white sucker was the most abundant species captured during fall sampling.

Hangingstone River Basin

The Hangingstone River flows predominantly from south to north with its headwaters located in the elevated boreal plateau in the vicinity of the Stony Mountain Park. It flows into the Clearwater River in the City of Fort McMurray. The drainage area is fed by low lying fens and bog-type lands in the region, as well as several small headwater lakes. A number of existing man-made disturbances are present in the vicinity of the Hangingstone River. These include road, pipeline and transmission line crossings and an urban development (the City of Fort McMurray) in the downstream reaches. Currently there is limited development associated with the headwater regions, with the exception of oil and gas exploration activities (i.e. seismic exploration). The following section provides a summary of the known fish and fish habitat information related to the Hangingstone River Basin.

Watercourses

MR1 (tributary to Hangingstone River) (Figure 8.5-2) – This tributary to the Hangingstone River was sampled in winter, spring and summer of 2001 in support of the Petro-Canada Meadow Creek EIA (Petro-Canada, 2001). Arctic grayling, lake chub and slimy sculpin were captured during summer sampling; slimy sculpin was the only species captured in the spring. Overwintering habitat potential was ranked low for this tributary.

MR2 (tributary to Hangingstone River) (Figure 8.5-2) – This tributary to the Hangingstone River was sampled in winter, spring and summer of 2001 in support of the Petro-Canada Meadow Creek EIA (Petro-Canada, 2001). Arctic grayling, white sucker and lake chub were captured during summer sampling, whereas no fish were captured in the spring. Overwintering habitat potential was ranked low for this tributary.

MR3 (tributary to Hangingstone River) (Figure 8.5-2) – This tributary to the Hangingstone River was sampled in winter, spring and summer of 2001 in support of the Petro-Canada Meadow Creek EIA (Petro-Canada, 2001). No fish were captured at this site. Overwintering habitat potential was ranked low for this tributary.

MR4 (tributary to Hangingstone River) (Figure 8.5-2) – This tributary to the Hangingstone River was sampled in winter, spring and summer of 2001 in support of the Petro-Canada Meadow Creek EIA (Petro-Canada, 2001). Brook stickleback, lake chub, pearl dace and slimy sculpin were captured in the summer; however no fish were captured in the spring. Overwintering habitat potential was ranked low for this tributary.

MR5 (tributary to Hangingstone River) (Figure 8.5-2) – This tributary to the Hangingstone River was sampled in winter, spring and summer of 2001 in support of the Petro-Canada Meadow Creek EIA (Petro-Canada, 2001). Lake chub were captured in the spring, however no fish were captured during summer sampling. Overwintering habitat potential was ranked low for this tributary.

MR6 (tributary to Hangingstone River) (Figure 8.5-2) – This tributary to the Hangingstone River was sampled in winter, spring and summer of 2001 in support of the Petro-Canada Meadow Creek EIA (Petro-Canada, 2001). Brook stickleback, pearl dace, white sucker, slimy sculpin and spottail shiner were captured in the summer; however no fish were captured in the spring. Overwintering habitat potential was ranked low at this site.

MR7 (tributary to Hangingstone River) (Figure 8.5-2) – This tributary to the Hangingstone River was sampled in winter, spring and summer of 2001 in support of the Petro-Canada Meadow Creek EIA (Petro-Canada, 2001). Brook stickleback were and lake chub were captured in the spring and summer. Lake chub were captured in the summer. Overwintering habitat potential was ranked low at this site.

MR8 (tributary to Hangingstone River) (Figure 8.5-2) – This tributary to the Hangingstone River was sampled in winter, spring and summer of 2001 in support of the Petro-Canada Meadow Creek EIA (Petro-Canada, 2001). Brook stickleback and pearl dace were captured during summer sampling; however no fish were captured in the spring. Overwintering habitat potential was ranked low for this tributary.

MR11 (Hangingstone River) (Figure 8.5-2) – The site, located near the Highway 63 bridge crossing was sampled in winter, spring and summer of 2001 in support of the Petro-Canada Meadow Creek EIA (Petro-Canada, 2001). Brook stickleback, longnose sucker, pearl dace and fathead minnow were captured during summer sampling; however no fish were captured in the spring. Overwintering habitat potential was ranked moderate at this site.

MR13 (Hangingstone River) (Figure 8.5-2) – This site, located in the headwater region of the Hangingstone River was sampled in winter, spring and summer of 2001 in support of the Petro-Canada Meadow Creek EIA (Petro-Canada, 2001). Brook stickleback, lake chub, longnose sucker and slimy sculpin were captured during summer sampling; however no fish were captured in the spring. Overwintering habitat potential was ranked moderate at this site.

Waterbodies

ML12 (Maqua Lake) (Figure 8.5-2) – Maqua Lake, connected to a tributary to the Hangingstone River, was sampled in winter, spring and summer of 2001 in support of the Petro-Canada Meadow Creek EIA (Petro-Canada, 2001). Brook stickleback and pearl dace were captured during summer sampling; only pearl dace were captured in the spring. Overwintering habitat potential was ranked low to moderate for the lake.

ML13 (unnamed lake) (Figure 8.5-2) – This unnamed lake, located at the headwaters of a tributary to the Hangingstone River, was sampled in winter, spring and summer of 2001 in support of the Petro-Canada Meadow Creek EIA (Petro-Canada, 2001). Brook stickleback and pearl dace were captured during summer sampling; brook stickleback were captured in the spring. Overwintering habitat potential was ranked low to moderate for the lake.

ML14 (unnamed lake) (Figure 8.5-2) – This unnamed lake, located at the headwaters of a tributary to the Hangingstone River, was sampled in winter, spring and summer of 2001 in support of the Petro-Canada Meadow Creek EIA (Petro-Canada, 2001). Lake chub were captured in the spring; brook stickleback were captured during summer sampling. Overwintering habitat potential was ranked low to moderate at this site.

ML15 (unnamed lake) (Figure 8.5-2) – This unnamed lake, located at the headwaters of a tributary to the Hangingstone River, was sampled in winter, spring and summer of 2001 in support of the Petro-Canada Meadow Creek EIA (Petro-Canada, 2001). Brook stickleback were captured in the spring. Overwintering habitat potential was ranked non-existent for the lake.

Saprae Creek Basin

LL11 (Caribou Horn Lake) (Figures 8.5-3 and 8.5-4) – Caribou Horn Lake was sampled in winter and summer of 2000 in support of the Nexen/OPTI Long Lake EIA (OPTI, 2000). White sucker and northern pike were captured at this site. Overwintering habitat potential was ranked moderate at this site.

8.5.1.2 Gregoire River Basin

Watercourses

LSR1 (Tributary to Meadow Creek) (Figures 8.5-3 and 8.5-4) – The tributary to Meadow Creek was sampled in spring of 2005 in support of the Nexen/OPTI Long Lake South EIA (Nexen/OPTI, 2006). Brook stickleback were captured at this site. Overwintering habitat potential was ranked non-existent for this tributary.

LSR2 (Kinosis Creek) (Figures 8.5-3 and 8.5-4) – Kinosis Creek was sampled in winter, spring and summer of 2005 in support of the Nexen/OPTI Long Lake South EIA (Nexen/OPTI, 2006). No fish were captured at this site. Overwintering habitat potential was ranked non-existent to low for large bodied/sport fish and moderate for forage fish.

LSR3 (Kinosis Creek) (Figures 8.5-3 and 8.5-4) – Kinosis Creek was sampled in winter, spring and summer of 2005 in support of the Nexen/OPTI Long Lake South EIA (Nexen/OPTI, 2006). Lake chub was the only species captured in the winter and no fish were captured in the spring. Brook stickleback, lake chub, white sucker and slimy sculpin were captured during summer sampling. Overwintering habitat potential was ranked low for large bodied/sport fish and low to moderate for forage fish species.

LSR4 (Kinosis Creek) (Figures 8.5-3 and 8.5-4) – Kinosis Creek was sampled in spring and summer of 2005 in support of the Nexen/OPTI Long Lake South EIA (Nexen/OPTI, 2006). No fish were captured at this site. Overwintering habitat potential was ranked non-existent to low for large bodied/sport fish and moderate for forage fish.

LSR5 (Kinosis Creek) (Figures 8.5-4 and 8.5-4) – Kinosis Creek was sampled in spring and summer of 2005 in support of the Nexen/OPTI Long Lake South EIA (Nexen/OPTI, 2006). Arctic grayling and slimy sculpin were captured in the spring; brook stickleback and lake chub were captured during summer sampling. Overwintering habitat potential was ranked low at this site.

LSR6 (Robert Creek) (Figures 8.5-3 and 8.5-4) – Robert Creek was sampled in winter, spring and fall of 2005 in support of the Nexen/OPTI Long Lake South EIA (Nexen/OPTI, 2006). No fish were captured in the winter or spring. Lake chub, white sucker and slimy sculpin were captured in the fall. Overwintering habitat potential was ranked moderate at this site.

LSR7 (tibutary to Kinosis Creek) (Figures 8.5-3 and 8.5-4) – The tributary to Kinosis Creek was sampled in spring and fall of 2005 in support of the Nexen/OPTI Long Lake South EIA (Nexen/OPTI, 2006). No fish were captured at this site. Overwintering habitat potential was ranked non-existent at this site.

LSR8 (tibutary to Robert) (Figures 8.5-3 and 8.5-4) – The tributary to Kinosis Creek was sampled in spring and summer of 2005 in support of the Nexen/OPTI Long Lake South EIA (Nexen/OPTI, 2006). No fish were captured in the spring and brook stickleback were captured in the summer. Overwintering habitat potential was ranked non-existent for large bodied/sport fish and non-existent to low for forage fish.

LSR9 (Meadow Creek) (Figures 8.5-3 and 8.5-4) – Meadow Creek was sampled in summer of 2005 in support of the Nexen/OPTI Long Lake South EIA (Nexen/OPTI, 2006). Only forage fish species (brook stickleback and lake chub) were captured at this time. Overwintering habitat potential was ranked non-existent at this site.

LSR10 (Kinosis Creek) (Figures 8.5-3 and 8.5-4) – Kinosis Creek was sampled in summer of 2005 in support of the Nexen/OPTI Long Lake South EIA (Nexen/OPTI, 2006). Brook stickleback were captured at this site. Overwintering habitat potential was ranked non-existent at this site.

LR1 (Gregoire River) (Figures 8.5-3 and 8.5-4) – The western reach of the Gregoire River was sampled in spring and summer of 2000 in support of the Nexen/OPTI Long Lake EIA (OPTI, 2000). Longnose sucker, spoonhead sculpin, pearl dace and trout-perch were captured during spring sampling; lake chub, longnose sucker and spoonhead sculpin were captured in the summer. Overwintering habitat potential was ranked moderate at this site.

LR2 (Gregoire River) (Figures 8.5-3 and 8.5-4) – The middle reach of the Gregoire River was sampled in spring and summer of 2000 in support of the Nexen/OPTI Long Lake EIA (OPTI, 2000). Lake chub, longnose sucker, spoonhead sculpin, pearl dace and trout-perch were captured during spring and summer sampling. Overwintering habitat potential was ranked moderate at this site.

LR3 (Gregoire River) (Figures 8.5-3 and 8.5-4) – The eastern reach of the Gregoire River was sampled in spring and summer of 2000 in support of the Nexen/OPTI Long Lake EIA (OPTI, 2000). White sucker were captured during spring sampling; no fish were captured in summer. Overwintering habitat potential was ranked moderate at this site.

LR4 (tributary to Gregoire River) (Figures 8.5-3 and 8.5-4) – This tributary to the Gregoire River was sampled in spring and summer of 2000 in support of the Nexen/OPTI Long Lake EIA (OPTI, 2000). No fish were captured at this site. Overwintering habitat potential was ranked non-existent in this stream.

LR5 (Tributary to the Gregoire River) (Figures 8.5-3 and 8.5-4) – This tributary to the Gregoire River was sampled in fall of 2000 in support of the Nexen/OPTI Long Lake EIA (OPTI, 2000). Pearl dace were captured at this site. Overwintering habitat potential was ranked moderate at this site.

LR6 (Gregoire River) (Figures 8.5-3 and 8.5-4) – The site on the Gregoire River was sampled in fall of 2000 in support of the Nexen/OPTI Long Lake EIA (OPTI, 2000). Longnose sucker, white sucker and trout-perch were captured at this site. Overwintering habitat potential was ranked high at this site.

LR7 (unnamed stream) (Figures 8.5-3 and 8.5-4) – This unnamed stream was sampled in fall of 2000 in support of the Nexen/OPTI Long Lake EIA (OPTI, 2000). No fish were captured at this site. Overwintering habitat potential was ranked low to non-existent at this site.

LR8 (unnamed stream) (Figures 8.5-3 and 8.5-4) – This unnamed stream was sampled in fall of 2000 in support of the Nexen/OPTI Long Lake EIA (OPTI, 2000). No fish were captured at this site. Overwintering habitat potential was ranked low at this site.

LR9 (unnamed stream) (Figures 8.5-3 and 8.5-4) – This unnamed stream was sampled in fall of 2000 in support of the Nexen/OPTI Long Lake EIA (OPTI, 2000). No fish were captured at this site. Overwintering habitat potential was ranked low to non-existent at this site.

LR10 (unnamed stream) (Figures 8.5-3 and 8.5-4) – This unnamed stream was sampled in fall of 2000 in support of the Nexen/OPTI Long Lake EIA (OPTI, 2000). No fish were captured at this site. Overwintering habitat potential was ranked non-existent at this site.

LR11 (unnamed stream) (Figures 8.5-3 and 8.5-4) – This unnamed stream was sampled in fall of 2000 in support of the Nexen/OPTI Long Lake EIA (OPTI, 2000). No fish were captured at this site. Overwintering habitat potential was ranked non-existent at this site.

MR9 (Surmont Creek) (Figures 8.5-3 and 8.5-4) – Surmont Creek was sampled in winter, spring and summer of 2001 in support of the Petro-Canada Meadow Creek EIA (Petro-Canada, 2001). Slimy sculpin were captured during spring and summer sampling. Overwintering habitat potential was ranked moderate at this site.

MR10 (unnamed stream) (Figures 8.5-3 and 8.5-4) – The unnamed stream was sampled in winter, spring and summer of 2001 in support of the Petro-Canada Meadow Creek EIA (Petro-Canada, 2001). No fish were captured in spring. Slimy sculpin were captured in the summer. Overwintering habitat potential was ranked moderate at this site.

MR12 (Surmont Creek) (Figures 8.5-3 and 8.5-4) – Surmont Creek was sampled in spring and summer of 2001 in support of the Petro-Canada Meadow Creek EIA (Petro-Canada, 2001). No fish were captured in the spring. Arctic grayling, longnose sucker and northern pike were captured in the summer. Overwintering habitat potential was ranked moderate at this site.

SR17 (Meadow Creek) (Figures 8.5-3 and 8.5-4) – Meadow Creek was sampled in spring, summer and fall of 1998 in support of the Gulf Canada Resources Limited Surmont EIA (Gulf Canada, 2001). Brook stickleback and white sucker were captured during spring, summer and fall sampling. Lake chub was captured in the summer and fall. Overwintering habitat potential was ranked good at this site.

SR18 (Meadow Creek) (Figures 8.5-3 and 8.5-4) – Meadow Creek were sampled in spring, summer and fall of 1998 in support of the Gulf Canada Resources Limited Surmont EIA (Gulf Canada, 2001). No fish were captured in the spring. Brook stickleback and white sucker were captured during fall sampling. Overwintering habitat potential was ranked good at this site.

SR19 (Meadow Creek) (Figures 8.5-3 and 8.5-4) – Meadow Creek was sampled in spring, summer and fall of 1998 in support of the Gulf Canada Resources Limited Surmont EIA (Gulf Canada, 2001). No fish were captured in the summer. Brook stickleback were captured during summer and fall sampling. Overwintering habitat potential was ranked good for both forage and large bodied/sport fish species.

SR20 (Meadow Creek) (Figures 8.5-3 and 8.5-4) – Meadow Creek was sampled in spring of 1998 in support of the Gulf Canada Resources Limited Surmont EIA (Gulf Canada, 2001). No fish were captured at this site.

SR21 (Meadow Creek) (Figures 8.5-3 and 8.5-4) – Meadow Creek was sampled in spring of 1998 in support of the Gulf Canada Resources Limited Surmont EIA (Gulf Canada, 2001). Brook stickleback were captured at this site.

SR22 (Meadow Creek) (Figures 8.5-3 and 8.5-4) – Meadow Creek was sampled in spring of 1998 in support of the Gulf Canada Resources Limited Surmont EIA (Gulf Canada, 2001). No fish were captured at this site.

SR23 (tributary to Meadow Creek) (Figures 8.5-3 and 8.5-4) – This tributary to Meadow Creek was sampled in spring of 1998 in support of the Gulf Canada Resources Limited Surmont EIA (Gulf Canada, 2001). No fish were captured at this site.

SR24 (tributary to Meadow Creek) (Figures 8.5-3 and 8.5-4) – This tributary to Meadow Creek was sampled in summer of 1998 in support of the Gulf Canada Resources Limited Surmont EIA (Gulf Canada, 2001). No fish were captured at this site.

SR25 (tributary to Meadow Creek) (Figures 8.5-3 and 8.5-4) – This tributary to Meadow Creek was sampled in summer and fall of 1998 in support of the Gulf Canada Resources Limited Surmont EIA (Gulf Canada, 2001). Brook stickleback and white sucker were captured at this site.

SR26 (Tributary to Meadow Creek) (Figures 8.5-3 and 8.5-4) – This tributary to Meadow Creek was sampled in summer and fall of 1998 in support of the Gulf Canada Resources Limited Surmont EIA (Gulf Canada, 2001). Brook stickleback were captured at this site.

Waterbodies

LSL1 (unnamed lake) (Figures 8.5-3 and 8.5-4) – This unnamed lake was sampled in spring and fall of 2005 in support of the Nexen/OPTI Long Lake South EIA (Nexen/OPTI, 2006). No fish were captured at this site. Overwintering habitat potential was ranked non-existent at this site.

LSL2 (Lake 51) (Figures 8.5-3 and 8.5-4) – Lake 51 was sampled in spring and fall of 2005 in support of the Nexen/OPTI Long Lake South EIA (Nexen/OPTI, 2006). No fish were captured in the spring. Brook stickleback and white sucker were captured in the fall. Overwintering habitat potential was ranked low at this site.

LSL3 (Horse Lake) (Figures 8.5-3 and 8.5-4) – Horse Lake was sampled in winter, spring and fall of 2005 in support of the Nexen/OPTI Long Lake South EIA (Nexen/OPTI, 2006). No fish were captured at this site. Overwintering habitat potential was ranked low at this site.

LSL4 (unnamed lake) (Figures 8.5-3 and 8.5-4) – This unnamed lake was sampled in spring and fall of 2005 in support of the Nexen/OPTI Long Lake South EIA (Nexen/OPTI, 2006). No fish were captured at this site. Overwintering habitat potential was ranked low at this site.

LSL5 (Lake 49) (Figures 8.5-3 and 8.5-4) – Lake 49 was sampled in winter, spring and fall of 2005 in support of the Nexen/OPTI Long Lake South EIA (Nexen/OPTI, 2006). No fish were captured during spring sampling. Brook stickleback, white sucker and northern pike were captured in the fall. Overwintering habitat potential was ranked non-existent at this site.

LSL6 (Long Lake) (Figures 8.5-3 and 8.5-4) – Long Lake was sampled in spring and fall of 2005 in support of the Nexen Long Lake South EIA (Nexen/OPTI, 2006). No fish were captured in the spring. Brook stickleback were abundant in the fall. Overwintering habitat potential was ranked non-existent for large bodied/sport fish and low for forage fish species.

LSL7 (unnamed lake) (Figures 8.5-3 and 8.5-4) – The unnamed lake was sampled in winter, spring and fall of 2005 in support of the Nexen Long Lake South EIA (Nexen/OPTI, 2006). No fish were captured in this lake. Overwintering habitat potential was ranked non-existent at this site.

LSL8 (unnamed lake) (Figures 8.5-3 and 8.5-4) – The unnamed lake was sampled in winter, spring and fall of 2005 in support of the Nexen Long Lake South EIA (Nexen/OPTI, 2006). No fish were captured in this lake. Overwintering habitat potential was ranked low at this site.

LSL9 (unnamed lake) (Figures 8.5-3 and 8.5-4) – The unnamed lake was sampled in spring and fall of 2005 in support of the Nexen Long Lake South EIA (Nexen/OPTI, 2006). No fish were captured in the spring. Brook stickleback were captured in the fall. Overwintering habitat potential was ranked low at this site.

LSL10 (unnamed lake) (Figures 8.5-3 and 8.5-4) – The unnamed lake was sampled in spring and fall of 2005 in support of the Nexen Long Lake South EIA (Nexen/OPTI, 2006). No fish were captured in this lake. Overwintering habitat potential was ranked non-existent to low at this site.

LSL11 (unnamed lake) (Figures 8.5-3 and 8.5-4) – The unnamed lake was sampled in spring and fall of 2005 in support of the Nexen Long Lake South EIA (Nexen/OPTI, 2006). No fish were captured in this lake. Overwintering habitat potential was ranked low at this site.

LSL12 (unnamed lake) (Figures 8.5-3 and 8.5-4) – The unnamed lake was sampled in spring and fall of 2005 in support of the Nexen Long Lake South EIA (Nexen/OPTI, 2006). No fish were captured in the spring. Brook stickleback were captured in the fall. Overwintering habitat potential was ranked non-existent at this site.

LSL13 (Kinosis Lake) (Figures 8.5-3 and 8.5-4) – Kinosis Lake was sampled in winter, spring and fall of 2005 in support of the Nexen Long Lake South EIA (Nexen/OPTI, 2006). No fish were captured in the spring. Northern pike were captured in the winter. Overwintering habitat potential was ranked low at this site.

LSL14 (Crazy Lake) (Figures 8.5-3 and 8.5-4) – Crazy Lake was sampled in winter, spring and fall of 2005 in support of the Nexen Long Lake South EIA (Nexen/OPTI, 2006). Brook stickleback were captured in the spring. No fish were captured in the fall. Overwintering habitat potential was ranked non-existent at this site.

LL1 (Birch Lake) (Figures 8.5-3 and 8.5-4) – Birch Lake was sampled in winter, spring and summer of 2000 in support of the Nexen/OPTI Long Lake EIA (OPTI, 2000). Brook stickleback were captured during spring and summer sampling. Overwintering habitat potential was ranked low for the lake.

LL2 (Canoe Lake) (Figures 8.5-3 and 8.5-4) – Canoe Lake was sampled in winter, spring and summer of 2000 in support of the Nexen/OPTI Long Lake EIA (OPTI, 2000). Lake chub was captured during spring and summer sampling. Overwintering habitat potential was ranked low for the lake at this site.

LL3 (Frog Lake) (Figures 8.5-3 and 8.5-4) – Frog Lake was sampled in winter, spring and summer of 2000 in support of the Nexen/OPTI Long Lake EIA (OPTI, 2000). No fish were captured in the spring. Brook stickleback were captured in the summer. Overwintering habitat potential was ranked low for the lake at this site.

LL4 (Long Lake) (Figures 8.5-3 and 8.5-4) – Long Lake was sampled in winter, spring and summer of 2000 in support of the Nexen/OPTI Long Lake EIA (OPTI, 2000). No fish were captured in this lake. Overwintering habitat potential was ranked low-non-existent for the lake at this site.

LL5 (Poison Lake) (Figures 8.5-3 and 8.5-4) – Poison Lake was sampled in winter, spring of 2000 in support of the Nexen/OPTI Long Lake EIA (OPTI, 2000). No fish were captured in this lake. Overwintering habitat potential was ranked non-existent at this site.

LL6 (Pushup Lake) (Figures 8.5-3 and 8.5-4) – Pushup Lake was sampled in winter, spring and summer of 2000 in support of the Nexen/OPTI Long Lake EIA (OPTI, 2000). Brook stickleback were captured during spring and summer. Overwintering habitat potential was ranked low at this site.

LL7 (Rat Lake) (Figures 8.5-3 and 8.5-4) – Rat Lake was sampled in winter, spring and summer of 2000 in support of the Nexen/OPTI Long Lake EIA (OPTI, 2000). Brook stickleback were captured in the spring. Brook stickleback and lake chub were captured in the summer. Overwintering habitat potential was ranked low at this site.

LL8 (unnamed lake) (Figures 8.5-3 and 8.5-4) – This unnamed lake was sampled in winter and spring of 2000 in support of the Nexen/OPTI Long Lake EIA (OPTI, 2000). No fish were captured in this lake. Overwintering habitat potential was ranked low to non-existent at this site.

LL9 (unnamed lake) (Figures 8.5-3 and 8.5-4) – This unnamed lake was sampled in winter and spring of 2000 in support of the Nexen/OPTI Long Lake EIA (OPTI, 2000). No fish were captured in this lake. Overwintering habitat potential was ranked low to non-existent at this site.

LL10 (unnamed lake) (Figures 8.5-3 and 8.5-4) – This unnamed lake was sampled in winter and spring of 2000 in support of the Nexen/OPTI Long Lake EIA (OPTI, 2000). No fish were captured in this lake. Overwintering habitat potential was ranked low to non-existent at this site.

LL12 (Willow (Gregoire) Lake) (Figures 8.5-3 and 8.5-4) – Willow Lake has been sampled on a number of occasions and nine species have been captured in the lake (Bradley 1969, Griffiths 1973, Tripp and Tsui 1980, Sullivan 1985, Mitchell and Prepas 1990). These include Arctic grayling, burbot, cisco, lake whitefish, longnose sucker, northern pike, walleye, trout-perch and yellow perch.

LL13 (Kiskatinaw Lake) (Figures 8.5-3 and 8.5-4) – Kiskatinaw Lake was sampled in winter and summer of 2000 in support of the Nexen/OPTI Long Lake EIA (OPTI, 2000). No fish were captured at this site. Overwintering habitat potential was ranked moderate at this site.

LL14 (Sucker Lake) (Figures 8.5-3 and 8.5-4) – Sucker Lake was surveyed for habitat in summer of 2000 in support of the Nexen/OPTI Long Lake EIA (OPTI, 2000). Overwintering habitat potential was ranked moderate to high at this site.

ML1 (Surmont Lake) (Figures 8.5-3 and 8.5-4) – Surmont Lake was sampled in winter, spring and summer of 2001 in support of the Petro-Canada Meadow Creek EIA (Petro-Canada, 2001). White sucker and northern pike were captured during spring and summer. Overwintering habitat potential was ranked high at this site.

ML2 (unnamed lake) (Figures 8.5-3 and 8.5-4) – This unnamed lake was sampled in winter, spring and summer of 2001 in support of the Petro-Canada Meadow Creek EIA (Petro-Canada, 2001). White sucker and northern pike were captured during spring and summer. Overwintering habitat potential was ranked low at this site.

ML3 (unnamed lake) (Figures 8.5-3 and 8.5-4) – This unnamed lake was sampled in winter, spring and summer of 2001 in support of the Petro-Canada Meadow Creek EIA (Petro-Canada, 2001). White sucker and northern pike were captured during spring and summer. Overwintering habitat potential was ranked low to moderate at this site.

ML4 (unnamed lake) (Figures 8.5-3 and 8.5-4) – This unnamed lake was sampled in winter, spring and summer of 2001 in support of the Petro-Canada Meadow Creek EIA (Petro-Canada, 2001). Northern pike were captured during spring and summer sampling. Overwintering habitat potential was ranked moderate at this site.

ML5 (unnamed lake) (Figures 8.5-3 and 8.5-4) – This unnamed lake was sampled in winter, spring and summer of 2001 in support of the Petro-Canada Meadow Creek EIA (Petro-Canada, 2001). No fish were captured in the spring. Northern pike were captured during summer sampling. Overwintering habitat potential was ranked moderate at this site.

ML6 (unnamed lake) (Figures 8.5-3 and 8.5-4) – This unnamed lake was sampled in winter, spring and summer of 2001 in support of the Petro-Canada Meadow Creek EIA (Petro-Canada, 2001). Brook stickleback were captured during spring and summer sampling. Overwintering habitat potential was ranked low to moderate at this site.

ML7 (unnamed lake) (Figures 8.5-3 and 8.5-4) – This unnamed lake was sampled in winter, spring and summer of 2001 in support of the Petro-Canada Meadow Creek EIA (Petro-Canada, 2001). Brook stickleback were captured during spring sampling. No fish were captured in the summer. Overwintering habitat potential was ranked non-existent to low at this site.

ML8 (unnamed lake) (Figures 8.5-3 and 8.5-4) – This unnamed lake was sampled in winter, spring and summer of 2001 in support of the Petro-Canada Meadow Creek EIA (Petro-Canada, 2001). Brook stickleback were captured during spring sampling. No fish were captured in the summer. Overwintering habitat potential was ranked non-existent to low at this site.

ML9 (unnamed lake) (Figures 8.5-3 and 8.5-4) – This unnamed lake was sampled in winter, spring and summer of 2001 in support of the Petro-Canada Meadow Creek EIA (Petro-Canada, 2001). Northern pike were captured during spring and summer sampling. Overwintering habitat potential was ranked moderate at this site.

ML10 (unnamed lake) (Figures 8.5-3 and 8.5-4) – This unnamed lake located at the headwaters of a tributary to the Hangingstone River, was sampled in winter, spring and summer of 2001 in support of the Petro-Canada Meadow Creek EIA (Petro-Canada, 2001). Brook stickleback were captured during both spring and summer sampling. Overwintering habitat potential was ranked moderate at this site.

ML11 (unnamed lake) (Figures 8.5-3 and 8.5-4) – This unnamed lake was sampled in winter, spring and summer of 2001 in support of the Petro-Canada Meadow Creek EIA (Petro-Canada, 2001). Brook stickleback were captured during spring and summer sampling. Overwintering habitat potential was ranked moderate at this site.

ML16 (unnamed lake) (Figures 8.5-3 and 8.5-4) – This unnamed lake was sampled in winter, spring and summer of 2001 in support of the Petro-Canada Meadow Creek EIA (Petro-Canada, 2001). Brook stickleback were captured in the spring. Brook stickleback and pearl dace were captured during summer sampling. Overwintering habitat potential was ranked moderate lake at this site.

ML17 (unnamed lake) (Figures 8.5-3 and 8.5-4) – This unnamed lake was sampled in winter, spring and summer of 2001 in support of the Petro-Canada Meadow Creek EIA (Petro-Canada, 2001). No fish were captured in this lake. Overwintering habitat potential was ranked low at this site.

ML18 (unnamed lake) (Figures 8.5-3 and 8.5-4) – This unnamed lake was sampled in winter, spring and summer of 2001 in support of the Petro-Canada Meadow Creek EIA (Petro-Canada, 2001). No fish were captured in this lake. Overwintering habitat potential was ranked moderate at this site.

ML19 (unnamed lake) (Figures 8.5-3 and 8.5-4) – This unnamed lake was sampled in winter, spring and summer of 2001 in support of the Petro-Canada Meadow Creek EIA (Petro-Canada, 2001). Brook stickleback were captured during spring sampling. No fish were captured in summer. Overwintering habitat potential was ranked moderate at this site.

ML20 (unnamed lake) (Figures 8.5-3 and 8.5-4) – This unnamed lake was sampled in winter, spring and summer of 2001 in support of the Petro-Canada Meadow Creek EIA (Petro-Canada, 2001). Brook stickleback were captured in the spring. No fish were captured during summer sampling. Overwintering habitat potential was ranked moderate at this site.

ML21 (unnamed lake) (Figures 8.5-3 and 8.5-4) – This unnamed lake was sampled in winter, spring and summer of 2001 in support of the Petro-Canada Meadow Creek EIA (Petro-Canada, 2001). Northern pike were captured in spring and summer. Overwintering habitat potential was ranked moderate at this site.

SL14 to SL23 (Engstrom Lake) (Figures 8.5-3 and 8.5-4) – Engstrom Lake was sampled in spring of 1998 in support of the Gulf Canada Resources Limited Surmont EIA (Gulf Canada, 2001). Brook stickleback, white sucker and rainbow trout were captured in the lake.

8.5.1.3 Gregoire River Confluence to Winefred River Confluence

Watercourses

SR1 (Cottonwood Creek) (Figure 8.5-5) – Cottonwood Creek was sampled in spring and fall of 1998 in support of the Gulf Canada Resources Limited Surmont EIA (Gulf Canada, 2001). White sucker and slimy sculpin were captured in the spring. Lake chub, slimy sculpin and burbot were captured during fall sampling. Overwintering habitat potential was ranked low at this site.

SR2 (Cottonwood Creek) (Figure 8.5-5) – Cottonwood Creek was sampled in spring of 1998 in support of the Gulf Canada Resources Limited Surmont EIA (Gulf Canada, 2001). White sucker and slimy sculpin were captured at this site. Overwintering habitat potential was ranked low at this site.

SR3 (Cottonwood Creek) (Figure 8.5-5) – Cottonwood Creek was sampled in spring of 1998 in support of the Gulf Canada Resources Limited Surmont EIA (Gulf Canada, 2001). Lake chub and slimy sculpin were captured at this site. Overwintering habitat potential was ranked low at this site.

SR4 (Cottonwood Creek) (Figure 8.5-5) – Cottonwood Creek was sampled in spring of 1998 in support of the Gulf Canada Resources Limited Surmont EIA (Gulf Canada, 2001). Slimy sculpin were captured at this site. Overwintering habitat potential was ranked low at this site.

SR5 (Cottonwood Creek) (Figure 8.5-5) – Cottonwood Creek was sampled in spring, summer and fall of 1998 in support of the Gulf Canada Resources Limited Surmont EIA (Gulf Canada, 2001). Slimy sculpin were captured in spring. A combination of brook stickleback, lake chub, white sucker, slimy sculpin and burbot were captured during summer and fall sampling. Overwintering habitat potential was ranked low to moderate at this site.

SR6 (Cottonwood Creek) (Figure 8.5-5) – Cottonwood Creek was sampled in spring of 1998 in support of the Gulf Canada Resources Limited Surmont EIA (Gulf Canada, 2001). Slimy sculpin were captured at this site. Overwintering habitat potential was ranked low at this site.

SR7 (Cottonwood Creek) (Figure 8.5-5) – Cottonwood Creek was sampled in spring of 1998 in support of the Gulf Canada Resources Limited Surmont EIA (Gulf Canada, 2001). Slimy sculpin were captured at this site. Overwintering habitat potential was ranked low at this site.

SR8 (Cottonwood Creek) (Figure 8.5-5) – Cottonwood Creek was sampled in spring and fall of 1998 in support of the Gulf Canada Resources Limited Surmont EIA (Gulf Canada, 2001). Lake chub, white sucker and slimy sculpin were captured in the spring. Slimy sculpin were captured during fall sampling. Overwintering habitat potential was ranked low to moderate at this site.

SR9 (Cottonwood Creek) (Figure 8.5-5) – Cottonwood Creek was sampled in spring, summer and fall of 1998 in support of the Gulf Canada Resources Limited Surmont EIA (Gulf Canada, 2001). Brook stickleback and slimy sculpin were captured in the spring, summer and fall. White sucker and burbot were captured during summer sampling. Overwintering habitat potential was ranked low to moderate at this site.

SR10 (Cottonwood Creek) (Figure 8.5-5) – Cottonwood Creek was sampled in spring and fall of 1998 in support of the Gulf Canada Resources Limited Surmont EIA (Gulf Canada, 2001). Spottail shiner was the only species captured in the spring. White sucker, finescale dace and yellow perch were captured during fall sampling. Overwintering habitat potential was ranked low at this site.

SR11 (Cottonwood Creek) (Figure 8.5-5) – Cottonwood Creek was sampled in spring of 1998 in support of the Gulf Canada Resources Limited Surmont EIA (Gulf Canada, 2001). Longnose sucker, trout-perch and white sucker were captured at this site. Overwintering habitat potential was ranked low.

SR12 (tributary to Cottonwood Creek) (Figure 8.5-5) – This tributary to Cottonwood Creek was sampled in spring of 1998 in support of the Gulf Canada Resources Limited Surmont EIA (Gulf Canada, 2001). No fish were captured at this site. Overwintering habitat potential was ranked non-existent.

SR13 (tributary to Cottonwood Creek) (Figure 8.5-5) – This tributary to Cottonwood Creek was sampled in summer of 1998 in support of the Gulf Canada Resources Limited Surmont EIA (Gulf Canada, 2001). No fish were captured at this site. Overwintering habitat potential was ranked non-existent.

SR14 (tributary to Cottonwood Creek) (Figure 8.5-5) – This tributary to Cottonwood Creek was sampled in summer and fall of 1998 in support of the Gulf Canada Resources Limited Surmont EIA (Gulf Canada, 2001). No fish were captured at this site. Overwintering habitat potential was ranked non-existent.

SR15 (tributary to Cottonwood Creek) (Figure 8.5-5) – This tributary to Cottonwood Creek was sampled in summer and fall of 1998 in support of the Gulf Canada Resources Limited Surmont EIA (Gulf Canada, 2001). Brook stickleback were captured during summer and fall sampling. Overwintering habitat potential was ranked non-existent at this site.

SR16 (tributary to Cottonwood Creek) (Figure 8.5-5) – This tributary to Cottonwood Creek was sampled in summer and fall of 1998 in support of the Gulf Canada Resources Limited Surmont EIA (Gulf Canada, 2001). Brook stickleback were captured during summer sampling. Brook stickleback and finescale dace were captured in the fall. Overwintering habitat potential was ranked non-existent at this site.

SR31 (Christina River) (Figure 8.5-5) – Christina River was sampled in spring and fall of 1998 in support of the Gulf Canada Resources Limited Surmont EIA (Gulf Canada, 2001). Longnose sucker, white sucker, northern pike and walleye were captured at this site.

SR32 (Christina River) (Figure 8.5-5) – Christina River was sampled in spring and fall of 1998 in support of the Gulf Canada Resources Limited Surmont EIA (Gulf Canada, 2001). Longnose sucker, white sucker, northern pike, goldeye and trout-perch were captured at this site.

SR33 (Christina River) (Figure 8.5-5) – Christina River was sampled in summer of 1998 in support of the Gulf Canada Resources Limited Surmont EIA (Gulf Canada, 2001). Longnose sucker, white sucker, northern pike, goldeye and walleye were captured at this site.

SR34 (Christina River) (Figure 8.5-5) – Christina River was sampled in summer of 1998 in support of the Gulf Canada Resources Limited Surmont EIA (Gulf Canada, 2001). Northern pike were captured at this site.

SR35 (Christina River) (Figure 8.5-5) – Christina River was sampled in summer of 1998 in support of the Gulf Canada Resources Limited Surmont EIA (Gulf Canada, 2001). White sucker, northern pike and goldeye were captured at this site.

SR36 (tributary to Cottonwood Creek) (Figure 8.5-5) – This tributary to Cottonwood Creek was sampled in summer of 1998 in support of the Gulf Canada Resources Limited Surmont EIA (Gulf Canada, 2001). Brook stickleback were captured at this site. Overwintering habitat potential was ranked non-existent.

SR37 (unnamed tributary to Christina River) (Figure 8.5-5) – This Tributary to Christina River was sampled in summer of 1998 in support of the Gulf Canada Resources Limited Surmont EIA (Gulf Canada, 2001). Brook stickleback and finescale dace were captured at this site.

SR38 (unnamed tributary to Christina River) (Figure 8.5-5) – This Tributary to Christina River was sampled in summer and fall of 1998 in support of the Gulf Canada Resources Limited Surmont EIA (Gulf Canada, 2001). Brook stickleback and finescale dace were captured during summer and fall sampling.

SR40 (Christina River) (Figure 8.5-5) – Christina River was sampled in fall of 1998 in support of the Gulf Canada Resources Limited Surmont EIA (Gulf Canada, 2001). Lake chub, longnose sucker, trout-perch, white sucker, northern pike and finescale dace were captured at this site.

SR41 (Christina River) (Figure 8.5-5) – Christina River was sampled in fall of 1998 in support of the Gulf Canada Resources Limited Surmont EIA (Gulf Canada, 2001). White sucker, northern pike and walleye were captured at this site.

SR42 (Christina River) (Figure 8.5-5) – Christina River was sampled in summer of 1998 in support of the Gulf Canada Resources Limited Surmont EIA (Gulf Canada, 2001). Trout-perch, white sucker, northern pike, walleye and spottail shiner were captured at this site.

SR45 (Christina River) (Figure 8.5-5) – Christina River was sampled in summer of 1998 in support of the Gulf Canada Resources Limited Surmont EIA (Gulf Canada, 2001). Trout perch, white sucker, northern pike and walleye were captured at this site.

Waterbodies

SL1 to SL13 (Cottonwood Lake) (Figure 8.5-5) – Cottonwood Lake was sampled in spring of 1998 in support of the Gulf Canada Resources Limited Surmont EIA (Gulf Canada, 2001). Brook stickleback and white sucker were captured at this site.

SL24 to SL34 (unnamed lake) (Figure 8.5-5) – This unnamed lake was sampled in spring of 1998 in support of the Gulf Canada Resources Limited Surmont EIA (Gulf Canada, 2001). No fish were captured at this site.

8.5.1.4 Winefred River Basin and Surrounding Tributaries

SR27 (Kettle River) (Figure 8.5-6) – Kettle River was sampled in spring of 1998 in support of the Gulf Canada Resources Limited Surmont EIA (Gulf Canada, 2001). Lake chub, pearl dace, white sucker and slimy sculpin were captured during at this site. Overwintering habitat potential was ranked low for large bodied/sport fish species and moderate for forage fish.

SR28 (Kettle River) (Figure 8.5-6) – Kettle River was sampled in spring of 1998 in support of the Gulf Canada Resources Limited Surmont EIA (Gulf Canada, 2001). Brook stickleback, lake chub, white sucker and slimy sculpin were captured at this site. Overwintering habitat potential was ranked low for large bodied/sport fish species and moderate for forage fish.

SR29 (Kettle River) (Figure 8.5-6) – Kettle River was sampled in spring of 1998 in support of the Gulf Canada Resources Limited Surmont EIA (Gulf Canada, 2001). Brook stickleback, longnose sucker and white sucker were captured at this site. Overwintering habitat potential was ranked low for large bodied/sport fish species and moderate for forage fish.

SR30 (Kettle River) (Figure 8.5-6) – Kettle River was sampled in spring and fall of 1998 in support of the Gulf Canada Resources Limited Surmont EIA (Gulf Canada, 2001). Arctic grayling and slimy sculpin were captured at this site. Overwintering habitat potential was ranked low for large bodied/sport fish species and moderate for forage fish.

RR4 (Christina River) (Figure 8.5-6) – The Christina River was sampled in fall of 2004 by RAMP (Regional Aquatics Monitoring Program) to assess its suitability for baseline data collection to support resource development impact determinations (RAMP, 2004). Longnose sucker, white sucker and trout-perch were captured at this site.

CR10 (tributary to Christina River) (Figure 8.5-6) – This unnamed tributary to the Christina River was sampled in spring and summer of 2004 in support of the MEG Energy Christina Lake EIA (MEG, 2005). No fish were captured at this site. Overwintering habitat potential was ranked non-existent for large bodied/sport fish and low to non-existent for forage fish.

CR11 (tributary to Christina River) (Figure 8.5-6) – This unnamed tributary to the Christina River was sampled in spring and summer of 2004 in support of the MEG Energy Christina Lake EIA (MEG, 2005). No fish were captured at this site. Overwintering habitat potential was ranked non-existent for large bodied/sport fish and low to non-existent for forage fish.

Winefred River Basin (Tributary to the Christina)

Watercourses

CR13 (tributary to Cowper Lake) (Figure 8.5-6) – This tributary to Cowper Lake was sampled in summer of 2004 in support of the MEG Energy Christina Lake EIA (MEG, 2005). Brook stickleback were captured at this site. Overwintering habitat potential was ranked non-existent.

KR2 (unnamed stream) (Figure 8.5-6) – This unnamed stream was sampled in summer of 2001 in support of the Rio Alto Kirby EIA (Rio Alto, 2002). Brook stickleback were captured at this site. Overall fish habitat potential was ranked low for large bodied/sport fish and moderate for forage fish.

KR3 (unnamed stream) (Figure 8.5-6) – This unnamed stream was sampled in summer of 2001 in support of the Rio Alto Kirby EIA (Rio Alto, 2002). Brook stickleback were captured at this site. Overall fish habitat potential was ranked low to non-existenta for large bodied/sport fish and low to moderate for forage fish.

KR4 (unnamed stream) (Figure 8.5-6) – This unnamed stream was sampled in summer of 2001 in support of the Rio Alto Kirby EIA (Rio Alto, 2002). Brook stickleback and northern pike were captured at this site. Fish habitat potential was ranked low to moderate for large bodied/sport fish and moderate for forage fish.

KR5 (unnamed stream) (Figure 8.5-6) – This unnamed stream was sampled in summer of 2001 in support of the Rio Alto Kirby EIA (Rio Alto, 2002). No fish were captured at this site. Fish habitat potential was ranked moderate to good.

Waterbodies

KL6 (unnamed lake) (Figure 8.5-6) – This unnamed lake was sampled in summer of 2001 in support of the Rio Alto Kirby EIA (Rio Alto, 2002). Brook stickleback were captured at this site.

8.5.1.5 Jackfish River Basin

Watercourses

CR1 (Sawbones Creek) (Figure 8.5-7) – Sawbones Creek was sampled in spring and summer of 2004 in support of the MEG Energy Christina Lake EIA (MEG, 2005). Walleye were captured in the spring. No fish were captured at this site. Overwintering habitat potential was ranked low to non-existent for large bodied/sport fish and low to moderate for forage fish.

CR2 (Sawbones Creek) (Figure 8.5-7) – Sawbones Creek was sampled in winter, spring and summer of 2004 in support of the MEG Energy Christina Lake EIA (MEG, 2005). No fish were captured at this site. Overwintering habitat potential was ranked low to non-existent for large bodied/sport fish and low to moderate for forage fish.

CR3 (Sawbones Creek) (Figure 8.5-7) – Sawbones Creek was sampled in spring and summer of 2004 in support of the MEG Energy Christina Lake EIA (MEG, 2005). No fish were captured at this site. Overwintering habitat potential was ranked low to non-existent for large bodied/sport fish and low to moderate for forage fish.

CR4 (Sawbones Creek) (Figure 8.5-7) – Sawbones Creek was sampled in winter, spring and summer of 2004 in support of the MEG Energy Christina Lake EIA (MEG, 2005). No fish were captured at this site. Overwintering habitat potential was ranked low to non-existent for large bodied/sport fish and low to moderate for forage fish.

CR5 (tributary to Sawbones Creek) (Figure 8.5-7) – This unnamed tributary to Sawbones Creek was sampled in spring and summer of 2004 in support of the MEG Energy Christina Lake EIA (MEG, 2005). No fish were captured at this site in the spring. White sucker were captured in the summer. Overwintering habitat potential was ranked low to non-existent for large bodied/sport fish and low to moderate for forage fish at this site.

CR6 (tributary to Christina Lake) (Figure 8.5-7) – This tributary to Christina Lake was sampled in winter, spring and summer of 2004 in support of the MEG Energy Christina Lake EIA (MEG, 2005). No fish were captured at this site. Overwintering habitat potential was ranked low to non-existent for large bodied/sport fish and low to moderate for forage fish.

CR7 (tributary to Christina Lake) (Figure 8.5-7) – This tributary to Christina Lake was sampled in winter, spring and summer of 2004 in support of the MEG Energy Christina Lake EIA (MEG, 2005). Brook stickleback were captured in the spring. No fish were captured during summer sampling. Overwintering habitat potential was ranked low to non-existent for large bodied/sport fish and low to moderate for forage fish at this site.

CR8 (tributary to Sawbones Creek) (Figure 8.5-7) – This tributary to Sawbones Creek was sampled in spring and summer of 2004 in support of the MEG Energy Christina Lake EIA (MEG, 2005). Brook stickleback were captured during spring and summer sampling. Overwintering habitat potential was ranked low to non-existent for large bodied/sport fish and low to moderate for forage fish at this site.

CR9 (tributary to Christina Lake) (Figure 8.5-7) – This tributary to Christina Lake was sampled in winter, spring and summer of 2004 in support of the MEG Energy Christina Lake EIA (MEG, 2005). No fish were captured at this site. Overwintering habitat potential was ranked low to non-existent for large bodied/sport fish and low to moderate for forage fish.

CR12 (tributary to Sawbones Creek) (Figure 8.5-7) – This unnamed tributary to Sawbones Creek was sampled in summer of 2004 in support of the MEG Energy Christina Lake EIA (MEG, 2005). No fish were captured at this site. Overwintering habitat potential was ranked non-existent.

JR1 (Sunday Creek) (Figure 8.5-7) – Sunday Creek was sampled in spring of 2002 and winter of 2003 in support of the Devon Jackfish EIA (Devon, 2003). No fish were captured at this site. Overwintering habitat potential was ranked low.

JR2 (unnamed (Monday) Creek) (Figure 8.5-7) – Monday Creek was sampled in spring of 2002 and winter of 2003 in support of the Devon Jackfish EIA (Devon, 2003). Brook stickleback were captured at this site in spring. Overwintering habitat potential was ranked low to non-existent at this site.

Waterbodies

CL1 (Christina Lake) (Figure 8.5-7) – Christina Lake has been sampled in the past and nine fish species have been identified as present in this lake (Mitchell and Prepas, 1990). These include Arctic grayling, burbot, cisco, lake whitefish, longnose sucker, northern pike, walleye, trout-perch and yellow perch.

CL3 (unnamed lake) (Figure 8.5-7) – This unnamed lake was sampled in spring and summer of 2004 in support of the MEG Energy Christina Lake EIA (MEG, 2005). No fish were captured in the spring. Northern pike were captured during summer sampling. Overwintering habitat potential was ranked low to non-existent for large bodied/sport fish and moderate for forage fish species at this site.

CL4 (unnamed lake) (Figure 8.5-7) – This unnamed lake was sampled in spring and summer of 2004 in support of the MEG Energy Christina Lake EIA (MEG, 2005). No fish were captured at this site. Overwintering habitat potential was ranked low to non-existent for large bodied/sport fish and low for forage fish species.

CL6 (unnamed lake) (Figure 8.5-7) – This unnamed lake was sampled in winter, spring and summer of 2004 in support of the MEG Energy Christina Lake EIA (MEG, 2005). Northern pike were captured in the spring and summer. Overwintering habitat potential was ranked low to non-existent for large bodied/sport fish and low for forage fish species.

CL7 (unnamed lake) (Figure 8.5-7) – This unnamed lake was sampled in winter, spring and summer of 2004 in support of the MEG Energy Christina Lake EIA (MEG, 2005). No fish were captured at this site. Overwintering habitat potential was ranked low to non-existent for large bodied/sport fish and low for forage fish species.

CL8 (unnamed lake) (Figure 8.5-7) – This unnamed lake was sampled in winter, spring and summer of 2004 in support of the MEG Energy Christina Lake EIA (MEG, 2005). No fish were captured at this site. Overwintering habitat potential was ranked low to non-existent for large bodied/sport fish and low for forage fish species.

CL9 (unnamed lake) (Figure 8.5-7) – This unnamed lake was sampled in winter, spring and summer of 2004 in support of the MEG Energy Christina Lake EIA (MEG, 2005). No fish were captured at this site. Overwintering habitat potential was ranked low to non-existent for large bodied/sport fish and low for forage fish species.

CL11 (unnamed lake) (Figure 8.5-7) – This unnamed lake was sampled in winter, spring and summer of 2004 in support of the MEG Energy Christina Lake EIA (MEG, 2005). No fish were captured in the spring. Brook stickleback were captured during summer sampling. Overwintering habitat potential was ranked low to non-existent for large bodied/sport fish and low for forage fish species.

CL12 (unnamed lake) (Figure 8.5-7) – This unnamed lake was sampled in winter, spring and summer of 2004 in support of the MEG Energy Christina Lake EIA (MEG, 2005). Brook stickleback and northern pike were captured in the lake during spring and summer sampling. Overwintering habitat potential was ranked low to moderate for large bodied/sport fish and moderate to high for forage fish species.

CL13 (unnamed lake) (Figure 8.5-7) – This unnamed lake was sampled in spring and summer of 2004 in support of the MEG Energy Christina Lake EIA (MEG, 2005). Brook stickleback were captured in the lake during both sampling seasons. Overwintering habitat potential was ranked low to non-existent for large bodied/sport fish and low for forage fish species.

CL15 (unnamed lake) (Figure 8.5-7) – This unnamed lake was sampled in spring and summer of 2004 in support of the MEG Energy Christina Lake EIA (MEG, 2005). No fish were captured at this site. Overwintering habitat potential was ranked low to non-existent for large bodied/sport fish and low for forage fish species.

CL16 (unnamed lake) (Figure 8.5-7) – This unnamed lake was sampled in winter, spring and summer of 2004 in support of the MEG Energy Christina Lake EIA (MEG, 2005). Brook stickleback were captured at this site. Overwintering habitat potential was ranked low to non-existent for large bodied/sport fish and moderate for forage fish species.

JL1 (unnamed lake) (Figure 8.5-7) – This unnamed lake was sampled in spring of 2002 and winter of 2003 in support of the Devon Jackfish EIA (Devon, 2003). Based upon results of these assessments, the authors concluded that this lake is unlikely to support fish.

JL2 (unnamed lake) (Figure 8.5-7) – Monday Creek was sampled in spring of 2002 and winter of 2003 in support of the Devon Jackfish EIA (Devon, 2003). Based upon results of these assessments, the authors concluded that this lake is unlikely to support fish.

8.5.1.6 Horse River Basin

Watercourses

HR1 (Horse Creek) (Figure 8.5-8) – Horse Creek was sampled in spring, summer and fall of 2001 in support of the JACOS Hangingstone EIA (unpublished data – Golder, 2002). Lake chub was the only species captured in the spring. No fish were captured at this site during summer or fall sampling.

HR2 (Horse Creek) (Figure 8.5-8) – Horse Creek was sampled in spring, summer and fall of 2001 in support of the JACOS Hangingstone EIA (unpublished data – Golder, 2002). No fish were captured at this site.

HR3 (Horse Creek) (Figure 8.5-8) – Horse Creek was sampled in spring, summer and fall of 2001 in support of the JACOS Hangingstone EIA (unpublished data – Golder, 2002). Longnose sucker, trout-perch and slimy sculpin were captured in the fall. Lake chub and slimy sculpin were captured in the summer. Longnose sucker were captured in the spring.

HR4 (Horse Creek) (Figure 8.5-8) – Horse Creek was sampled in summer of 2001 in support of the JACOS Hangingstone EIA (unpublished data – Golder, 2002). No fish were captured at this site. Habitat potential was ranked low to non-existent for large bodied/sport fish and moderate for forage fish species.

HR5 (Horse Creek) (Figure 8.5-8) – Horse Creek was sampled in spring, summer and fall of 2001 in support of the JACOS Hangingstone EIA (unpublished data – Golder, 2002). A total of nine fish species were captured at this site. Slimy sculpin were the most abundant fish in the fall and white sucker were the most abundant during spring sampling. Arctic grayling, lake chub, longnose sucker, trout-perch, walleye, longnose dace and mountain whitefish were also captured at this site.

HR6 (Horse Creek) (Figure 8.5-8) – Horse Creek was sampled in summer of 2001 in support of the JACOS Hangingstone EIA (unpublished data – Golder, 2002). No fish were captured at this site.

HR7 (Horse Creek) (Figure 8.5-8) – Horse Creek was sampled in summer of 2001 in support of the JACOS Hangingstone EIA. No fish were captured at this site.

HR8 (Horse River) (Figure 8.5-8) – The Horse River was sampled in spring, summer and fall of 2001 in support of the JACOS Hangingstone EIA (unpublished data – Golder, 2002). A total of eight fish species were captured at this site. Lake chub, longnose sucker and white sucker were captured during each sampling season. Other species captured at this site include trout-perch, slimy sculpin, walleye, Arctic grayling and mountain whitefish.

HR9 (Horse River) (Figure 8.5-8) – The Horse River was sampled in spring, summer and fall of 2001 in support of the JACOS Hangingstone EIA (unpublished data – Golder, 2002). A total of nine fish species were captured at this site. These include white sucker, lake chub, longnose sucker, trout-perch, slimy sculpin, walleye, emerald shiner, goldeye and flathead chub.

HR10 (tributary to Horse Creek) (Figure 8.5-8) – This tributary to Horse Creek was sampled in spring, summer and fall of 2001 in support of the JACOS Hangingstone EIA (unpublished data – Golder, 2002). Lake chub was the only species captured in the summer. A combination of brook stickleback, lake chub and slimy sculpin were captured during spring and fall sampling.

HR11 (tributary to Horse Creek) (Figure 8.5-8) – This tributary to Horse Creek was sampled in spring, summer and fall of 2001 in support of the JACOS Hangingstone EIA (unpublished data – Golder, 2002). Brook stickleback and slimy sculpin were captured during all three sampling seasons.

HR12 (tributary to Horse Creek) (Figure 8.5-8) – This tributary to Horse Creek was sampled in spring, summer and fall of 2001 in support of the JACOS Hangingstone EIA (unpublished data – Golder, 2002). Brook stickleback and slimy sculpin were captured during all three seasons. Additional species captured were lake chub, longnose sucker, pearl dace, white sucker, Arctic grayling and fathead minnow.

HR13 (tributary to Horse Creek) (Figure 8.5-8) – This tributary to Horse Creek was sampled in spring, summer and fall of 2001 in support of the JACOS Hangingstone EIA (unpublished data – Golder, 2002). Slimy sculpin were the most abundant species captured during each sampling season. Arctic grayling, lake chub, longnose sucker, white sucker, longnose dace and finescale dace were also captured at this site.

HR14 (tributary to Horse Creek) (Figure 8.5-8) – This tributary to Horse Creek was sampled in spring and fall of 2001 in support of the JACOS Hangingstone EIA (unpublished data – Golder, 2002). White sucker and slimy sculpin were captured in the spring. Trout-perch, longnose sucker, white sucker and slimy sculpin were captured during fall sampling.

8.5.2 Species of Special Concern

Arctic grayling is the only species of concern within the LSA, as referenced by either provincial or federal classification systems. Currently, the Arctic grayling is listed as ‘sensitive’ by Alberta Sustainable Resource Development (ASRD) in the *General Status of Alberta Wild Species 2005* report (ASRD, 2005). Sensitive status species are defined as “any species that is not at risk of extinction or extirpation, but may require special attention or protection to prevent it from becoming at risk” (ASRD, 2005). At this time, the Arctic grayling appears on the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) candidate list as a Group 3 (lower priority) species and has not qualified for protection under Canada’s *Species at Risk Act* (SARA).

8.5.3 Waterbody and Watercourse Assessment Results

Observations recorded during the field surveys of waterbodies and watercourses are presented in Figures 8.5-9to 8.5-42 These figures provide a detailed description of existing conditions and illustrate the baseline condition of the fish and fish habitat study sites for the purpose of the impact assessment and any future monitoring that may be required. The information presented in the figures includes detailed habitat mapping, summaries of the recorded surface water quality characteristics, identification of observed fish species and an overall ranking of fish habitat potential. These information categories are further discussed below.

- The habitat map and accompanying description of each watercourse or waterbody illustrates the conditions observed during survey seasons. Included is lakebed composition (shape and substrate composition), the presence and location of inlet and outlet channels, and the presence of potential fish habitat (including depth, cover and vegetation).

- The field water quality data represented in the figures includes the temperature (^{o}C), DO (mg/L), pH and conductivity (uS/cm) recorded during the field surveys. Water quality was recorded throughout the water column of the lakes to provide an indication of conditions from the surface to the substrate. Temperature was recorded to determine the suitability of the waterbody to temperature sensitive specie. Optimum temperature ranges for cold water species are less than 18^{o}C with spawning temperatures less than 15^{o}C. Optimum temperature ranges for cool water species are less than 27^{o}C with spawning temperatures less than 21^{o}C (Mitchell and Prepas, 1990). Dissolved oxygen levels were recorded in order to determine the waterbody's capacity to sustain fish (i.e., DO levels below 5.5 mg/L were considered to be unsuitable [sub-optimum] for sport fish) (CCME, 1999). Recorded pH levels provide an indication of water acidity and conductivity, indicating the ion concentrations in the water.

- The fish collection data provides a summary of the species captured or observed during surveys and the methods (baited minnow traps, gill nets, set-lines and angling) and effort required (recorded in hours and minutes) to capture the fish.

- The habitat potential ranking table provided in the figures summarizes the overall fish habitat observed for both forage and large bodied/sport fish species. The rankings were derived using observations of existing fish habitat and water quality data, combined with the fish species observed during field surveys. Rankings are provided for spawning, rearing, feeding and overwintering habitat potential.

8.5.4 Watercourses – Baseline Data Summary

As detailed in section 8.2, the LSA was divided into three areas. These areas, detailed below, reflect the three watershed areas that the Project encompasses. They include:

- The Hangingstone study area, which captures the headwater regions of the Christina and the Hangingstone Rivers.

- The Corner study area, which is geographically divided by an elevated plateau captures tributaries of the upper Christina River watershed to the west and tributaries of the middle Christina River watershed to the east.

- The Leismer study area, which includes sections of the Christina River and its tributaries, as well as tributaries of the House River to the west.

The following section outlines the information collected at watercourses during the baseline surveys at each of the outlined study areas.

8.5.4.1 Hangingstone

Of the six watercourses surveyed for spawning, rearing and feeding in the Hangingstone study area, all (WCH1, WCH2, WCH3, WCH4, WCH5 and WCH6) were found to have low or low to moderate habitat potential for large bodied/sport fish species and moderate potential for forage fish species.

Overwintering habitat potential was ranked nil for WCH5. One watercourse (WCH2) had low overwintering habitat potential for both large bodied/sport fish and forage fish and one watercourse (WCH3) had low overwintering potential for large bodies/sport fish and moderate potential for forage fish species. Overwintering habitat potential was unknown for three sites (WCH1, WCH4 and WCH6).

During the fish and fish habitat surveys, fish were captured in several watercourses in the study area. Brook stickleback were captured at WCH1, WCH2, WCH3, WCH4 and WCH6. Spottail shiner were captured at WCH1, WCH2 and WCH6. Pearl dace were captured at WCH2 and WCH6. Fathead minnow and longnose sucker were captured at WCH6.

Detailed summaries of the baseline data collected for the watercourses in the Hangingstone study area are presented in Figures 8.5-9 to 8.5-14.

8.5.4.2 Corner

Of the three watercourses surveyed for spawning, rearing and feeding in the Corner study area, two (WCC1, WCC2) were found to have low habitat potential for large bodied/sport fish species and one watercourse (WCC3) was found to have low to moderate habitat potential for large bodied/sport fish species. All three watercourses (WCC1, WCC2 and WCC3) were found to have moderate potential for forage fish species.

Overwintering habitat potential was ranked low for WCC3 and was unknown for the other two sites (WCC1 and WCC2).

During the fish and fish habitat surveys, fish were captured at all three watercourses in the study area. Brook stickleback were captured in WCC1, WCC2 and WCC3. Pearl dace was captured in WCC1. Fathead minnow were captured in WCC1 and WCC2. Longnose sucker were captured in WCC3.

Detailed summaries of the baseline data collected for the watercourses in the Corner study area are presented in Figures 8.5-15 to 8.5-17.

8.5.4.3 Leismer

Of the 15 watercourses surveyed for spawning, rearing and feeding in the Leismer study area, eight (WCL2, WCL3, WCL4, WCL5, WCL6, WCL8, WCL13 and WCL15) were found to have low or low to moderate habitat potential for large bodied/sport fish species. Seven watercourses (WCL1, WCL7, WCL9, WCL10, WCL11, WCL12 and WCL14) had moderate or moderate to high potential for large bodied/sport fish species. Nine watercourses (WCL2, WCL3, WCL4, WCL5, WCL6, WCL8, WCL13, WCL14 and WCL15) had moderate potential for forage fish species. Six watercourses (WCL1, WCL7, WCL9, WCL10, WCL11 and WCL12) had high potential for forage fish species.

Overwintering habitat potential at WCL6 was ranked nil to low for large bodied/sport fish species and low potential for forage fish. Two watercourses (WCL5 and WCL9) were ranked low for both large bodied/sport fish and forage fish species and five watercourses (WCL2, WCL4, WCL11, WCL12 and WCL13) had low overwintering habitat for large bodied/sport fish and moderate potential for forage fish. Overwintering habitat potential was unknown for seven sites (WCL1, WCL3, WCL7, WCL8, WCL10, WCL14 and WCL15).

During the fish and fish habitat surveys, fish were captured in all but two watercourses in the Leismer study area. Brook stickleback were captured in WCL1, WCL2, WCL3, WCL5, WCL6, WCL8 and WCL11. Spottail shiner were captured in WCL1, WCL7 and WCL10. Pearl dace were captured in WCL2, WCL7 and WCL14. Longnose sucker were captured in WCL4, WCL7, WCL10 and WCL11. Lake chub were captured in WCL4, WCL11 and WCL12. White sucker were captured in WCL7, WCL10 and WCL11. Arctic grayling were captured in WCL7, WCL9, WCL10, WCL11 and WCL12. Burbot were captured in WCL11 and WCL12. Fathead minnow were captured in WCL8. Goldeye and trout-perch were captured in WCL11.

Detailed summaries of the baseline data collected for the watercourses in the Leismer study area are presented in Figures 8.5-18 to 8.5-32.

8.5.5 Waterbodies – Baseline Data Summary

8.5.5.1 Hangingstone

Of the three waterbodies surveyed in the Hangingstone study area, one (LH3) was assessed as having low habitat potential for spawning, rearing and feeding for large bodied/sport fish species. Two waterbodies (LH1 and LH2) were assessed as having moderate to high habitat for large bodied/sport fish species. Spawning, rearing and feeding habitat potential for forage fish was high at two waterbodies (LH1 and LH2), and moderate at one waterbody (LH3).

Overwintering habitat potential at LH1 was high for both large bodied/sport fish and forage fish species. LH3 was assessed as having low potential for large bodied/sport fish species and moderate potential for forage fish species. Overwintering habitat potential was unknown for one site (LH2).

During the fish and fish habitat surveys, fish were captured in all three waterbodies surveyed. Brook stickleback were captured in LH1, LH2 and LH3. Pearl dace were captured in LH1 and LH2. Spottail shiner and white sucker were captured in LH1 and northern pike were captured in LH2.

Detailed summaries of the baseline data collected for the waterbodies in the Hangingstone study area are presented in Figures 8.5-33 to 8.5-35.

8.5.5.2 Corner

Of the two waterbodies surveyed in the Corner study area, LC1 was determined to have high spawning, rearing and feeding habitat potential for both large bodied/sport fish and forage fish species. Rearing and feeding habitat potential at LC2 was high, whereas spawning was rated as low for large bodied/sport fish species. Spawning, rearing and feeding potential at LC2 was high for forage fish.

Overwintering habitat potential at LC1 was low for large bodied/sport fish species and moderate for forage fish species. Overwintering habitat potential was unknown for LC2.

During the fish and fish habitat surveys, fish were captured at both lakes in the Corner study area. Brook stickleback, white sucker, longnose sucker and spottail shiner were captured at both LC1 and LC2. Northern pike, lake chub and pearl dace were captured at LC1.

Detailed summaries of the baseline data collected for the waterbodies in the Corner study area are presented in Figures 8.5-36 to 8.5-37.

8.5.5.3 Leismer

Of the five waterbodies surveyed in the Leismer study area, two (LL1 and LL5) were assessed as having nil or low spawning, rearing and feeding habitat potential for large bodied/sport fish species; whereas, three waterbodies (LL2, LL3 and LL4) had high habitat potential for both large bodied/sport fish and forage fish species. LL1 was determined to have low habitat potential for spawning, rearing and feeding for forage fish and LL5 was determined to have moderate potential.

Overwintering habitat potential at LL2, LL4 and LL5 was nil to low for large bodied/sport fish species. Waterbodies LL2 and LL4 were determined to have moderate potential for forage fish species; whereas LL5 was determined to have low potential for forage species. Overwintering habitat potential was unknown for two sites (LL1 and LL3).

During the fish and fish habitat surveys, fish were captured in four out of five waterbodies in the Leismer study area. Brook stickleback were captured in LL2, LL4 and LL5. Fathead minnow were captured in LL2 and LL4. Spottail shiner were captured in LL2. White sucker and pearl dace were captured in LL2 and LL4. Northern pike were captured in LL3 and LL4. Arctic grayling and longnose sucker were captured in LL4.

Detailed summaries of the baseline data collected for the waterbodies in the Leismer study area are presented in Figures 8.5-38 to 8.5-42.

8.5.6 Benthic Invertebrates

Mean abundance of benthic invertebrates in regional waterbodies was variable. Abundance in regional waterbodies ranged from about 350 organisms/m^2 to more than 68,000 organisms/m^2, while richness ranged between 5 taxa and 32 taxa (lowest practical level). Mean abundance in regional watercourses ranged between 2 organisms/m^2 and 63,000 organisms/m^2, while richness ranged between 2 taxa and 44 taxa (lowest practical level). Overall, abundances of large groups and taxonomic richness were slightly higher among depositional watercourse sites than either erosional watercourses or waterbodies. Appendix 8A provides more detail.

In waterbodies and in depositional watercourse habitats, community composition was often dominated by midge larvae (Chironomini, Tanytarsini, Orthocladiinae and Tanypodinae) and aquatic worms (Lumbriculidae, Naididae, and Tubuficidae). Ephemoptera, Plecoptera and Trichoptera made up the largest contribution to community composition in erosional watercourse habitats. Appendix 8A provides more detail.

Results from principal component analysis (PCA) indicate 54% of the variance in the data are explained by the first two components (Figure 8.5-43 and Table 8.5-2). An additional 9% of the variance is explained by the third component. Results appear to suggest community composition is strongly influenced by habitat type. Taxonomic groups that are generally considered typical of communities found in erosional areas (Trichoptera, Ephemeroptera, and Plecoptera) and the taxonomically diverse groups labeled “non-Chironomid Diptera” and “Other” had high positive loadings on the first principal component (PC-1). This can be seen in the ordination plot where the erosional sites are clustered to the right of the plot. Three large taxonomic groups (Tanypodinae, Ostracoda, Molluska), the midge Chironommini and one smaller group (Hirudinea) had high positive loadings on the second principal component (PC-2).

Table 8.5-2 Summary of Principal Component Analysis Results for Benthic Invertebrates South of Fort McMurray

Taxon	Component Loadings [(a)]		
	PC-1	**PC-2**	**PC-3**
Trichoptera	0.837	-0.304	0.122
Orthocladiinae	0.813	-0.000	-0.095
Ephemeroptera	0.806	-0.224	0.218
Diptera	0.782	0.117	-0.127
Plecoptera	0.698	-0.590	0.237
Other	0.645	0.349	0.518
Tanytarsini	0.629	0.342	0.372

Taxon	Component Loadings [a]		
	PC-1	**PC-2**	**PC-3**
Ostracoda	0.043	**0.857**	-0.014
Tanypodinae	0.216	**0.782**	-0.277
Mollusk	0.210	**0.743**	-0.202
Hirudinea	-0.157	**0.715**	0.435
Chironomini	0.103	**0.714**	-0.054
Nematoda	0.137	0.440	0.589
Odonata	0.398	0.064	0.058
Oligochaeta	0.358	0.259	-0.387
Amphioda	-0.472	0.399	0.327
Eigenvalue	**4.577**	**4.085**	**1.468**
Percent Variance Explained	**28.7**	**25.5**	**9.2**

[a] Component loadings greater than 0.6 are bolded.

Benthic invertebrate communities sampled in lake bottom substrates and depositional watercourse habitat in 2005 generally appeared similar to regional benthic invertebrate communities sampled in similar habitats in the past (Figure 8.5-43). However, two watercourse sites had higher PC-1 values than other depositional sites. Site WCL11 from the Christina River and Site WCL6 from a smaller tributary to the Christina River had a larger proportion of "uncommon taxa" (organisms comprising less than one percent of overall abundance) than the other depositional sites and waterbodies. In addition, these two sites had greater mean abundances and richness than other depositional watercourses and waterbody sites in the region.

The samples from the two erosional sites appeared similar to the regional benthic invertebrate communities sampled in the past (Figure 8.5-43). The community at WCL11 from the Christina River had a somewhat higher PC-1 score that the other sites. With 44 taxa identified, samples from this site can be considered highly diverse.

8.5.7 Data Considerations

Due to the large geographic extent of the study areas and access constraints, it is likely that potential data limitations exist. Sufficient data has been collected for regional fish and fish habitat assessments related to watercourses and waterbodies in the Hangingstone, Corner and Leismer study areas. North American will conduct onsite assessments and monitoring during construction activities carried out in close proximity of watercourses or waterbodies. In the event that proposed developments impact a waterbody or watercourse directly (i.e., pad locations and facilities development, pipeline and road crossings), the appropriate authorizations and mitigation measures will be applied on a site specific basis.

8.6 Impact Assessment and Mitigative Measures

Fish and fish habitat in the Project area were assessed in terms of indicator species. Impacts to indicators were evaluated in the context of Project development, operation and reclamation activities including plant facilities, well pads, access roads, utility corridors and pipelines. Two areas of concern for aquatic resources were identified. Firstly, riparian and instream habitat loss or alteration including altered flow regimes and secondly, combined industrial disturbance of fish habitat. Criteria for evaluating impacts are outlined in Volume 2, Section 1 (Impact Assessment Approach). Mitigative measures for impacts include management of operations, best management practices for construction and maintenance activities, and prevention initiatives.

8.6.1 Indicators

Indicator resources depend upon a number of elements in the aquatic environment. They may be affected at various levels (e.g., population abundance, community diversity, health) when the aquatic environment undergoes change (e.g., effects from industry, over fishing, etc.). Indicators are species (e.g., northern pike) or groups of organisms (e.g., benthic invertebrates) that represent larger groups or processes in the aquatic environment. By acting as surrogates for the larger system, they help to focus the assessment. Specific indicators are chosen because they are able to signal environmental changes that may be caused by certain Project-related activities. It is important to choose indicators with relevance to stakeholders, regulators and the aquatic environment.

Environmental changes in aquatic environments are often reflected in alteration to the fish community. Changes to habitat (e.g., substrate, water chemistry, water flow, cover, etc.) and food (e.g., macroinvertebrates) may affect fish in ways that include, but are not limited to:

- Decreased fish population;
- Altered spawning activity;
- Altered movement of fish in or out of an area; or
- Compromised fish health (e.g., low weight to length ratio, lesions, reduced fecundity, etc.)

According to recent literature on indicator species, the appropriateness of each indicator to detect environmental change should be assessed and the natural history of each indicator should be considered to include a variety of indicator responses to detect environmental changes (Karr and Chu, 1999). Fish from different trophic levels (position in the food chain) should be included among the chosen indicators (Shuter and Post, 1990). Generalists (e.g., fish that can eat a variety of food types) tend to do better than specialists (e.g., predators) when environmental changes affect food sources (e.g., macroinvertebrates, algae, small bodied fish, etc.). Small bodied fish tend to mature rapidly and have a short lifespan. Consequently their populations are greatly affected by stressors that affect larval development or fecundity (e.g., changes to pH).

The use of the benthic macroinvertebrate community (benthics and benthic invertebrates) as an indicator has increased in recent years as this community has many attributes that allow it to respond quickly to environmental change. Benthics are short lived (one generation every two years to more than one generation in a year) and spend most of their lives in a localized area. Benthic invertebrates are generally easy to sample and community attributes (e.g., abundance, diversity, composition) are simple to calculate. Changes in these attributes are also easy to monitor, providing an indication of changes in the aquatic environment.

The following groups were chosen as indicators for the Project.

Benthic Macroinvertebrates

Benthic macroinvertebrates generally dwell in natural aquatic habitats. Habitat types tend to support identifiable invertebrate communities (e.g., erosional watercourse communities vs. depositional watercourse communities). A rapid response to environmental change (e.g., water quality, sedimentation, etc.) by the invertebrate community is a result of various attributes. These include:

- Short life span;

- Small territory;
- Species with very defined niche requirements; and
- Numerous trophic levels.

The role that benthic macroinvertebrates play in the food chain is important and is the reason for their inclusion in the aquatic assessment. Fish species in northern Alberta generally depend on invertebrates for food during at least one life stage (Scott and Crossman, 1998).

Brook Stickleback

Brook stickleback is a common fish species throughout most of Alberta and exist in a variety of habitats including small ponds, lakes and streams with varying velocity and substrate type (Scott and Crossman, 1998). Being tolerant of a wide range of environmental conditions, the brook stickleback can populate many marginal habitats. They are known to tolerate low oxygen levels (Nelson and Paetz, 1992) and high salinities and can survive where other species cannot exist (Scott and Crossman, 1998). Populations are known to occur in numerous waterbodies and watercourses in the Christina River basin (OPTI, 2000; Devon, 2003; Petro-Canada, 2001).

Brook stickleback are predaceous. They feed upon fish eggs, benthic invertebrates and the larvae of various aquatic insects and fishes (Scott and Crossman, 1998). They are also a food source for larger bodied fish including northern pike (Scott and Crossman, 1998). The fish mature in about one year and live for about two to three breeding seasons.

White Sucker

White sucker is a fish species captured in rivers and lakes in many habitats throughout Alberta, except for high mountainous areas (Scott and Crossman, 1998; Nelson and Paetz, 1992). They are generally bottom feeders with a diet made up primarily of benthic invertebrates, mollusks and algae.

White suckers often favour specific tributaries for spawning, which occurs in Alberta from mid May through June when water temperature is about 10ºC. When conditions are right, hundreds of white sucker may migrate from their resident lake to a suitable stream with shallow water and a gravel substrate. White suckers are known to spawn around shoreline areas of lakes. Fecundity is related to size, with females producing an average of 10,000 eggs to 35,000 eggs during a spawning season. Their life span is generally between 14 and 17 years. Although this species is not considered commercially important, it may be captured with sport fish including northern pike, walleye, yellow perch, lake whitefish, cisco and burbot.

Northern Pike

Northern pike is a popular sport fish captured throughout most of Alberta except in some high mountainous areas (Nelson and Paetz, 1992). They prefer weedy, clear waters in lakes and marshes but are also commonly captured in slower rivers and streams. Spawning occurs in early spring, often while ice is still present (Scott and Crossman, 1998). They typically find shallow, marshy locations or flooded grassy areas with ample vegetation to deposit their eggs.

Northern pike generally lie in wait for prey rather than hunt (Scott and Crossman, 1998). They are, however, aggressive and will eat other fish, crustaceans, insects, young muskrats and ducklings. Young of the year have been documented feeding on minnows, suckers, trout perch and brook stickleback.

8.6.2 Assessment Criteria

The assessment criteria provide a framework of measurable or predictable responses to potential environmental changes associated with the Project (Volume 2, Section 1). The criteria are used to predict potential changes in the indicators provided above. The anticipated response of these indicators is intended to be representative of alterations to the overall aquatic environment over the life of the Project.

8.6.3 Riparian and Instream Fish Habitat Alteration

A number of potential Project-related impacts to riparian and instream fish habitat were identified. These included changes in sedimentation, alterations to surface water flows and drainage, disturbance to riparian habitat and changes to the benthic invertebrate community structure. Details of potential changes to riparian and instream habitat are elaborated upon in the following section.

8.6.3.1 Sedimentation

Changes in sedimentation levels in watercourses and waterbodies are often the result of silt and clay particles, originating from the terrestrial environment, being released into the aquatic environment via surface water runoff. Runoff water flowing over a disturbed area collects and transports silt and clay particles that contribute to the sediment loading of surface water. Construction activities in close proximity to watercourses and waterbodies lead to an increase in the potential for both the disturbance and suspension of sediments in the water column. Activities that may be associated with an increase in sediment loading include:

- Bridge and roadway construction and operation;
- Site clearing and facility construction; and
- Pipeline crossings.

Increased sediment loading (e.g., suspended sediments or turbidity) may in turn result in changes to fish habitat and fish health.

Potential Environmental Changes

An increase of sediment loading into watercourses and waterbodies can have an impact on the aquatic environment in which fish and benthic invertebrate communities thrive. Sedimentation reduces overall fish habitat quality by filling the interstitial spaces in the gravel, rock or sand, leaving the substrate unsuitable for spawning and/or causing the smothering of fish eggs. Increased turbidity causes many benthic invertebrate species to drift downstream, thereby reducing available food for resident fish populations. Where deposition occurs, benthic invertebrate communities can change from erosional habitat favouring organisms to depositional habitat favouring organisms, thus changing the type of food available for local fish.

An increase of sediment loading into watercourses and waterbodies can also have an impact on the health of fish and benthic invertebrate communities. Fish behavior can be affected by an increase in turbidity. For example, the feeding ability of visual feeder species such as Arctic grayling is reduced. Additionally, some fish species avoid turbid streams (Scott and Crossman, 1998) or move out of areas with high turbidity. Thus, they are prevented from using traditional migration routes, feeding areas and spawning habitats. Fine sediments in moving water may act as a scouring agent, resulting in erosion to external gills on some benthic invertebrates (e.g., mayfly species). Sediments may also adhere to fish gills by sticking to mucous, resulting in the irritation of the gill membranes. This may then lead to increased infections in the gill tissues and inhibited respiration.

Mitigation

Increases in suspended sediment will be prevented by implementing mitigation measures and using best management practices. The construction of well pads and pipeline and road crossings within the LSA will adhere to the mitigation measures recommended in the pipeline and road crossing code of practices outlined below. This will minimize the potential for sedimentation in the waterbodies and watercourses within the Project development area.

Fisheries information was collected for the major waterbodies and watercourses in the Project LSA. These assessments provide the appropriate information required to characterize the fish and fish habitat in the area and allow for predictions to be made regarding Project-related impacts. This information can also be used for pipeline and road stream crossing assessments required by AENV and the DFO. In cases where proposed roads and pipeline crossings lack required assessment data, North American will ensure that site specific fisheries assessments will be conducted.

A series of access roads will be constructed within the Project lease areas as part of Project development. It is anticipated that there will be several watercourse crossings associated with these roads, which will require regulatory approval and proper mitigation and monitoring.

- An experienced construction supervisor or fisheries specialist will be onsite during construction to ensure regulatory compliance and oversee implementation of the environmental protection measures.
- Appropriate precautions will be taken to minimize disturbance of the stream bed and banks.
- Appropriate precautions will be taken to ensure deleterious substances do not enter the watercourse. The cleaning, fuelling and servicing of equipment will be conducted at a reasonable distance from any watercourse. Equipment operating near any watercourse will be free of external grease, oil, mud or fluid leaks.
- Sediment deposition will be minimized through the implementation of measures (e.g., sediment fences, seeding) to control erosion and sediment where necessary.
- A Spill Response Plan will be created that includes contact numbers and general mitigation to direct hazardous spill clean-up.
- All environmental emergencies and/or spills will be reported to AENV and DFO.
- All unused material and construction debris will be removed for proper disposal immediately after completion of construction.
- North American will be responsible for ensuring that installation of road crossings occurs in accordance with the appropriate mitigation measures.
- Instream construction activities will be confined to the isolated channel section and will not interrupt downstream flow.
- Construction will be suspended during heavy rains.

- Disturbed ground will be re-vegetated with an approved, regionally specific native seed mix.

A series of pipelines will be constructed within the Project area as part of Project development. It is anticipated that there will be several pipeline crossings associated with the Project, which will require regulatory approval and proper mitigation and monitoring.

- If the watercourse is not dry or frozen to the substrate at the time of construction, temporary watercourse crossings for access roads will be built to preserve channel beds and banks.
- An experienced engineer, construction supervisor or fisheries specialist will be onsite to ensure regulatory compliance and oversee implementation of the environmental protection measures contained within this document.
- A copy of this report and all approvals and licenses will be onsite during construction activities.
- All work activities will meet or exceed the construction standards outlined in "Water Crossings, 2nd Edition" (Canadian Pipeline Water Crossing Committee, 1999).
- Mitigation measures outlined in the Alberta *Code of Practice for Pipelines and Telecommunication Lines Crossing a Water Body* (AENV, 2006) should be followed by the construction team to ensure the protection of fish and fish habitat.
- Appropriate precautions will be taken to minimize disturbance of the stream bed and banks.
- Appropriate precautions will be taken to ensure deleterious substances do not enter any watercourse. The cleaning, fuelling and servicing of equipment will be conducted at an appropriate distance from any watercourse. Equipment operating near any watercourse should be free of external grease, oil, mud or fluid leaks.
- Sediment deposition will be minimized through the implementation of measures to control erosion and sediment such as sediment fences and seeding where appropriate.
- A review of the Spill Response Plan will be conducted prior to the start of construction.
- Spills will be reported immediately to AENV and DFO.
- Instream construction activities will be confined to the isolated channel section and will not interrupt downstream flow.
- Construction will be suspended during heavy rains.
- All unused material and construction debris will be removed immediately after completion of construction for proper disposal.
- North American will be responsible for ensuring that installation of pipeline crossings occur in accordance with the appropriate mitigation measures.

- Sites will be re-visited to monitor the stability of the watercourse crossing sites until each site is re-vegetated. Site instability or bank erosion will be noted and repaired in a timely manner.

- The Project's proposed watercourse crossings will incorporate design and mitigation measures to minimize potential impacts to fish and fish habitat.

Conclusion

Environmental effects to riparian and instream fish habitat due to sedimentation are predicted to be occasional, short term and localized with a low magnitude. Environmental impacts on the receiving environments (i.e., watercourses and waterbodies) are predicted to be low.

8.6.3.2 Water Levels and Flows

Surface water levels and stream flows are important environmental characteristics that, when altered, can affect the quality of fish habitat. Water levels determine the amount of available habitat and the associated stream flow velocity strongly affects habitat quality (e.g., substrate composition). Development activities within the LSA have the potential to change surface water flow characteristics throughout the lease area. The creation of artificial drainage, straightening or alteration of existing channels and the removal of existing vegetation may increase flows and subsequently alter downstream habitat. Alternately, the extraction of groundwater in the region may cause surface waterbody and watercourse levels to drop.

Changes in surface flow are not always the result of development activities. Natural processes such as beaver activity in the area can also influence local surface water flow patterns. When watercourses associated with small lakes are influenced by beaver activity, changes in waterbody levels can occur. These changes can confound predictions regarding surface water flow dynamics. In addition, altered surface water flow patterns related to beaver activity can strongly affect fish and fish habitat. Beaver dams can restrict the migration of fish between overwintering or rearing areas and habitat suitable for spawning (e.g., head water streams used by Arctic grayling). Flooding regime alterations can also affect conditions necessary for species like northern pike to spawn. For example, access to lakes may be impounded and result in the restriction of fish movement in and out of these habitats.

Potential Environmental Changes

A waterbody can be affected by changes in water level. Shoreline habitat and the littoral zone are considered critical for the health of the aquatic environment. The littoral zone (areas where adequate light can penetrate the bottom of the water column and allow for plant growth, generally 1 m to 2 m), provides food and cover for many aquatic insects. In turn, many fish species use these areas to gain access to food (smaller fish and invertebrates), for vegetative cover and in some cases for spawning habitat (e.g., northern pike). Small decreases in water level at shallow shoreline areas can cause the waters edge to recede considerably, thus eliminating these areas of available habitat. In shallow lakes, a drop in the water level may allow sunlight to penetrate throughout the water column over the extent of the lake and cause an increase in primary productivity, thereby altering lake trophic levels. A drop in water level may also reduce the capacity of some waterbodies to provide overwintering habitat.

Watercourses can be affected by alterations in water levels in ways similar to waterbodies. Decreases in stream flow levels expose substrate at the shoreline and may also decrease shoreline cover. Decreased stream flows result in alterations to pool depths, impacting the fish habitat used for spawning, rearing, feeding, migration and overwintering. Additionally, increased velocities and changes to water volume may result in scouring of stream beds and changes to channel alignments.

Water quality parameters such as temperature, pH, DO and chemical load are important for fish health and can change as a result of fluctuations in water levels. During the open water season, changes in water temperature can be a function of water volume and depth. Temperatures observed in shallow waterbodies tend to fluctuate more rapidly than in those that are deeper. Chemical and biological processes (e.g., photosynthesis and respiration) may become more pronounced in lakes with reduced water levels. Fluctuations in pH levels and the oxygen/carbon dioxide ratio may change considerably, potentially affecting fish health. In addition, the chemical load (the amount of a given chemical that a waterbody can safely assimilate) decreases as water levels go down.

Benthic invertebrate communities provide an important source of food for a number of fish species and alterations in stream flows impact these communities. Some benthic invertebrates find the effects of modified stream velocities unfavourable, resulting in decreased food available for fish.

Mitigation

Changes in stream flows and lake levels will be prevented through a number of mitigation measures implemented during both design and construction activities. Measures will include the placement of well pads in areas that are not in close proximity to surface watercourses and waterbodies. In the event that resource extraction and engineering constraints necessitate well pad placement that may affect surface water flows, drainage will be directed around the well pad to maintain surface water flow, protect water quality and maintain downgradient drainage patterns. Channels allowing water movement around well pads will be constructed to maintain the free flow of water and prevent erosion.

Road crossings will be designed and constructed to minimize flow restrictions and potential erosion. Proper design and maintenance of bridges and culverts in the Project area will ensure that fish habitat fragmentation is minimized over the life of the Project.

The Project will include a series of pads required for bitumen extraction and several bitumen processing locations (hubs) as part of Project development. It is anticipated that there will be 218 pad locations associated with the Project and 10 hubs required for processing. During the construction and operation of these facilities, a number of mitigative steps will be followed to ensure that no aquatic-related adverse affects occur. The following general guidelines will be followed to minimize potential impacts:

- Access roads to facilities will be constructed in a manner that meets provincial standards and minimizes impact to aquatic resources related to runoff and spills.
- Bridges and culverts will be monitored over the life of the Project to ensure fish habitat fragmentation does not occur. In the event that a barrier to fish movement is realized at a crossing location, appropriate mitigation measures (e.g., consideration of new culvert design) will be employed.
- Facilities and pads will be constructed with a setback from watercourses and waterbodies.
- In the event that a facility or pad interrupts the natural flow of water related to a watercourse or waterbody, proper surface drainage will be installed to redirect flow around the facilities.

- An experienced construction supervisor or fisheries specialist will be onsite during construction in or around waterbodies to ensure regulatory compliance and oversee implementation of environmental protection measures.

- Berms constructed around facilities will be vegetated and proper sediment catchment devices will be installed to minimize runoff.

Conclusions

Changes in surface water levels related to water withdrawals are predicted to be within natural variation (Volume 3, Section 6). Mitigation measures used to manage surface water flows will maintain flow patterns in the LSA. Changes are predicted to be low in magnitude, short-term and isolated resulting in negligible environmental impacts to fish and fish habitat.

Surface water level monitoring in waterbodies and watercourses, where appropriate, will be included in any post approval monitoring program.

8.6.3.3 Riparian Habitat

Riparian zones provide ecosystem features that influence the aquatic habitats that support fish. Riparian areas are characterized as the bank and shoreline features of watercourses and waterbodies and associated vegetation. This includes moist soils and substrates above the waterline and trees, shrubs, grasses and forbs growing along the bank. Riparian zones provide several features of fish habitat including overhanging vegetation, submerged large woody debris and root wads. During periods of spring freshet, flooded areas in the riparian zone may also provide spawning habitat for species such as the northern pike that deposit eggs on inundated vegetation. These flooded areas may also provide refuge for various species during periods when stream flows are elevated.

Potential Environmental Changes

Project activities with the greatest potential to impact riparian habitat are associated with road and pipeline crossing construction. These activities require the removal of bank vegetation, which may cause increased sedimentation.

Physical effects resulting from surface water runoff are moderated by vegetative cover in the riparian zones, slowing flow velocity that would otherwise cause stream bank erosion. Shoreline vegetation also acts as a filter for suspended sediments, reducing the sediment loading in watercourses and waterbodies. Additionally, many nutrients are absorbed by vegetation in the riparian zone, thus reducing nutrient loading and the associated effects they may have on trophic structure within the water column.

Alteration to riparian habitat may therefore result in impacts to fish health and fish community structure. Additional discussion on riparian vegetation is presented in Volume 4, Section 10.

Mitigation

There will be numerous pipeline and road crossings within the Project area. Impacts to riparian habitat will be limited to the areas of localized construction activities. With the appropriate mitigation activities disturbed riparian habitat would be restored to conditions consistent with "no net loss" principles. In the unlikely event the riparian habitat at a crossing cannot be restored, alternative techniques will be discussed with regulators. Impacts to riparian habitats associated with the Project are predicted to be short term and localized. North American is committed to following best management practices to ensure that the impacts to fish and fish habitat will be minimized.

Conclusion

Environmental effects to riparian habitat are predicted to be isolated, short term and localized with a low magnitude. Environmental impacts on riparian habitat are predicted to be low as a result of the implementation of best management practices associated with the construction of pipeline and road crossings.

8.6.3.4 Benthic Invertebrate Abundance and Composition

The benthic invertebrate community includes a variety of insects that live on or in the substrates of waterbodies and watercourses. This community of organisms includes the larval and pupal stages of terrestrial adult insects (e.g., mayflies, dragonflies, black flies, midges, etc.) and some groups that spend their whole life under water (e.g., aquatic worms, beetles, nematodes, some crustaceans, snails, etc.) Benthic habitat is typically defined as the interface between sediment and the water column, on the surface of sand, rocks and boulders. Invertebrates living on woody debris, on plant surfaces under the water and within the sediment itself are also included in this group.

Benthic invertebrates play an important role within the aquatic ecosystem. Populations of midges and aquatic worms cause the release of nutrients from sediment that is then available to bacteria, algae and aquatic vegetation for primary production. Organic plant material is broken down and consumed by some benthic organisms, thus continuing the nutrient cycle in the aquatic system. Because many benthic organisms are prey items for fish, they also provide an important link for energy to be transferred to higher animals (e.g., fish and birds).

Potential Environmental Changes

Benthic invertebrate populations are susceptible to many of the same impacts as fish, including sedimentation, fluctuation in water level, alteration to water quality and general habitat degradation. As the benthic invertebrate community is a source of food for many fish species, changes in their health or population will inevitably affect the fish community as well. Changes in water levels and flows (Section 8.6.3.2) may result in a reduction of habitat area and changes to overall water quality. Benthic invertebrate community composition is often largely attributed to the effects of water velocity. Increased sedimentation (Section 8.6.3.1) may damage external gills. Project activities with the greatest potential to impact riparian habitat are associated with road and pipeline crossing construction. These activities require the removal of bank vegetation, which may cause increased sedimentation. Emissions related effects can alter concentrations of major ions in waterbodies and affect pH levels (Section 8.6.4.2). These changes in water quality may impact some sensitive invertebrates. Additionally, the construction of roads and pipeline crossings may directly disturb sediments, thereby affecting invertebrates in localized areas.

Mitigation

Construction of site facilities and associated pipelines will comply with pertinent regulatory guidelines and practices. Effects to the benthic invertebrate community associated with the construction and operation of the Project will be alleviated by mitigation described further in Section 8.6.3.1.

Conclusions

Planned mitigation will ensure that construction activities associated with the Project and watercourse crossings will have a negligible effect on suspended sediment concentrations in receiving streams, lakes, ponds and wetlands. Therefore, impact to the benthic invertebrate community from altered water quality due to the release of sediment is expected to be negligible.

Changes in surface water levels and flows from Project construction and operation activities are predicted to be negligible. Therefore, loss of benthic invertebrate habitat from changes in water levels will be no greater than natural variation.

Small areas of benthic habitat may be altered with the construction of roads and pipeline crossings. However, effects are predicted to be localized and short-term. Once construction with mitigation measures is completed, the benthic community will be able to re-colonize disturbed habitats naturally.

The benthic invertebrate community is not likely to experience many changes from acidification of waterbodies. Most of the lakes in the LSA are well buffered and therefore, the occurrence of acidification in the Project is not likely. Overall the majority of lakes located within the Project's RSA were found to be well buffered, with concentrations of $CaCO_3$ commonly greater than 100 mg/L. Based upon the results from Surface Water Quality (Volume 3, Section 7) and Air Quality (Volume 2, Section 2) assessments, 12 lakes within the Hangingstone Basin and Gregoire River sub-basin of the RSA were determined to have the potential to be sensitive to acidification at baseline (i.e., before Project commencement). Project activities are not expected to add additional lakes to this list. The lakes identified with low alkalinities are located in the Stony Mountain area (headwaters of the Hangingstone River, Christina River and Surmont Creek) and one in the Gregoire River sub-basin. Only two lakes within the LSA (sites LH1 and LH3) are considered potentially sensitive to acidification. If acidification occurs, impacts to benthic invertebrates will be negative, sub-regional in extent with medium magnitude. The duration will be long-term with isolated frequency and long-term permanence. These predictions have moderate confidence. The potential environmental impact to benthic invertebrates is predicted to be moderate under acidifying conditions.

Most activities associated with the Project development, operation and reclamation are conducted with measures to protect the aquatic environment. Where acidification is not a concern, impacts are predicted to be neutral and of negligible magnitude, short-term in duration and occur in occasional frequency. Impacts are expected to be reversible in the medium term. The overall environmental impact rating for benthic invertebrates is considered to be low impact.

8.6.4 Combined Industrial Disturbance on Fish Habitat

A number of areas were identified to have the potential to impact fish and fish habitat from combined industrial disturbances associated with the Project. The areas of potential impact included spills and discharges, changes in surface water pH and increased angling pressure due to increased access to waterbodies and watercourses within the LSA.

8.6.4.1 Spills and Discharges

The introduction of toxic or anthropogenic substances into the watercourses and waterbodies in the LSA may result in changes to surface water or groundwater quality. Accidental releases of toxic substances may occur from a variety of activities during construction, operation and reclamation of the Project.

Potential Environmental Changes

Fish species, such as Arctic grayling, are susceptible to changes in water quality as a result of pollution (Nelson and Paetz, 1992). Elevated concentrations of foreign substances may result in changes in fish behavior (e.g., predator avoidance, spawning, feeding) and physiology (e.g., respiration, sensory mechanisms). Water quality alterations may also result in adverse affects on fish tissue quality (i.e., chemical burdens, tainting). Stormwater runoff has the potential to introduce substances into surface waters.

Process waters will be recycled and products that cannot be reused will be deep well injected. With regard to spills, engineering design of facilities and well pads will reduce the potential to impact surface water and groundwater. At the central processing facilities, runoff water will be collected in stormwater retention ponds where it will be tested and if necessary, treated to meet AENV guidelines before release into natural areas.

Sewage will be treated according to AENV regulations and will not be released into the surface water bodies. Therefore, no effects are expected on surface water quality.

Mitigation

During the Project development and operation phases, various measures will be taken to minimize the occurrence of spills and upset conditions. Spills are not anticipated at proposed Project facilities and well pads. Spills will be cleaned up as per the North American emergency response procedures. Potential leaks and spills at pad facilities will be collected into a bermed collection system for further handling and removal. Additionally, vehicles, machinery and facilities will be maintained in a manner that prevents the introduction of hydrocarbons or other deleterious substances into the environment.

To mitigate the introduction of hydrocarbons and chemicals into watercourses during pipeline and road crossings, construction crews will use best management practices and adhere to the construction environmental protection measures. These measures may include the seasonal timing of construction activities near watercourses, onsite environmental monitoring during construction activities and assigning setback distances from watercourses when fueling and maintaining equipment to minimize the potential for a direct release into a watercourse.

Conclusions

As a result of proposed emergency response measures, environmental impacts to fish and fish habitat as a result of spills and accidental discharges are predicted to be low.

8.6.4.2 Changes in pH

The deposition of aerial emissions as a result of industrial activities has the potential to alter the chemistry of surface water in surrounding areas. The primary pollutants associated with aerial depositions include NO_x and SO_2, the precursors to nitric and sulphuric acid, which are the main constituents contributing to the acidification of waterbodies and watercourses.

Potential Environmental Changes

The effects of acidification within aquatic communities generally occur as pH levels reach 6.0 to 5.5 (Carbone et al., 1998; Husky, 2003). When pH levels fall below 5.0, impacts to aquatic communities become more severe, at times leading to the extirpation of aquatic species.

Waters with observed alkalinity levels less than 20 mg/L $CaCO_3$ are considered to have a low acid neutralizing capacity and are more susceptible to the effects of acidification (Saffran and Trew, 1996). Waters with alkalinities at higher levels are considered to have a greater buffering capacity from the effects of acidification. Further discussion on surface water acidification from aerial deposition is included in Volume 3, Section 7 – Surface Water Quality.

Because of the large geographic extent of the Project area, it is useful to look at each study area (Hangingstone, Corner and Leismer) with regards to potential alteration to aquatic habitat due to changes in pH.

Based upon the results from Surface Water Quality and Air Quality assessments, 12 lakes within the Hangingstone study area were determined to have the potential to be sensitive to acidification at baseline (i.e., before Project commencement). Project activities are not expected to add additional lakes to this list.

Data were available for 4 of the 12 lakes that were identified as being acid sensitive. Two of these lakes had historic data available (ML10 and LL6) (Section 8.5.1.2) and two were sampled in 2005 (LH1 and LH3). Brook stickleback were captured in all four of these lakes. White sucker, pearl dace and spottail shiner were also captured in LH1 (section 8.5.5.1). The remaining waterbodies within the RSA near the Hangingstone study area appear to be well buffered.

Altered pH levels in regional waterbodies resultant from aerial deposition are considered a potential impact to fish and fish habitat. Changes associated with acidification would likely be long-term and, notably, irreversible in the short-term.

Mitigation

As a result of findings from the Surface Water Quality and Air Quality assessments for the Project, acidification from aerial deposition may potentially occur within the Hangingstone Basin and Gregoire River sub-basin in the RSA. Ongoing monitoring for acidification of waterbodies within this area of the RSA should be included as part of the approval monitoring programs for projects identified in the baseline assessment as causing the potential impacts.

Conclusion

Overall, the majority of lakes located within the Project's RSA were found to be well buffered, with concentrations of $CaCO_3$ commonly greater than 100 mg/L. The lakes identified with low alkalinities are located in the northern section of the RSA, in the Hangingstone Basin and the Gregoire River sub-basin. The level of environmental impact is projected to be medium for the lakes identified as potentially sensitive to acidification and low for the remaining lakes in the RSA. It is reasonable to predict that the overall impact to fish and fish habitat related to project activities and altered pH will be low. This topic is discussed in detail in Volume 3, Section 7.

Most of the lakes in the LSA are well buffered and therefore, the occurrence of acidification in the Project area would notably be rare.

The environmental effects related to the changes in pH associated with acidifying emissions on the 12 waterbodies identified as being potentially acid sensitive are predicted to be isolated, long-term, and sub-regional with a medium magnitude. Environmental impacts from acidifying emissions for the Project are predicted to moderate.

The environmental effects related to changes in pH associated with acidifying emissions on waterbodies not considered to be sensitive to acidification are predicted to be isolated, short-term and localized with a negligible magnitude. No environmental impacts resulting from acidifying emissions on these waterbodies are predicted.

8.6.4.3 Access

The development of new projects can result in the creation of access to formerly isolated watercourses and waterbodies, potentially increasing angling activities. An increase in angling pressure in the vicinity of the Project would be directed at local sport fisheries including northern pike and Arctic grayling. Sport fisheries within the LSA are not considered locally significant; however, even a small increase in angling pressure has the potential to impact local fish populations.

Potential Environmental Changes

Fishing activities within Alberta are regulated by ASRD. The Province has been divided into three distinct management zones based on ecosystem type (i.e., Eastern Slopes, Parkland-Prairie and Northern Boreal). The ecosystem zones are further divided into watershed units to ensure that fishing regulations meet the specific needs of waterbodies and fish populations in different areas (Alberta Outdoorsman, 2005). The Project LSA and RSA are located within Fisheries Management Zone 3 (Northern Boreal Zone), Watershed Unit NB4. This area is characterized by low gradient streams draining areas of muskeg, which in turn drain into the larger watersheds of the area (Alberta Outdoorsman, 2005). The watersheds located within the Project area include the Clearwater River, the Christina River and their tributaries.

Popular game fish of the Northern Boreal Zone are yellow perch, northern pike, walleye, lake whitefish, Arctic grayling and lake trout (Alberta Outdoorsman, 2005). Within the LSA, sport fish were found in Egg Lake (LC1) and three unnamed lakes (LH2, LL3, and LL4). Several watercourses in the RSA are known to support sport fish. The main fishing locations within the RSA are all readily accessible (i.e., by automobile) and include the Christina River, the Clearwater River, Willow (Gregoire) Lake and Cheecham Lake.

The development of project infrastructure (e.g., roads, pipelines and utility corridors) has the potential to increase access to fish bearing waterbodies and watercourses within the LSA, potentially resulting in increased fishing pressure. Increased fishing pressure, if dramatic, could alter the populations of local fish communities.

Mitigation

North American has limited authority to prevent access to areas within the Project lease boundary that are considered public lands. Management of development strategies, including the ongoing reclamation of roads and the rollback of cutlines, will effectively constrain access to watercourses and waterbodies that have the potential to support fish populations (e.g., Arctic grayling and northern pike). Additionally, security measures designed for Project facilities are hoped to provide a deterrent for illegal fishing activities.

During development, operation and closure activities related to the Project, staff and contractors will be required to follow provincial policies related to fishing.

Conclusions

Environmental effects on fish populations resulting from increased angling pressures due to the construction of access roads to formerly isolated watercourses and waterbodies are predicted to be occasional, long-term and sub-regional with a low magnitude. During all aspects of the project, staff and contractors working on Project sites will be expected to follow North American's and the Province of Alberta's fishing regulations. Therefore, it is predicted that the environmental impacts related to access will be low.

8.7 Cumulative Effects Assessment

A cumulative effects assessment (CEA) considers the potential impacts associated with the Project in combination with other existing and future projects located within the Project's RSA. The potential impacts to fish and fish habitat from the Project are anticipated to be low and acceptable. However, the addition of effects from other industrial developments in the region may require mitigative measures in order to prevent an impact to fish and fish habitat.

In order for the Project to contribute to the cumulative impacts on fish and fish habitat within the RSA, there must be impacts to fish and fish habitat from the Project. Impacts to fish and fish habitat are generally predicted to be low and localized as a result of North American's commitment to adhering to the industries best management practices as they relate to activities in the vicinity of all watercourses and waterbodies. Currently, there are a number of projects that have been announced in the RSA. A list of these projects is presented in Volume 2, Section 1.

Although impacts to fish and fish habitat within the RSA are not anticipated in relation to the construction of infrastructure (i.e., roads, telecommunication lines, pipelines and facilities), it has been identified that several lakes within the RSA are potentially sensitive to acid deposition under baseline conditions. A single lake (ML9) has the potential to receive acid inputs greater than its critical load under cumulative effects conditions. A review of historic fish capture data shows that northern pike has been captured in this lake (Section 8.5.1.2). The environmental impacts from acidification are considered low except in the aforementioned waterbody (ML9) where PAI may be greater than its critical load. Here the impact is predicted to be moderate.

In the event that acidification is identified through water quality monitoring, timely and appropriate mitigation measures, determined through consultation with regulators (i.e., AENV, DFO), will be implemented.

8.8 Follow-up and Monitoring

North American will adhere to monitoring and mitigation activities during Project development, operation and closure (e.g., road/bridge stream crossings) where required by DFO and AENV regulations.

North American will develop, if necessary, a lake monitoring program to determine the potential effects of increased acid deposition on lakes within the RSA.

For construction activities occurring at or near watercourses and waterbodies, appropriate authorization will be obtained prior to activity commencement. Monitoring and mitigation programs that will be conducted in the LSA in association with the construction activities are further discussed in the mitigation sections outlined in Section 8.6.

8.9 Summary

The fish and fish habitat LSA was delineated based on the Project lease and footprint areas, and local drainage basin boundaries. The LSA includes waterbodies and watercourses which may be affected, directly or indirectly, by the Project. The RSA was selected based on potential effects to fish and fish habitat resulting from changes in water flows, levels and quality. In addition, the RSA encompasses the area where the cumulative effects assessment would be focused.

Baseline studies on fish and fish habitat were conducted in 2005 and 2006. Study locations in 10 waterbodies and 24 watercourses were selected to characterize fish habitat potential and identify resident fish populations. Historic data sources were reviewed and used to supplement the baseline data collected during field surveys. The overall fish habitat quality observed in the area in both watercourses and waterbodies ranged from low to moderate. Both forage fish and large-bodied/sport fish species were observed during the field surveys and included brook stickleback, white sucker, northern pike, lake chub, spottail shiner, longnose sucker, fathead minnow, pearl dace, goldeye, trout perch, burbot and Arctic grayling.

The fish and fish habitat assessment considered the Project activities that had the potential to cause direct or indirect impact to fish and fish habitat, surface water quality and hydrology. Key issues related to riparian and instream fish habitat alteration and combined industrial disturbance on fish habitat were assessed in relation to the Project. In general, the Project is not expected to have any impacts on fish and fish habitat.

Table 8.9-1 Potential Impacts Associated with the Kai Kos Dehseh Project

Environmental Impact Associated With Fish And Fish Habitat	Direction	Extent	Magnitude	Duration	Frequency	Permanence	Confidence	Environmental Impact
Changes to fish habitat through sedimentation	neutral	local	low	short term	occasional	reversible in short term	medium	low impact
Changes to water levels, flows and drainage patterns	neutral	local	low	short term	isolated	reversible in short term	medium	low impact
Riparian habitat degradation	negative	local	low	short term	isolated	reversible in medium term	high	low impact
Changes in benthic invertebrate abundance and composition	neutral	local	low	short term	occasional	reversible in medium term	high	low impact
Effects related to facility and operation spills	neutral	local	low	short term	isolated	reversible in medium term	high	low impact
Acidifying emissions on fish in 12 potentially sensitive waterbodies with PAI exceedances	negative	sub-regional	medium	long term	isolated	long term	moderate	moderate impact
Acidifying emissions on fish in waterbodies not considered acid sensitive	neutral	local	negligible	short term	isolated	short term	moderate	no impact
Changes to fish abundance from increased angling pressure	negative	sub-regional	low	long term	occasional	reversible in long term	medium	low impact

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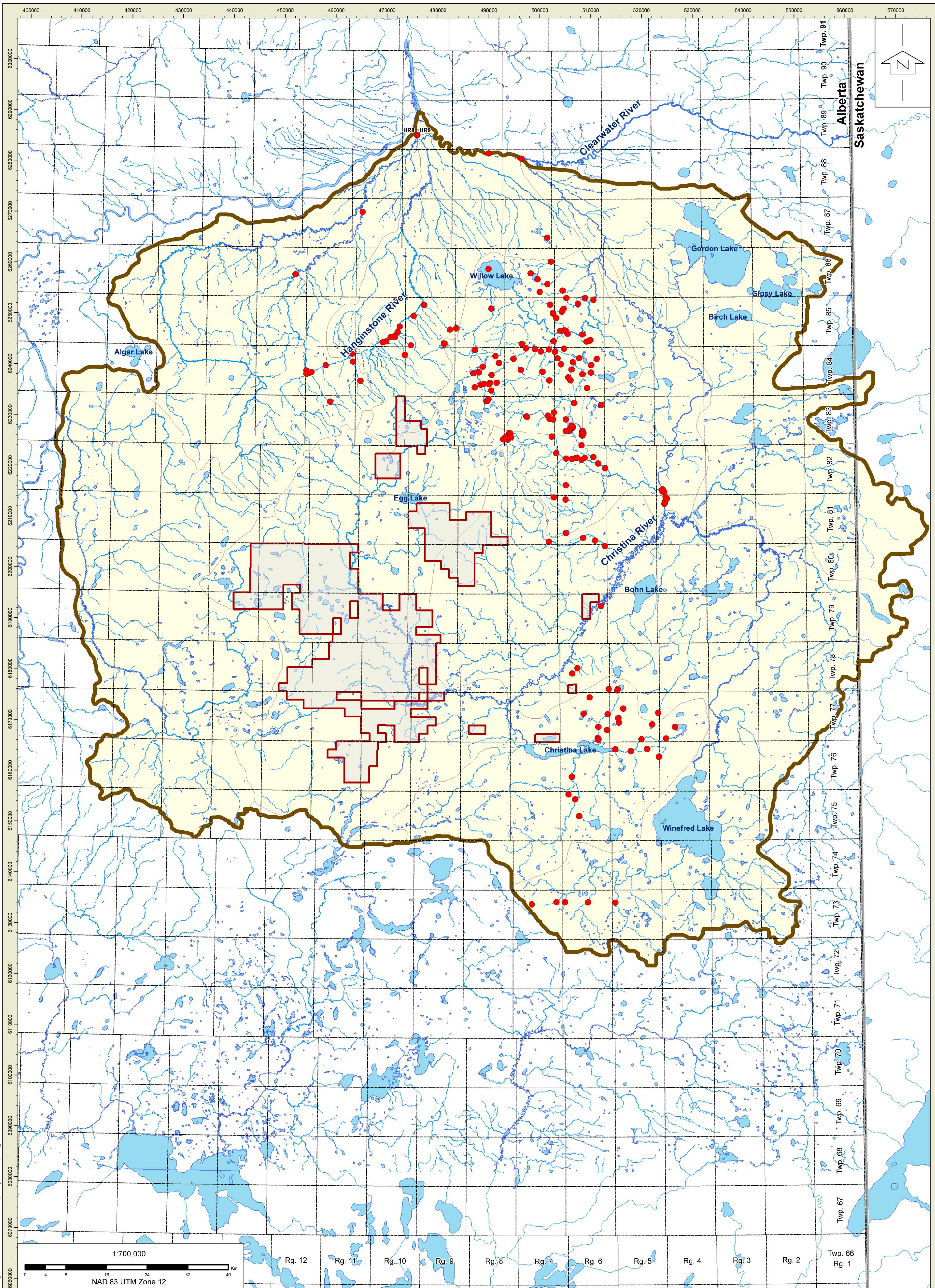

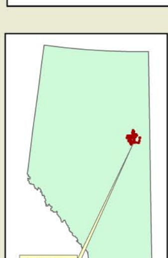

Legend

- North American Leases
- Regional Study Area
- Lake
- Stream
- Historic Fish Data Sites

Title:

HISTORIC FISH DATA IN THE PROJECT REGIONAL STUDY AREA

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:
DJ	June 11, 2007

File: Fig. 8.5-1 Historic Fish Data in the project regional study area_20070611.mxd

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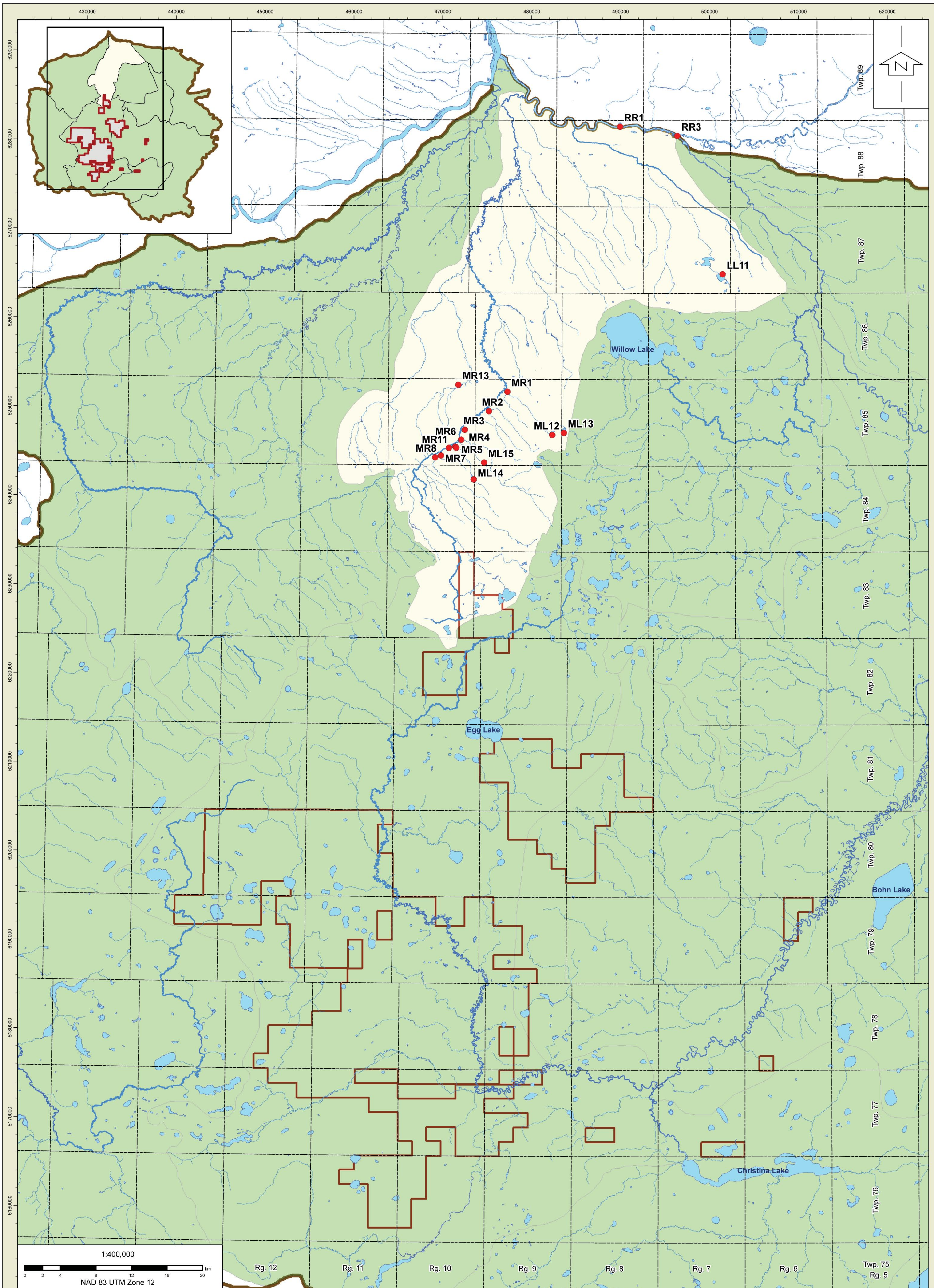
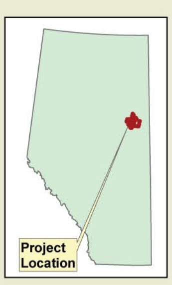
JC	LZ	8.5-1





Legend

North American Lease Boundary	Lake
Regional Study Area	Stream
Hangingstone River and Saprae Creek Basins	Historic Fish Data Site

Title:

CLEARWATER RIVER AND HANGINGSTONE RIVER/SAPRAE CREEK BASINS

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:
DJ	June 11, 2007

File: Fig 8.5-2 Clearwater River and Hangingstone River_Saprae Creek Basins_20070611.mxd

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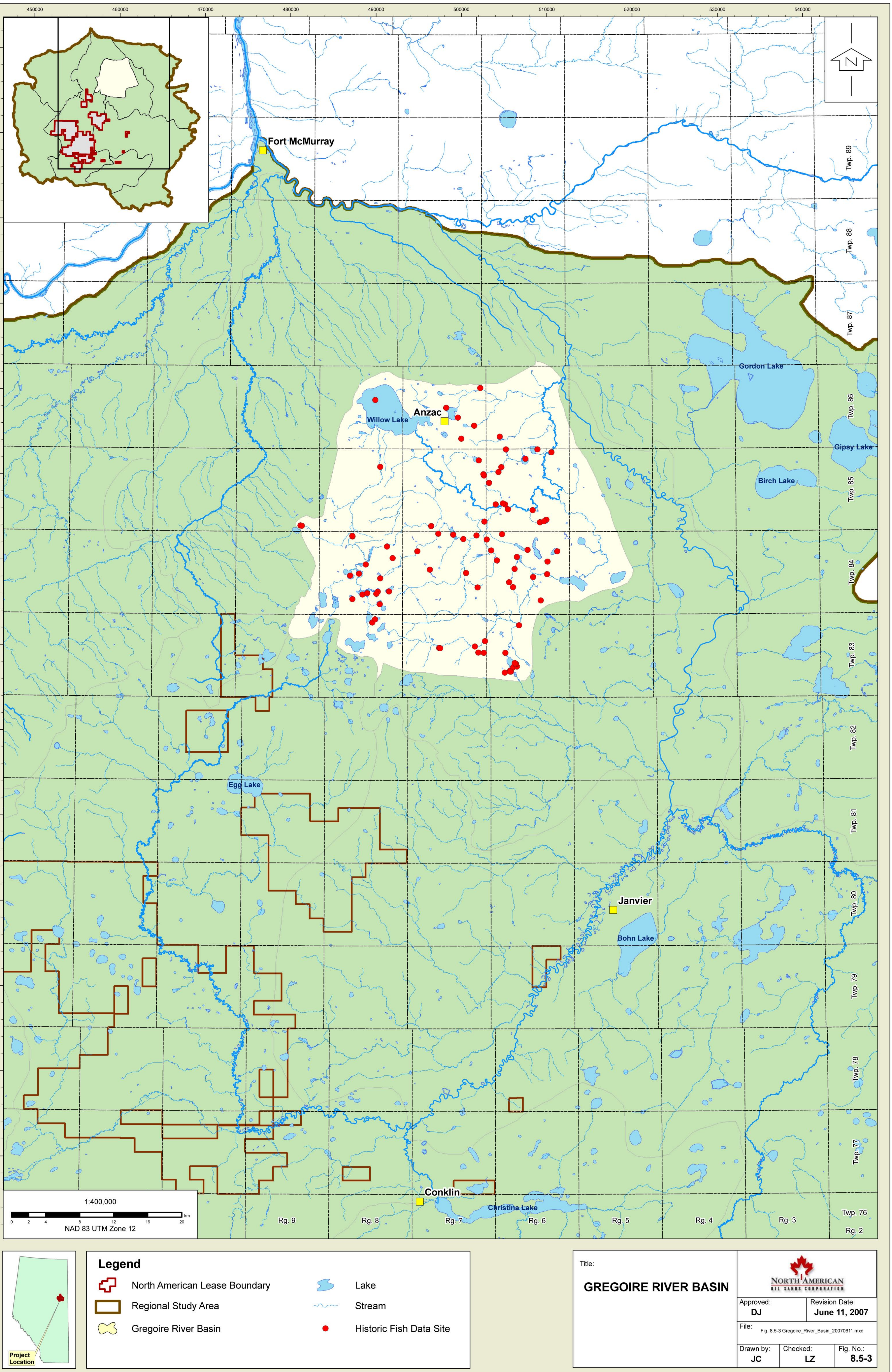
JC	LZ	8.5-2



Title: GREGOIRE RIVER BASIN

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:	
DJ	June 11, 2007	
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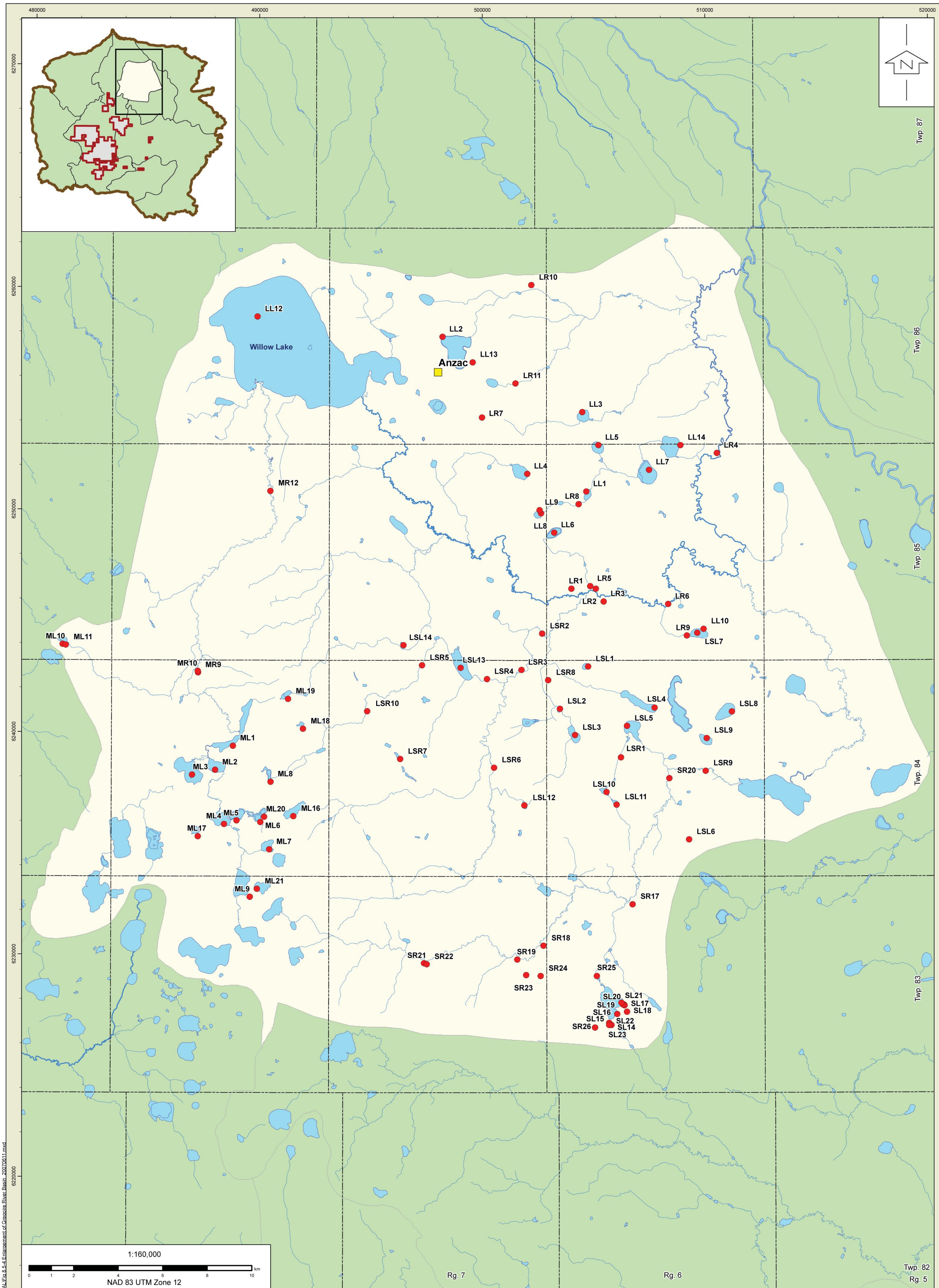

Legend

- North American Leases
- Regional Study Area
- Gregoire River Basin
- Lake
- Stream
- Historic Fish Data Site

Title:

ENLARGEMENT OF GREGOIRE RIVER BASIN

NORTH AMERICAN OIL SANDS CORPORATION

Approved: DJ	Revision Date: June 11, 2007	
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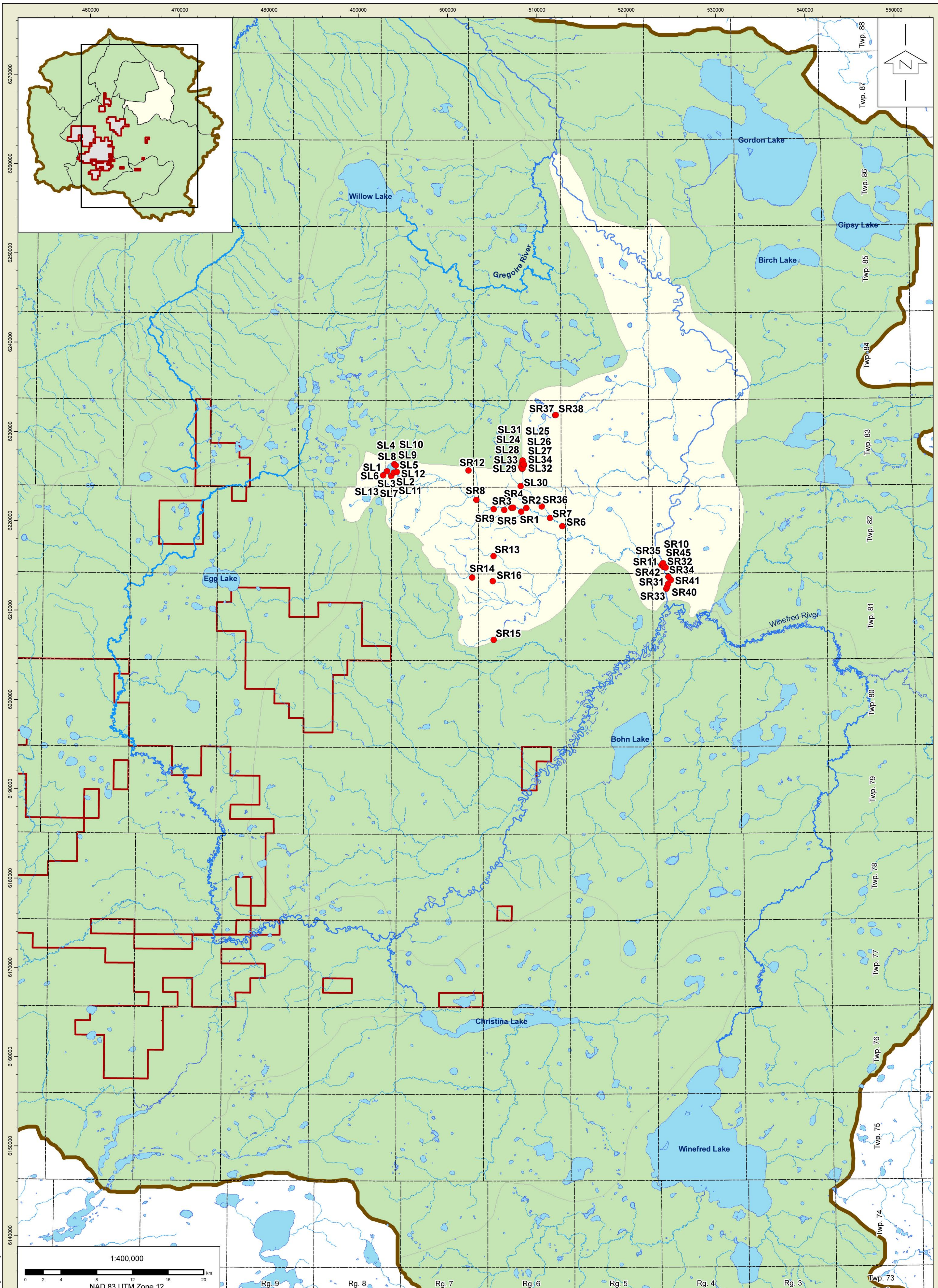
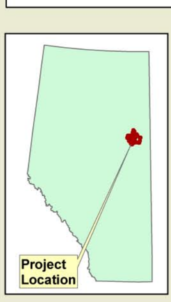
Drawn by: JC	Checked: LZ	Fig. No.: 8.5-4





Legend

- North American Lease Boundary
- Regional Study Area
- Gregoire River Confluence to Winefred River Confluence
- Lake
- Stream
- Historic Fish Data Site

Title:

GREGOIRE RIVER CONFLUENCE TO WINEFRED RIVER CONFLUENCE

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:
DJ	June 11, 2007

File: Fig 8.5-5 Gregoire River Confluence to Winefred River Confluence 20070611.mxd

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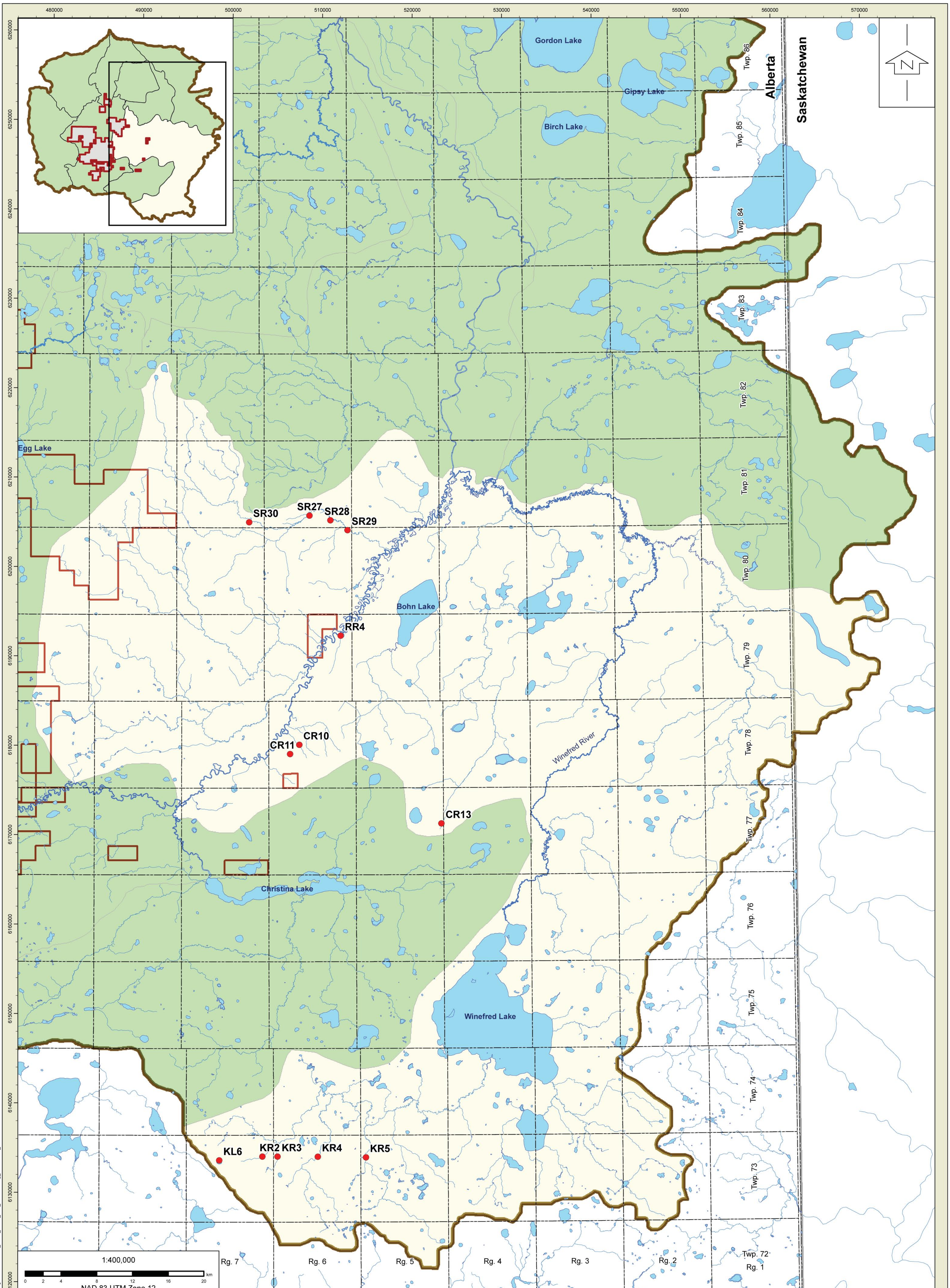

Project Location

Legend

- North American Lease Boundary
- Regional Study Area
- Winefred River Basin and Surrounding Tributaries
- Lake
- Stream
- Historic Fish Data Site

Title:

WINEFRED RIVER BASIN AND SURROUNDING TRIBUTARIES

NORTH AMERICAN OIL SANDS CORPORATION

Approved: DJ	Revision Date: June 11, 2007	
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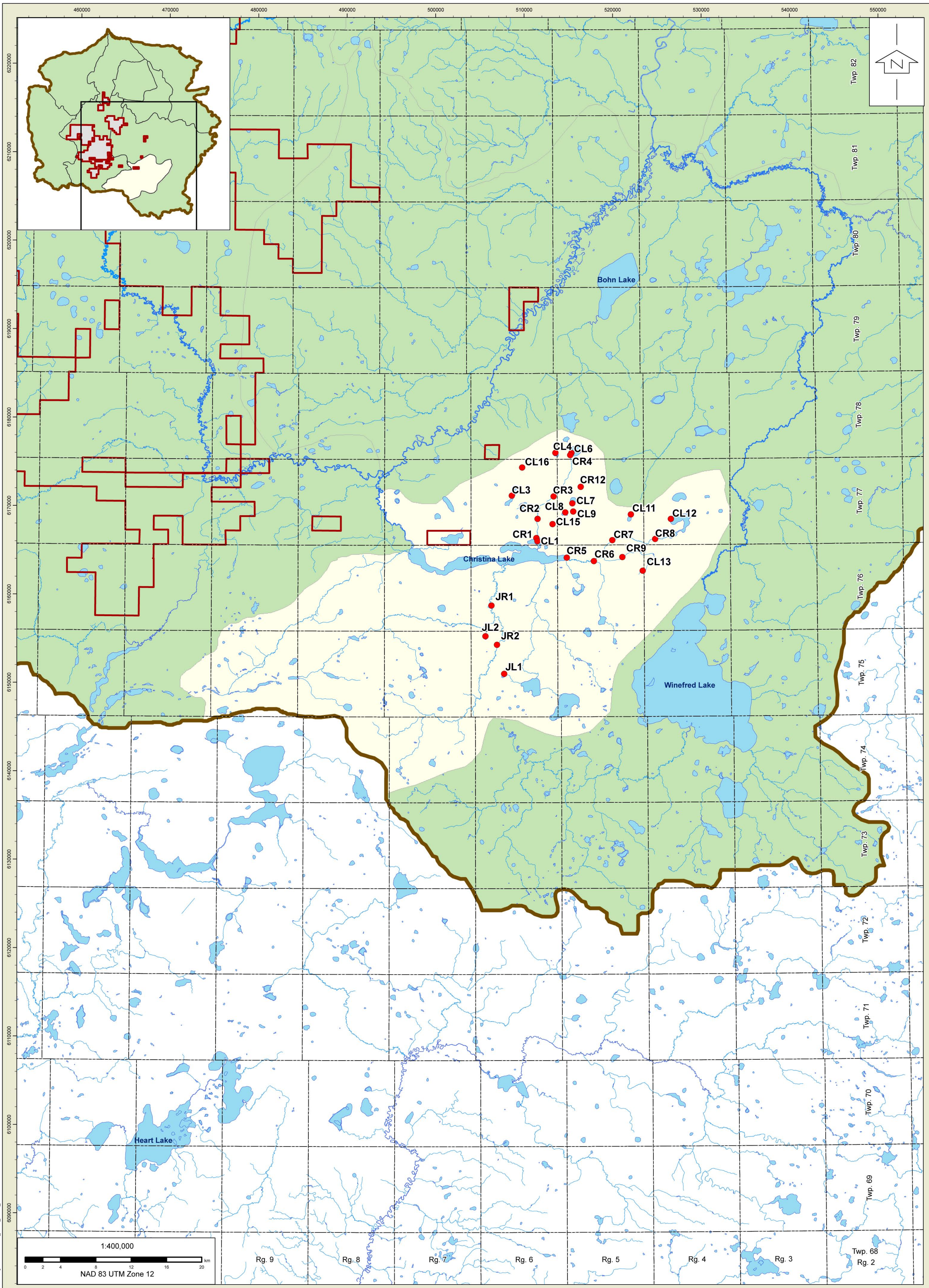

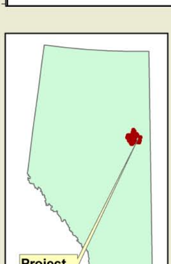

Legend

- North American Lease Boundary
- Regional Study Area
- Jackfish River Basin
- Lake
- Stream
- Historic Fish Data Site

Title:

JACKFISH RIVER BASIN

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:
DJ	June 11, 2007

File: Fig 8.5-7 Jackfish_River_Basin_20070611.mxd

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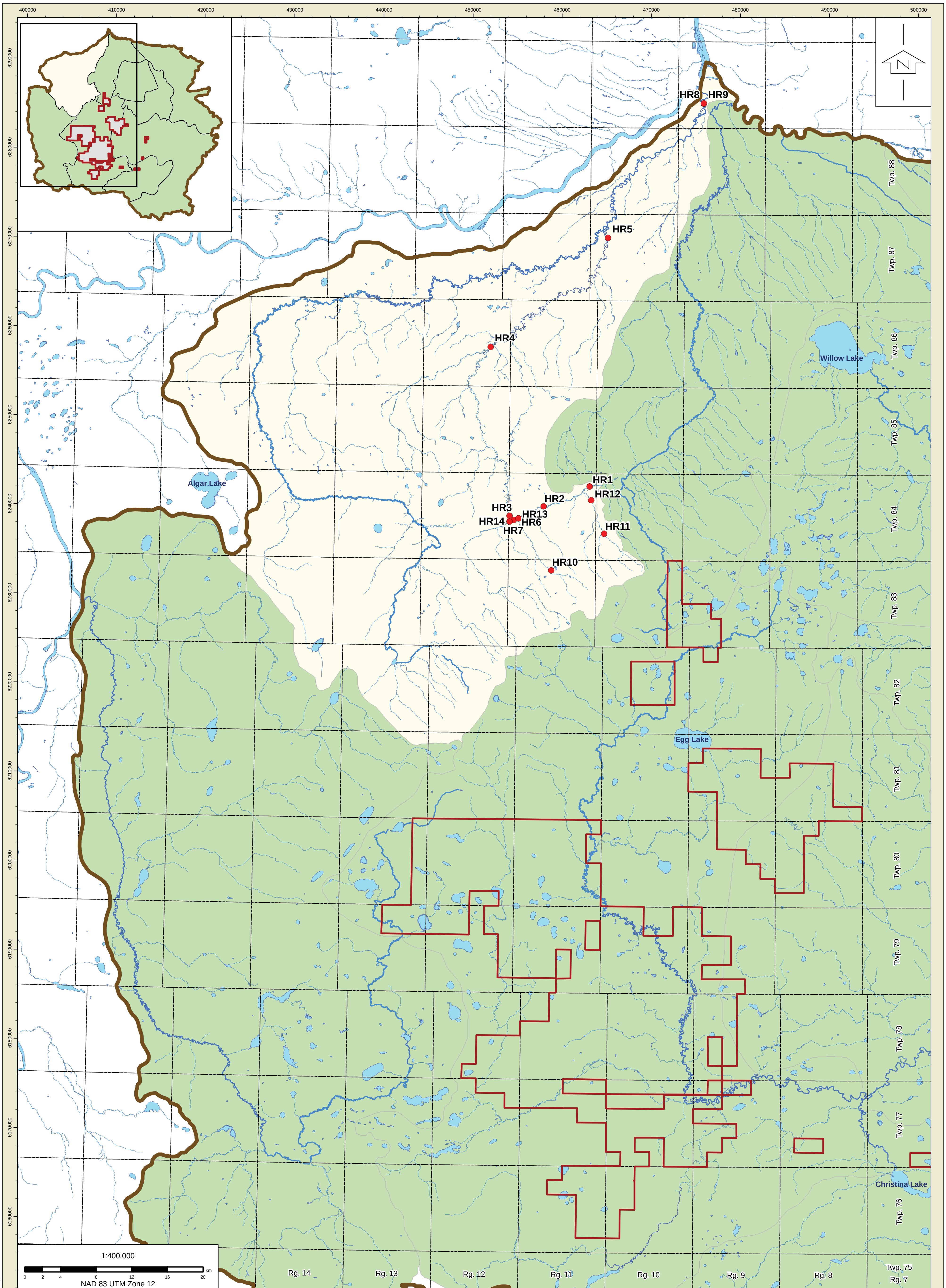

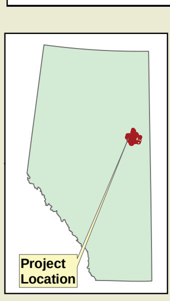

Legend

- North American Lease Boundary
- Regional Study Area
- Horse River Basin
- Lake
- Stream
- Historic Fish Data Site

Title:

HORSE RIVER BASIN

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:
DJ	June 12, 2007

File: Fig 8.5-8 Horse River Basin_20070612.mxd

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JC	LZ	8.5-8

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LEGEND

Ba BARE GROUND
Bd BEDROCK
Bo BOULDER
L.Bo LARGE BOULDER
Co COBBLE
S.Co SMALL COBBLE
L.Co LARGE COBBLE
Gr GRAVEL
S.Gr SMALL GRAVEL
L.Gr LARGE GRAVEL

ESCARPMENT

Sa SAND
Si SILT
Or ORGANIC MATERIAL
DP DEBRIS PILE
BL BEAVER LODGE
BD BEAVER DAM
EM EMERGENT MACROPHYTES
SM SUBMERGENT MACROPHYTES
FM FLOATING MACROPHYTES
IV INSTREAM VEGETATION
TV TERRESTIAL VEGETATION
DEADFALL
RW ROOTWAD
SH SHRUB

MF MIXEDWOOD FOREST
CF CONIFEROUS FOREST
DF DECIDUOUS FOREST
SE SEDGES
GF GRASS/FORBES
MO MOSS

MT MINNOW TRAP

UCB UNDERCUT BANK
OHC OVERHEAD COVER
OHV OVERHANGING VEGETATION
ISC INSTREAM COVER
INV INUNDATED VEGETATION

USB UNSTABLE BANK

BW BACKWATER
IP IMPOUNDMENT POND
SN SNYE
CH CHUTE
CA CASCADE

SHALLOW SLOPE
MODERATE SLOPE
MODERATELY STEEP SLOPE
STEEP SLOPE
FLOW DIRECTION

RA RAPIDS
RF RIFFLE
R1 CLASS 1 RUN
R2 CLASS 2 RUN
R3 CLASS 3 RUN
P1 CLASS 1 POOL
P2 CLASS 2 POOL
P3 CLASS 3 POOL
FL FLAT
FA FALLS

WATER DEPTH

T1 TRANSECT

WCH1 AQUATIC HABITAT MAP

NOT TO SCALE

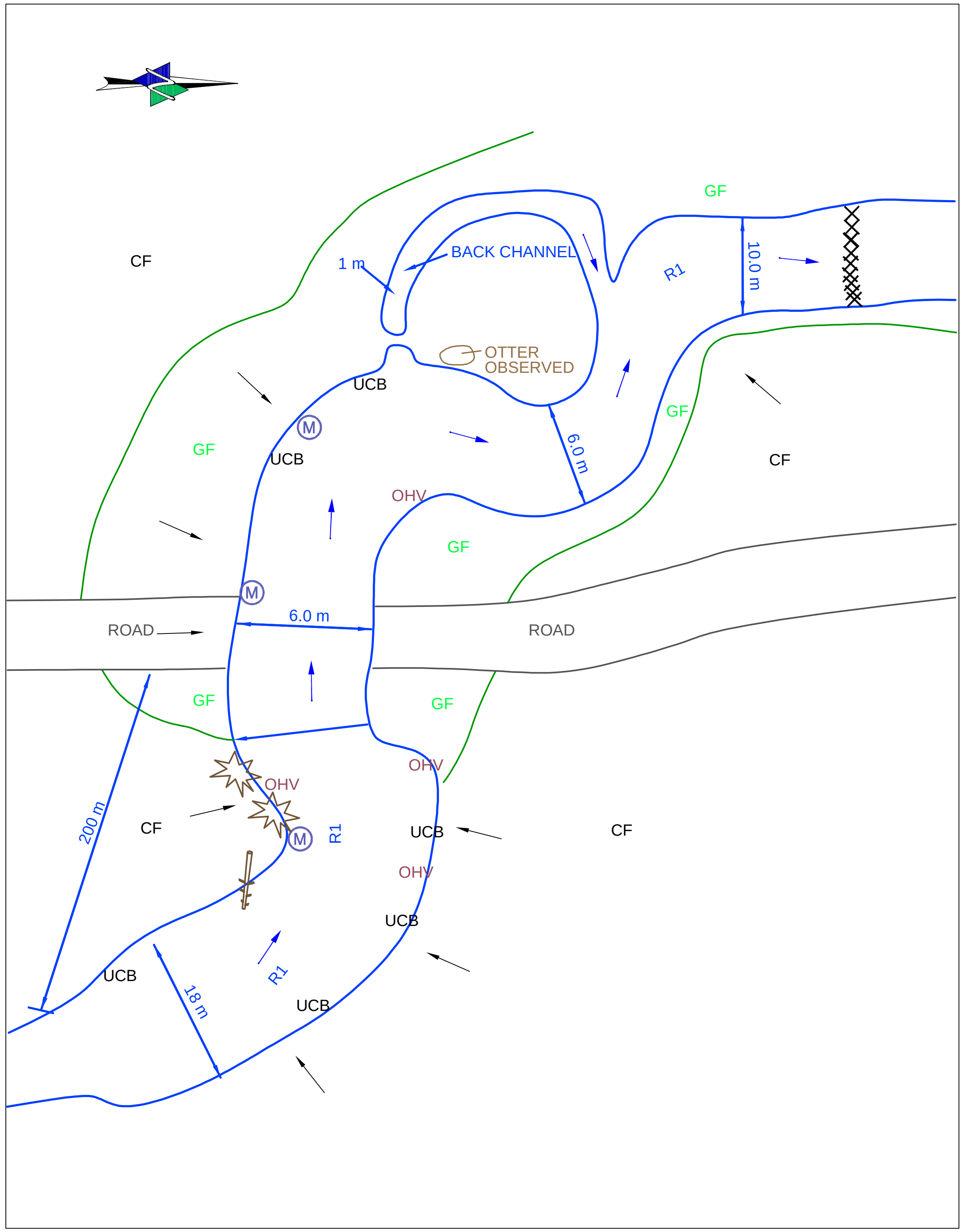


PHOTO 1. Left downstream bank at study site WCH1 on the Hangingstone River.

PHOTO 2. Downstream view of the Hangingstone River from WCH1, showing beaver activity.

WCH1 (Hangingstone River)

WCH1 was located on the Hangingstone River, which followed an irregular meander pattern, with an average channel width of approximately 6.0 m. The watercourse was located in a mature coniferous forest with primarily tall grasses and willows bordering the banks of the river. The habitat in the study area included riffles, runs, and pools created by beaver activity. Substrate was composed of organic fines. The watercourse provided moderate rearing, spawning, and feeding habitat potential for forage fish species, and low habitat potential for large bodied/sport fish. Overwintering habitat potential is unknown because the site was not visited in the winter season.

PHOTO 3. Upstream view of the Hangingstone River from WCH1.

WCH1 HABITAT POTENTIAL RANKING

Fish Habitat Potential	Large Bodied/Sport Fish	Forage Fish
Overwintering	--	--
Spawning	low	moderate
Rearing	low	moderate
Feeding	low	moderate

Note(s):
'--' = not sampled

WCH1 FISHERIES COLLECTION DATA

Sampling Season	Angling		Minnow Trap		Electrofishing	
	Fish Captured	Effort (h)	Fish Captured	Effort (h)	Fish Captured	Effort (s)
Winter	N/A	N/A	N/A	N/A	N/A	N/A
Spring	--	--	3 SPSH	6.00	2 BRST	400
Summer	--	--	0	2.55	--	--
Fall	--	--	0	2.50	--	--
Total	**--**	**--**	**3 SPSH**	**11.05**	**2 BRST**	**400**

Note(s):
N/A = not surveyed; '--' = method not used during this survey
BRST = Brook Stickleback, SPSH = Spottail Shiner

WCH1 SURFACE WATER QUALITY DATA

Sampling Date	Water Depth (m)	Discharge (m^3/s)	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (µS/cm)	pH (units)	Turbidity (NTU)
Feb-06	--	--	--	--	--	--	--
4-May-06	1.30	0.20	4.64	11.92	103	--	2.90
7-Aug-05	0.85	1.76	15.80	10.50	124	9.26	--
1-Oct-05	0.78	0.02	3.60	12.50	91	9.60	--

Note(s):
'--' = not sampled

Title:

HANGINGSTONE STUDY AREA, WCH1, WATERCOURSE DATA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: GI	Revision Date: JUNE 7, 07	
File: 4455-HABITAT-07-WC		
Drawn by: BSW	Checked: TJ	Fig. No.: 8.5-9

*PLOT 1:1=11x17 (L)

LEGEND

Ba BARE GROUND
Bd BEDROCK
Bo BOULDER
L.Bo LARGE BOULDER
Co COBBLE
S.Co SMALL COBBLE
L.Co LARGE COBBLE
Gr GRAVEL
S.Gr SMALL GRAVEL
L.Gr LARGE GRAVEL

ESCARPMENT

Sa SAND
Si SILT
Or ORGANIC MATERIAL
DP DEBRIS PILE
BL BEAVER LODGE
BD BEAVER DAM
EM EMERGENT MACROPHYTES
SM SUBMERGENT MACROPHYTES
FM FLOATING MACROPHYTES
IV INSTREAM VEGETATION
TV TERRESTIAL VEGETATION
DEADFALL
RW ROOTWAD
SH SHRUB

MF MIXEDWOOD FOREST
CF CONIFEROUS FOREST
DF DECIDUOUS FOREST
SE SEDGES
GF GRASS/FORBES
MO MOSS

MT MINNOW TRAP

UCB UNDERCUT BANK
OHC OVERHEAD COVER
OHV OVERHANGING VEGETATION
ISC INSTREAM COVER
INV INUNDATED VEGETATION

USB UNSTABLE BANK

BW BACKWATER
IP IMPOUNDMENT POND
SN SNYE
CH CHUTE
CA CASCADE

SHALLOW SLOPE
MODERATE SLOPE
MODERATELY STEEP SLOPE
STEEP SLOPE
FLOW DIRECTION

RA RAPIDS
RF RIFFLE
R1 CLASS 1 RUN
R2 CLASS 2 RUN
R3 CLASS 3 RUN
P1 CLASS 1 POOL
P2 CLASS 2 POOL
P3 CLASS 3 POOL
FL FLAT
FA FALLS

WATER DEPTH

T1 TRANSECT

WCH2 AQUATIC HABITAT MAP

NOT TO SCALE

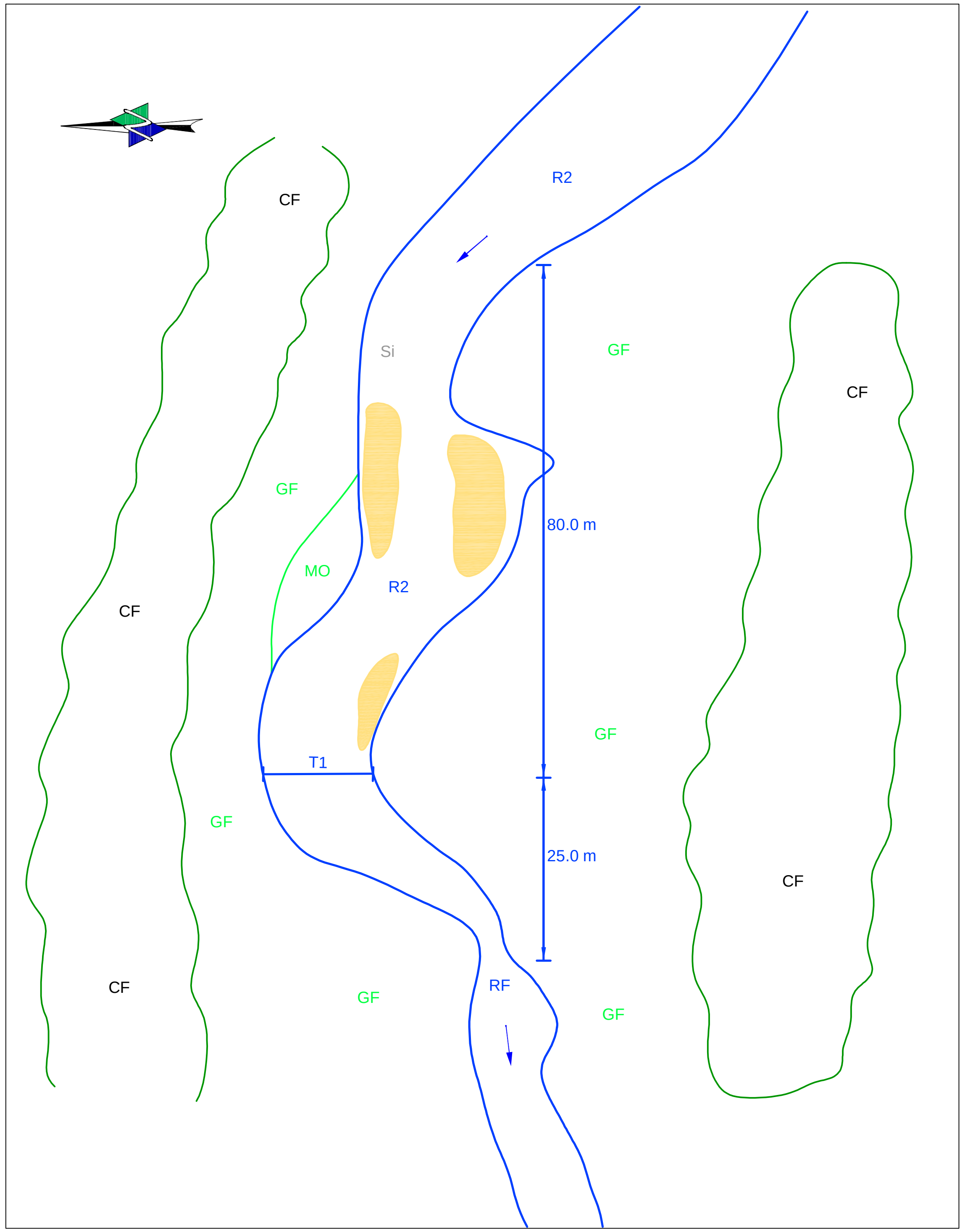


PHOTO 1. Aerial view of the WCH2 study area on the Hangingstone River.

PHOTO 2. Downstream view of the Hangingstone River from WCH2.

WCH2 (Hangingstone River)

WCH2 was located on the Hangingstone River, upstream of WCH1, and exhibited an irregular meander pattern. The watercourse was located in a coniferous forest, and was bordered primarily by willows and tall grasses. The habitat was mainly characterized as class 2 run (R2); however, there was one small riffle area approximately 100 m downstream of the study site, immediately downstream of a blown out beaver dam. Substrate was mainly organic fines, however there was some boulder cover and some gravel present in the downstream area of study. The watercourse provided moderate spawning, rearing and feeding habitat potential for forage fish species, and low to moderate habitat potential for large bodied/sport fish. Overwintering habitat potential was low for both forage fish and sport fish species due to the shallow water present under the ice.

PHOTO 3. Upstream view of the Hangingstone River from WCH2.

WCH2 FISHERIES COLLECTION DATA

Sampling Season	Angling		Minnow Trap		Electrofishing	
	Fish Captured	Effort (h)	Fish Captured	Effort (h)	Fish Captured	Effort (s)
Winter	--	--	0	1.16	--	--
Spring	--	--	1 BRST	6.00	0	427
Summer	--	--	8 BRST 2 SPSH 1PRDC	5.18	--	--
Fall	--	--	--	--	--	--
Total	**--**	**--**	**8 BRST 2 SPSH 1 PRDC**	**12.34**	**0**	**427**

Note(s):
'--' = method not used during this survey.
BRST = Brook Stickleback, SPSH = Spottail Shiner, PRDC = Pearl Dace

WCH2 SURFACE WATER QUALITY DATA

Sampling Date	Water Depth (m)	Discharge (m^3/s)	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (μS/cm)	pH (units)	Turbidity (NTU)
9-Feb-06	0.16	2.30	5.20	--	419	5.40	16.54
4-May-06	0.82	0.93	5.68	13.40	30	--	--
7-Aug-05	0.82	0.46	16.00	9.69	108	9.23	--
30-Sep-05	0.95	0.08	5.10	11.90	57	9.60	8.10

Note(s):
'--' = not sampled

WCH2 HABITAT POTENTIAL RANKING

Fish Habitat Potential	Large Bodied/Sport Fish	Forage Fish
Overwintering	low	low
Spawning	low to moderate	moderate
Rearing	low to moderate	moderate
Feeding	low to moderate	moderate

Title:
HANGINGSTONE STUDY AREA, WCH2, WATERCOURSE DATA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: GI	Revision Date: JUNE 7, 07	
File: 4455-HABITAT-07-WC		
Drawn by: BSW	Checked: TJ	Fig. No.: 8.5-10

F:\4455 NAOSC\Drafting\2007\4455-HABITAT-07-WC.dwg - WCH2 - Jun. 15, 2007 11:03am - bwheeler

LEGEND

- Ba BARE GROUND
- Bd BEDROCK
- Bo BOULDER
- L.Bo LARGE BOULDER
- Co COBBLE
- S.Co SMALL COBBLE
- L.Co LARGE COBBLE
- Gr GRAVEL
- S.Gr SMALL GRAVEL
- L.Gr LARGE GRAVEL
- ESCARPMENT
- Sa SAND
- Si SILT
- Or ORGANIC MATERIAL
- DP DEBRIS PILE
- BL BEAVER LODGE
- BD BEAVER DAM
- EM EMERGENT MACROPHYTES
- SM SUBMERGENT MACROPHYTES
- FM FLOATING MACROPHYTES
- IV INSTREAM VEGETATION
- TV TERRESTIAL VEGETATION
- DEADFALL
- RW ROOTWAD
- SH SHRUB
- MF MIXEDWOOD FOREST
- CF CONIFEROUS FOREST
- DF DECIDUOUS FOREST
- SE SEDGES
- GF GRASS/FORBES
- MO MOSS
- MT MINNOW TRAP
- UCB UNDERCUT BANK
- OHC OVERHEAD COVER
- OHV OVERHANGING VEGETATION
- ISC INSTREAM COVER
- INV INUNDATED VEGETATION
- USB UNSTABLE BANK
- BW BACKWATER
- IP IMPOUNDMENT POND
- SN SNYE
- CH CHUTE
- CA CASCADE
- SHALLOW SLOPE
- MODERATE SLOPE
- MODERATELY STEEP SLOPE
- STEEP SLOPE
- FLOW DIRECTION
- RA RAPIDS
- RF RIFFLE
- R1 CLASS 1 RUN
- R2 CLASS 2 RUN
- R3 CLASS 3 RUN
- P1 CLASS 1 POOL
- P2 CLASS 2 POOL
- P3 CLASS 3 POOL
- FL FLAT
- FA FALLS
- WATER DEPTH
- T1 TRANSECT

WCH3 AQUATIC HABITAT MAP

NOT TO SCALE

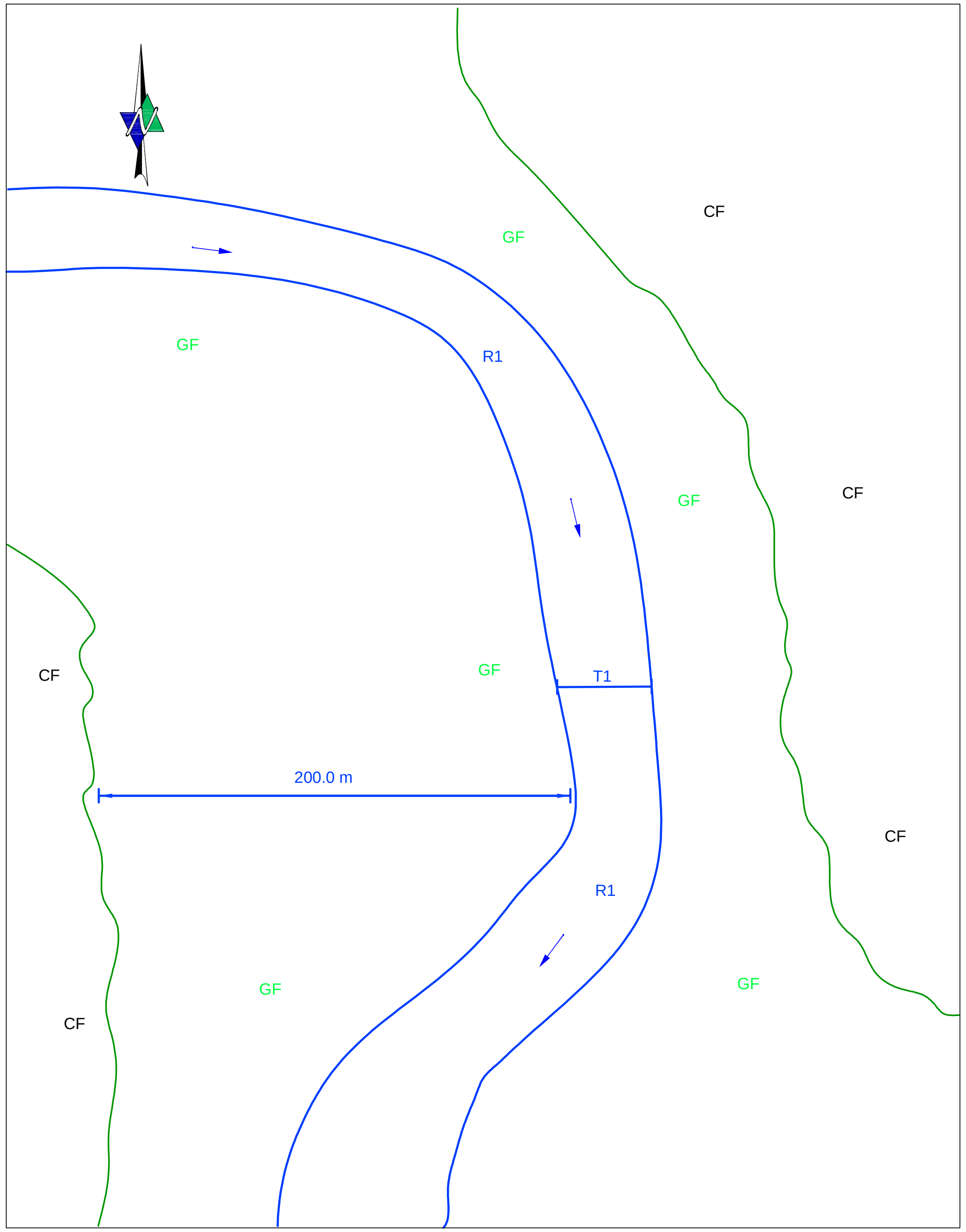


PHOTO 1. Aerial view of WCH3 located on an unnamed tributary to the Christina River.

PHOTO 2. Downstream view of the Christina River tributary from WCH3.

WCH3 (Christina River)

WCH3 was located on the Christina River, near the headwaters and had an average channel width of 6.25 m. The watercourse exhibited an irregular meander pattern, and was located in a mature coniferous forest dominated by black spruce. The watercourse was bordered primarily by tall grasses and sedges. The habitat type was class 1 run (R1) from the upstream to the downstream reaches of the study area. The substrate was composed entirely of organic fines. The watercourse provided moderate spawning, rearing, and feeding habitat potential for forage fish and low habitat potential for large bodied/sport fish. Overwintering habitat was moderate for forage fish species and low for large bodied/sport fish due to an under-ice water depth of less than one metre.

PHOTO 3. Upstream view of the Christina River tributary from WCH3.

WCH3 HABITAT POTENTIAL RANKING

Fish Habitat Potential	Large Bodied/Sport Fish	Forage Fish
Overwintering	low	moderate
Spawning	low	moderate
Rearing	low	moderate
Feeding	low	moderate

WCH3 FISHERIES COLLECTION DATA

Sampling Season	Angling		Minnow Trap		Electrofishing	
	Fish Captured	Effort (h)	Fish Captured	Effort (h)	Fish Captured	Effort (s)
Winter	--	--	5 BRST	1.16	--	--
Spring	--	--	0	5.00	3 BRST	429
Summer	--	--	--	--	--	--
Fall	--	--	--	--	0	2413
Total	--	--	**5 BRST**	**6.16**	**3 BRST**	**2842**

Note(s):
'--' = method not used during this survey
BRST = Brook Stickleback

WCH3 SURFACE WATER QUALITY DATA

Sampling Date	Water Depth (m)	Discharge (m^3/s)	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (µS/cm)	pH (units)	Turbidity (NTU)
9-Feb-06	0.85	--	0.14	11.25	84	5.08	9.24
4-May-06	1.22	0.81	3.01	--	26	--	3.82
7-Aug-05	1.83	5.59	16.20	10.79	103	9.15	--
30-Sep-05	1.16	0.80	5.50	12.30	52	9.60	10.70

Note(s):
'--' = not sampled

Title:

HANGINGSTONE STUDY AREA, WCH3, WATERCOURSE DATA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: GI	Revision Date: JUNE 7, 07	
File: 4455-HABITAT-07-WC		
Drawn by: BSW	Checked: TJ	Fig. No.: 8.5-11

*PLOT 1:1=11x17 (L)

F:\4455 NAOSC\Drafting\2007\4455-HABITAT-07-Wc.dwg - WCH3 - Jun. 15, 2007 11:03am - bwheeler

*PLOT 1:1=11x17 (L)

LEGEND

Ba BARE GROUND
Bd BEDROCK
Bo BOULDER
L.Bo LARGE BOULDER
Co COBBLE
S.Co SMALL COBBLE
L.Co LARGE COBBLE
Gr GRAVEL
S.Gr SMALL GRAVEL
L.Gr LARGE GRAVEL

ESCARPMENT

Sa SAND
Si SILT
Or ORGANIC MATERIAL
DP DEBRIS PILE
BL BEAVER LODGE
BD BEAVER DAM
EM EMERGENT MACROPHYTES
SM SUBMERGENT MACROPHYTES
FM FLOATING MACROPHYTES
IV INSTREAM VEGETATION
TV TERRESTIAL VEGETATION
DEADFALL
RW ROOTWAD
SH SHRUB

MF MIXEDWOOD FOREST
CF CONIFEROUS FOREST
DF DECIDUOUS FOREST
SE SEDGES
GF GRASS/FORBES
MO MOSS

MT MINNOW TRAP

UCB UNDERCUT BANK
OHC OVERHEAD COVER
OHV OVERHANGING VEGETATION
ISC INSTREAM COVER
INV INUNDATED VEGETATION

USB UNSTABLE BANK

BW BACKWATER
IP IMPOUNDMENT POND
SN SNYE
CH CHUTE
CA CASCADE

SHALLOW SLOPE
MODERATE SLOPE
MODERATELY STEEP SLOPE
STEEP SLOPE
FLOW DIRECTION

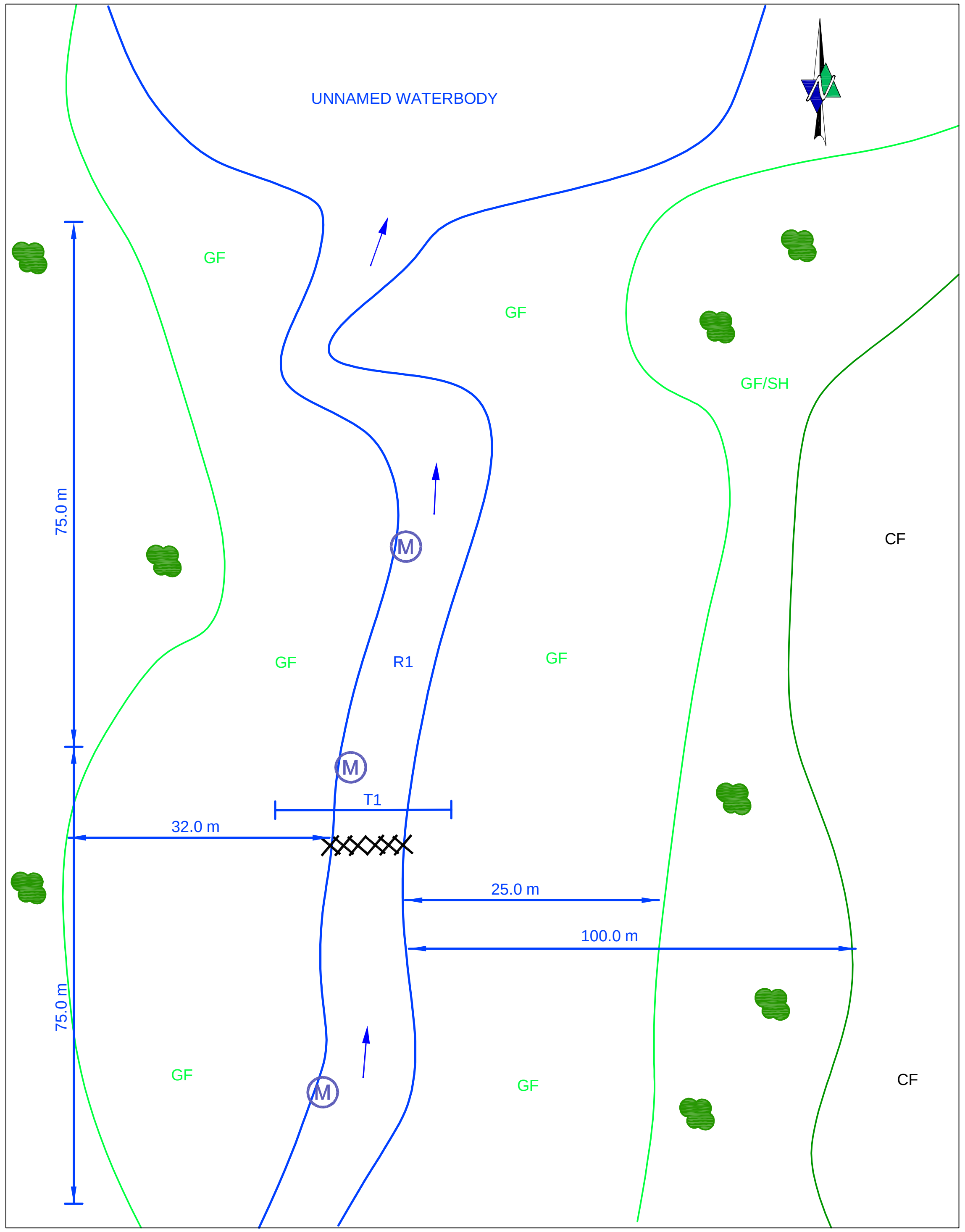
RA RAPIDS
RF RIFFLE
R1 CLASS 1 RUN
R2 CLASS 2 RUN
R3 CLASS 3 RUN
P1 CLASS 1 POOL
P2 CLASS 2 POOL
P3 CLASS 3 POOL
FL FLAT
FA FALLS

WATER DEPTH

T1 TRANSECT

WCH4 AQUATIC HABITAT MAP

NOT TO SCALE



WCH4 SURFACE WATER QUALITY DATA

Sampling Date	Water Depth (m)	Discharge (m^3/s)	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (µS/cm)	pH (units)	Turbidity (NTU)
Feb-06	--	--	--	--	--	--	--
4-May-06	1.10	0.19	4.42	15.02	61	5.82	--
6-Aug-05	0.95	0.74	17.06	4.40	37	5.81	2.40
3-Oct-05	0.60	0.07	1.50	10.52	76	9.57	--

Note(s):
'--' = not sampled

PHOTO 1. Aerial view of WCH4 located on an unnamed tributary to the Christina River.

PHOTO 2. Downstream view of the Christina River tributary from WCH4.

WCH4 (Christina River tributary)
WCH4 was located in the Christina River watershed and exhibited an irregular meander pattern. The watercourse was located in a coniferous forest and vegetation along the water edge consisted of grasses, forbes and sedges. The habitat in the study area consisted of class 1 run (R1) habitat, however, approximately 100 m downstream of the study site, the watercourse disseminated into broken channels of slow moving water. The substrate was composed entirely of organic fines. The watercourse provided moderate rearing, spawning and feeding habitat potential for forage fish species and low habitat potential for large bodied/sport fish. Overwintering habitat potential could not be determined as the site was not visited in the winter season.

WCH4 HABITAT POTENTIAL RANKING

Fish Habitat Potential	Large Bodied/Sport Fish	Forage Fish
Overwintering	--	--
Spawning	low	moderate
Rearing	low	moderate
Feeding	low	moderate

Note(s):
'--' = not sampled

PHOTO 3. Upstream view of the Christina River tributary from WCH4.

WCH4 FISHERIES COLLECTION DATA

Sampling Season	Angling		Minnow Trap		Electrofishing	
	Fish Captured	Effort (h)	Fish Captured	Effort (h)	Fish Captured	Effort (s)
Winter	N/A	N/A	N/A	N/A	N/A	N/A
Spring	--	--	0	4.70	0	200
Summer	--	--	0	1.02	--	--
Fall	--	--	1 BRST	2.16	--	--
Total	**--**	**--**	**1 BRST**	**7.88**	**0**	**200**

Note(s):
N/A = not surveyed; '--' = method not used during this survey
BRST = Brook Stickleback

Title:
HANGINGSTONE STUDY AREA, WCH4, WATERCOURSE DATA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: GI	Revision Date: JUNE 7, 07	
File: 4455-HABITAT-07-WC		
Drawn by: BSW	Checked: TJ	Fig. No.: 8.5-12

F:\4455 NAOSC\Drafting\2007\4455-HABITAT-07-Wc.dwg - WCH4 - Jun. 15, 2007 1:16pm - bwheeler

LEGEND

Ba BARE GROUND
Bd BEDROCK
Bo BOULDER
L.Bo LARGE BOULDER
Co COBBLE
S.Co SMALL COBBLE
L.Co LARGE COBBLE
Gr GRAVEL
S.Gr SMALL GRAVEL
L.Gr LARGE GRAVEL

ESCARPMENT

Sa SAND
Si SILT
Or ORGANIC MATERIAL
DP DEBRIS PILE
BL BEAVER LODGE
BD BEAVER DAM
EM EMERGENT MACROPHYTES
SM SUBMERGENT MACROPHYTES
FM FLOATING MACROPHYTES
IV INSTREAM VEGETATION
TV TERRESTIAL VEGETATION

DEADFALL

RW ROOTWAD
SH SHRUB

MF MIXEDWOOD FOREST
CF CONIFEROUS FOREST
DF DECIDUOUS FOREST
SE SEDGES
GF GRASS/FORBES
MO MOSS

MT MINNOW TRAP

UCB UNDERCUT BANK
OHC OVERHEAD COVER
OHV OVERHANGING VEGETATION
ISC INSTREAM COVER
INV INUNDATED VEGETATION

USB UNSTABLE BANK

BW BACKWATER
IP IMPOUNDMENT POND
SN SNYE
CH CHUTE
CA CASCADE

SHALLOW SLOPE
MODERATE SLOPE
MODERATELY STEEP SLOPE
STEEP SLOPE
FLOW DIRECTION

RA RAPIDS
RF RIFFLE
R1 CLASS 1 RUN
R2 CLASS 2 RUN
R3 CLASS 3 RUN
P1 CLASS 1 POOL
P2 CLASS 2 POOL
P3 CLASS 3 POOL
FL FLAT
FA FALLS

WATER DEPTH

T1 TRANSECT

WCH5 AQUATIC HABITAT MAP

NOT TO SCALE

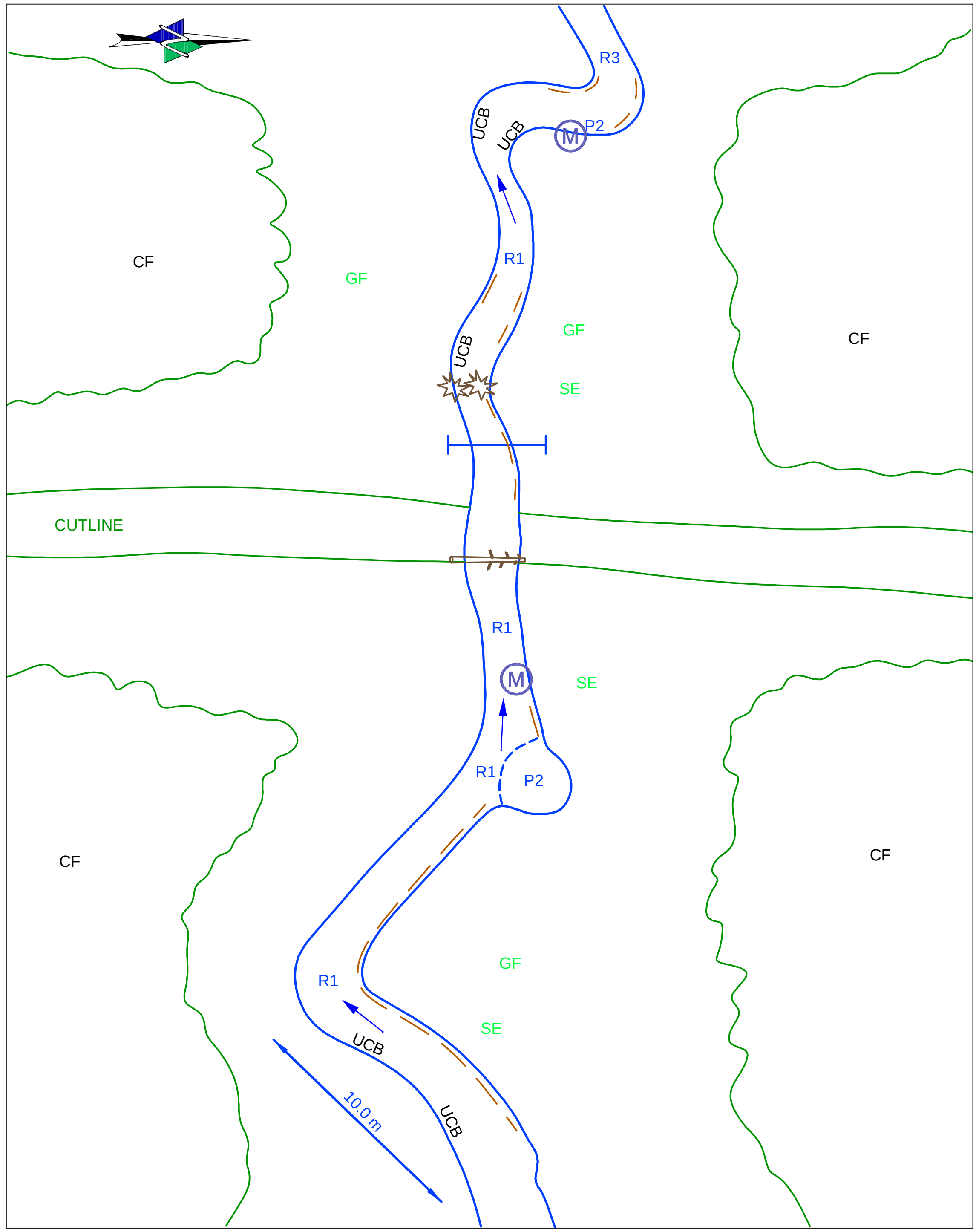


PHOTO 1. Aerial view of WCH5 located on an unnamed tributary of the Christina River.

PHOTO 2. Upstream view of the Christina River tributary at WCH5.

WCH5 (Christina River tributary)
WCH5 was located in the Christina River watershed, and exhibited an irregular meander pattern. The habitat was located in a coniferous forest, and the water was primarily bordered by tall grasses and forbes. The habitat present consisted of class 1 run (R1) sections, with one small class 3 run (R3) section downstream of the WCH5 site. Substrate consisted of organic fines throughout the study area. The watercourse provided moderate spawning, rearing, and feeding habitat potential for forage fish, and low habitat potential for large bodied/sport fish species. Overwintering habitat potential was not present for forage fish or large bodied fish species due to frozen substrate conditions.

PHOTO 3. Downstream view of right bank from WCH5.

WCH5 HABITAT POTENTIAL RANKING

Fish Habitat Potential	Large Bodied/Sport Fish	Forage Fish
Overwintering	nil*	nil*
Spawning	low	moderate
Rearing	low	moderate
Feeding	low	moderate

Note(s):
nil* = no habitat observed

WCH5 FISHERIES COLLECTION DATA

Sampling Season	Angling		Minnow Trap		Electrofishing	
	Fish Captured	Effort (h)	Fish Captured	Effort (h)	Fish Captured	Effort (s)
Winter	N/A	N/A	N/A	N/A	N/A	N/A
Spring	--	--	0	3.90	0	343
Summer	--	--	0	2.95	--	--
Fall	--	--	--	--	--	--
Total	**--**	**--**	**0**	**6.85**	**0**	**343**

Note(s):
N/A = not surveyed; '--' = method not used during this survey

WCH5 SURFACE WATER QUALITY DATA

Sampling Date	Water Depth (m)	Discharge (m^3/s)	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (µS/cm)	pH (units)	Turbidity (NTU)
8-Feb-06	--*	--*	--*	--*	--*	--*	--*
5-May-06	0.44	0.05	4.74	11.50	30	4.40	1.76
6-Aug-05	0.58	0.11	17.10	13.56	59	9.18	2.62
20-Aug-06	--	--	14.62	7.10	42	4.30	1.38
3-Oct-05	0.33	0.05	2.60	12.07	57	9.55	--

Note(s):
'--' = not sampled; * = frozen to substrate

Title:
HANGINGSTONE STUDY AREA, WCH5, WATERCOURSE DATA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: GI	Revision Date: JUNE 7, 07	
File: 4455-HABITAT-07-WC		
Drawn by: BSW	Checked: TJ	Fig. No.: 8.5-13

LEGEND

Ba BARE GROUND
Bd BEDROCK
Bo BOULDER
L.Bo LARGE BOULDER
Co COBBLE
S.Co SMALL COBBLE
L.Co LARGE COBBLE
Gr GRAVEL
S.Gr SMALL GRAVEL
L.Gr LARGE GRAVEL

ESCARPMENT
Sa SAND
Si SILT
Or ORGANIC MATERIAL
DP DEBRIS PILE
BL BEAVER LODGE
BD BEAVER DAM
EM EMERGENT MACROPHYTES
SM SUBMERGENT MACROPHYTES
FM FLOATING MACROPHYTES
IV INSTREAM VEGETATION
TV TERRESTIAL VEGETATION
DEADFALL
RW ROOTWAD
SH SHRUB

MF MIXEDWOOD FOREST
CF CONIFEROUS FOREST
DF DECIDUOUS FOREST
SE SEDGES
GF GRASS/FORBES
MO MOSS

MT MINNOW TRAP

UCB UNDERCUT BANK
OHC OVERHEAD COVER
OHV OVERHANGING VEGETATION
ISC INSTREAM COVER
INV INUNDATED VEGETATION

USB UNSTABLE BANK

BW BACKWATER
IP IMPOUNDMENT POND
SN SNYE
CH CHUTE
CA CASCADE

SHALLOW SLOPE
MODERATE SLOPE
MODERATELY STEEP SLOPE
STEEP SLOPE
FLOW DIRECTION

RA RAPIDS
RF RIFFLE
R1 CLASS 1 RUN
R2 CLASS 2 RUN
R3 CLASS 3 RUN
P1 CLASS 1 POOL
P2 CLASS 2 POOL
P3 CLASS 3 POOL
FL FLAT
FA FALLS

WATER DEPTH

T1 TRANSECT

WCH6 AQUATIC HABITAT MAP

NOT TO SCALE

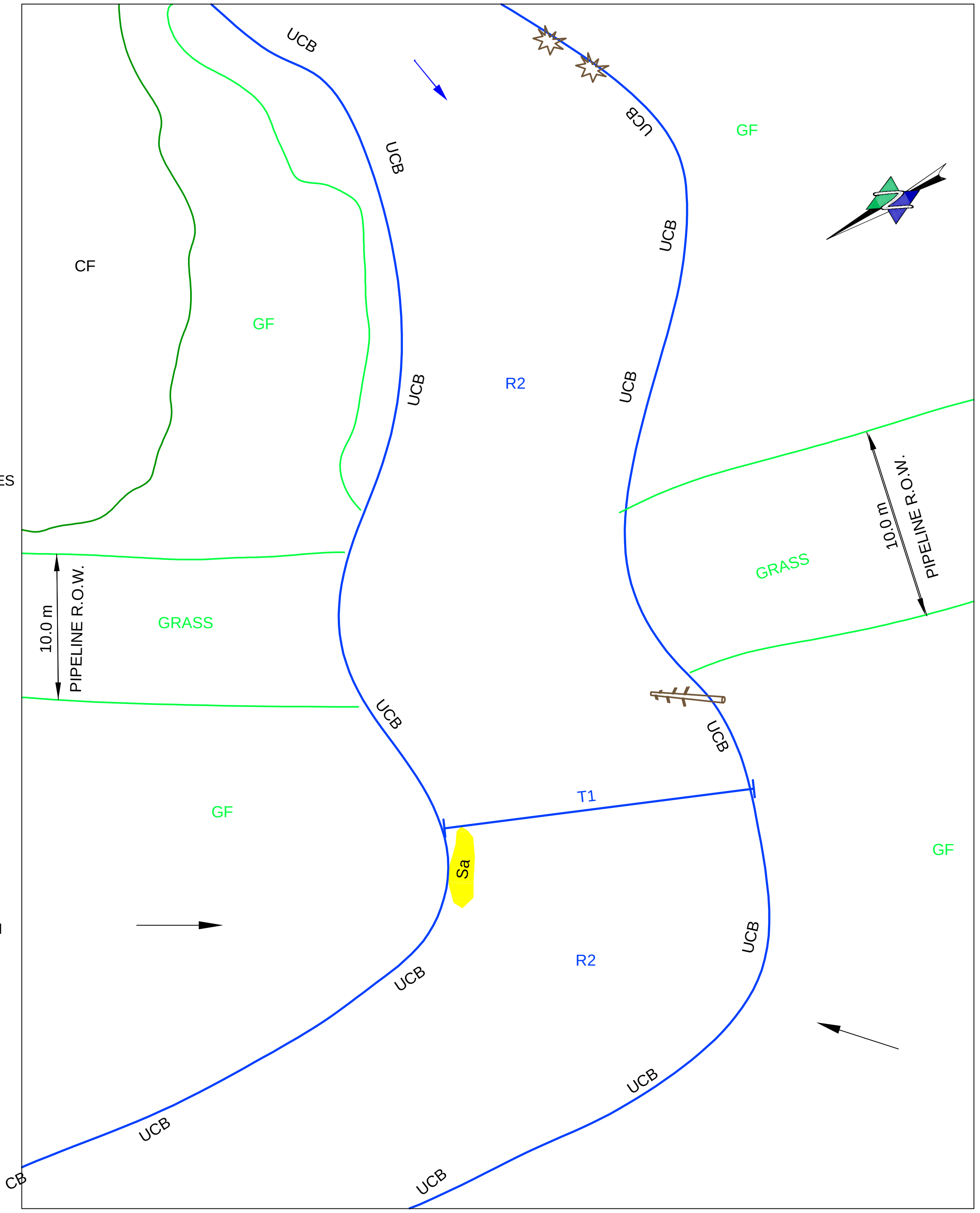


PHOTO 1. Aerial view of the Christina River at WCH6.

PHOTO 2. Upstream view from WCH6.

PHOTO 3. Downstream view from WCH6.

WCH6 (Christina River)
WCH6 was located on the Christina River at a stretch of river where an irregular meander pattern existed. The river was located in a mature coniferous forest, and tall grasses and willows bordered the watercourse. The habitat present consisted of class 2 run (R2) habitat. The substrate was composed of organic fines throughout the study area. The watercourse provided moderate spawning, rearing, and feeding habitat potential for forage fish, and low habitat potential for large bodied/sport fish species. Overwintering habitat potential is not known because the site was not visited in the winter months.

WCH6 HABITAT POTENTIAL RANKING

Fish Habitat Potential	Large Bodied/Sport Fish	Forage Fish
Overwintering	--	--
Spawning	low	moderate
Rearing	low	moderate
Feeding	low	moderate

Note(s):
'--' = not sampled

WCH6 FISHERIES COLLECTION DATA

Sampling Season	Angling		Minnow Trap		Electrofishing	
	Fish Captured	Effort (h)	Fish Captured	Effort (h)	Fish Captured	Effort (s)
Winter	NA	NA	NA	NA	NA	NA
Spring	0	0.5	1 SPSH 2 PRDC 2 BRST 1 FTMN	6	3 BRST	151
Summer	--	--	0	2.43	--	--
Fall	--	--	1 LNSC	4.13	--	--
Total	**0**	**0.5**	**1 SPSH 2 PRDC 2 BRST 1 FTMN 1 LNSC**	**12.56**	**3 BRST**	**151**

Note(s):
N/A = not surveyed; '--' = method not used during this survey
BRST = Brook Stickleback, SPSH = Spottail Shiner, FTMN = Fathead Minnow,
LNSC = Longnose Sucker, PRDC = Pearl Dace

WCH6 SURFACE WATER QUALITY DATA

Sampling Date	Water Depth (m)	Discharge (m^3/s)	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (µS/cm)	pH (units)	Turbidity (NTU)
Feb-06	--	--	--	--	--	--	--
5-May-06	1.38	1.74	6.97	10.52	30	6.37	4.87
6-Aug-05	1.57	6.13	16.34	6.10	27	5.40	2.64
29-Sep-05	1.00	1.05	6.17	11.38	56	7.20	7.84

Note(s):
'--' = not sampled

Title:
HANGINGSTONE STUDY AREA, WCH6, WATERCOURSE DATA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: GI	Revision Date: JUNE 7, 07	
File: 4455-HABITAT-07-WC		
Drawn by: BSW	Checked: TJ	Fig. No.: 8.5-14

LEGEND

Ba	BARE GROUND
Bd	BEDROCK
Bo	BOULDER
L.Bo	LARGE BOULDER
Co	COBBLE
S.Co	SMALL COBBLE
L.Co	LARGE COBBLE
Gr	GRAVEL
S.Gr	SMALL GRAVEL
L.Gr	LARGE GRAVEL
	ESCARPMENT
Sa	SAND
Si	SILT
Or	ORGANIC MATERIAL
DP	DEBRIS PILE
BL	BEAVER LODGE
BD	BEAVER DAM
EM	EMERGENT MACROPHYTES
SM	SUBMERGENT MACROPHYTES
FM	FLOATING MACROPHYTES
IV	INSTREAM VEGETATION
TV	TERRESTIAL VEGETATION
	DEADFALL
RW	ROOTWAD
SH	SHRUB
MF	MIXEDWOOD FOREST
CF	CONIFEROUS FOREST
DF	DECIDUOUS FOREST
SE	SEDGES
GF	GRASS/FORBES
MO	MOSS
MT	MINNOW TRAP
UCB	UNDERCUT BANK
OHC	OVERHEAD COVER
OHV	OVERHANGING VEGETATION
ISC	INSTREAM COVER
INV	INUNDATED VEGETATION
USB	UNSTABLE BANK
BW	BACKWATER
IP	IMPOUNDMENT POND
SN	SNYE
CH	CHUTE
CA	CASCADE
	SHALLOW SLOPE
	MODERATE SLOPE
	MODERATELY STEEP SLOPE
	STEEP SLOPE
	FLOW DIRECTION
RA	RAPIDS
RF	RIFFLE
R1	CLASS 1 RUN
R2	CLASS 2 RUN
R3	CLASS 3 RUN
P1	CLASS 1 POOL
P2	CLASS 2 POOL
P3	CLASS 3 POOL
FL	FLAT
FA	FALLS
	WATER DEPTH
T1	TRANSECT

WCC1 AQUATIC HABITAT MAP

NOT TO SCALE

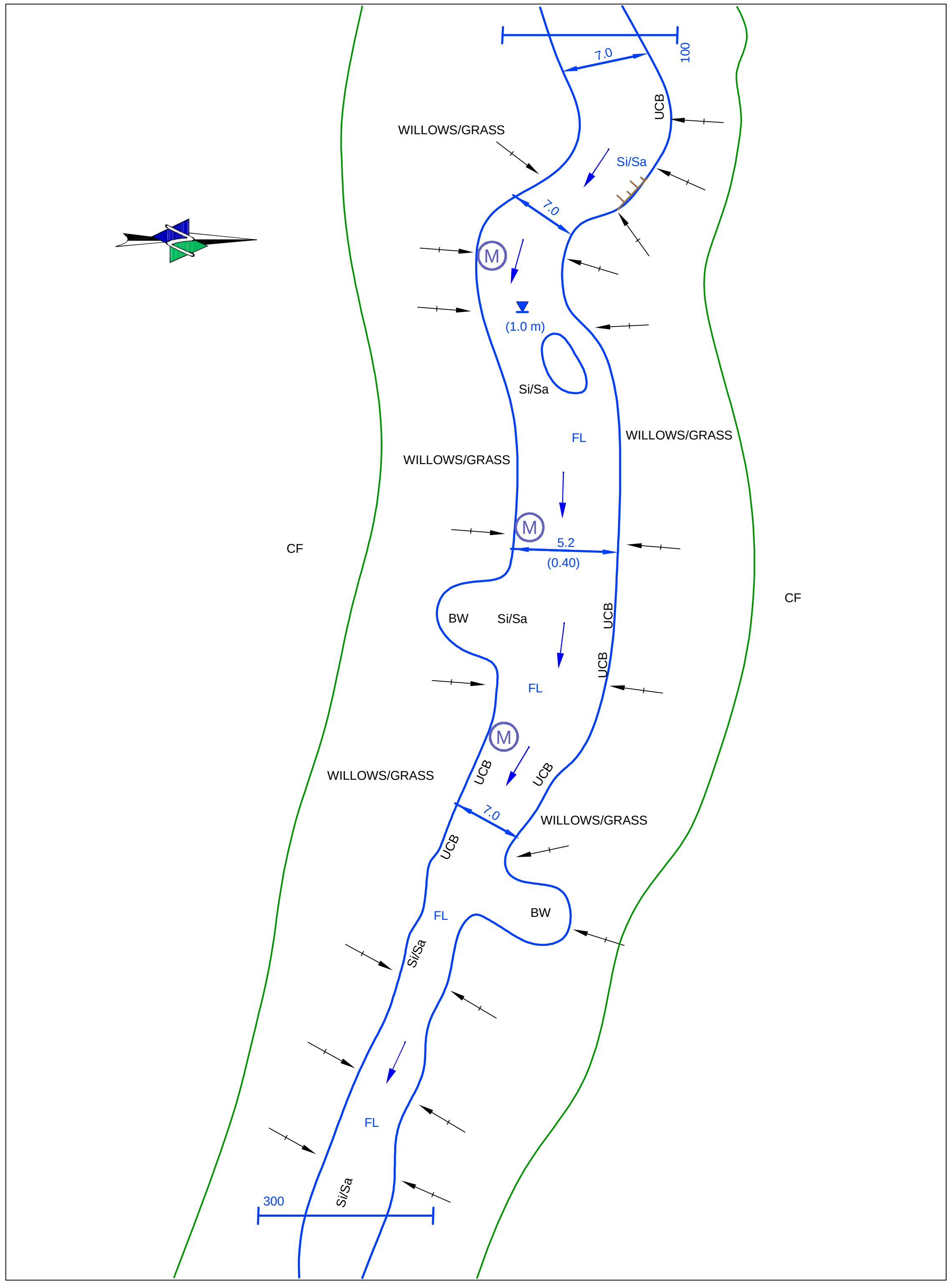


PHOTO 1. Aerial view of WCC1.

PHOTO 2. Upstream view from WCC1.

WCC1 (Christina River tributary)
WCC1 was located in the Christina River watershed on an irregular and meandering stream. The watercourse was located in a coniferous forest and bordered by grasses and forbes. There was little overhanging vegetation, mostly composed of tall grasses. The substrate was characterized by sand and silt fines. The entire stretch of the watercourse was a shallow run, providing moderate rearing, spawning, and feeding habitat potential for forage fish species and low habitat potential for large bodied/sport fish species. Overwintering habitat potential was unknown as the site was not visited during the winter season.

PHOTO 3. Downstream view from WCC1.

WCC1 SURFACE WATER QUALITY DATA

Sampling Date	Water Depth (m)	Discharge (m^3/s)	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (µS/cm)	pH (units)	Turbidity (NTU)
Feb-06	--	--	--	--	--	--	--
5-May-06	0.62	1.03	5.63	9.19	12	--	3.49
6-Aug-05	1.60	0.46	15.40	8.87	101	9.14	6.36
20-Aug-06	--	--	12.66	6.75	81	6.20	8.83
29-Sep-05	1.43	0.35	5.11	8.45	66	7.40	15.30

Note(s):
'--' = not sampled

WCC1 FISHERIES COLLECTION DATA

Sampling Season	Angling		Minnow Trap		Electrofishing	
	Fish Captured	Effort (h)	Fish Captured	Effort (h)	Fish Captured	Effort (s)
Winter	N/A	N/A	N/A	N/A	N/A	N/A
Spring	--	--	0	7.00	0	400
Summer	--	--	8 PRDC 1 FTMN 2 BRST	2.70	--	--
Fall	--	--	1 BRST	2.37	--	--
Total	**--**	**--**	**8 PRDC 1 FTMN 3 BRST**	**12.07**	**0**	**400**

Note(s):
N/A = not surveyed; '--' = method not used during this survey
PRDC = Pearl Dace, FTMN = Fathead Minnow, BRST = Brook Stickleback

WCC1 HABITAT POTENTIAL RANKING

Fish Habitat Potential	Large Bodied/Sport Fish	Forage Fish
Overwintering	nil*	nil*
Spawning	low	moderate
Rearing	low	moderate
Feeding	low	moderate

Note(s):
nil* = no habitat observed

Title:	NORTH AMERICAN OIL SANDS CORPORATION		
CORNER STUDY AREA, WCC1, WATERCOURSE DATA	Approved: GI	Revision Date: JUNE 7, 07	
	File: 4455-HABITAT-07-WC		
	Drawn by: BSW	Checked: TJ	Fig. No.: 8.5-15

*PLOT 1:1=11X17 (L)
F:\4455 NAOSC\Drafting\2007\4455-HABITAT-07-WC.dwg - WCC2 - Jun. 15, 2007 11:00am - bwheeler

LEGEND

- Ba BARE GROUND
- Bd BEDROCK
- Bo BOULDER
- L.Bo LARGE BOULDER
- Co COBBLE
- S.Co SMALL COBBLE
- L.Co LARGE COBBLE
- Gr GRAVEL
- S.Gr SMALL GRAVEL
- L.Gr LARGE GRAVEL
- ESCARPMENT
- Sa SAND
- Si SILT
- Or ORGANIC MATERIAL
- DP DEBRIS PILE
- BL BEAVER LODGE
- BD BEAVER DAM
- EM EMERGENT MACROPHYTES
- SM SUBMERGENT MACROPHYTES
- FM FLOATING MACROPHYTES
- IV INSTREAM VEGETATION
- TV TERRESTIAL VEGETATION
- DEADFALL
- RW ROOTWAD
- SH SHRUB
- MF MIXEDWOOD FOREST
- CF CONIFEROUS FOREST
- DF DECIDUOUS FOREST
- SE SEDGES
- GF GRASS/FORBES
- MO MOSS
- MT MINNOW TRAP
- UCB UNDERCUT BANK
- OHC OVERHEAD COVER
- OHV OVERHANGING VEGETATION
- ISC INSTREAM COVER
- INV INUNDATED VEGETATION
- USB UNSTABLE BANK
- BW BACKWATER
- IP IMPOUNDMENT POND
- SN SNYE
- CH CHUTE
- CA CASCADE
- SHALLOW SLOPE
- MODERATE SLOPE
- MODERATELY STEEP SLOPE
- STEEP SLOPE
- FLOW DIRECTION
- RA RAPIDS
- RF RIFFLE
- R1 CLASS 1 RUN
- R2 CLASS 2 RUN
- R3 CLASS 3 RUN
- P1 CLASS 1 POOL
- P2 CLASS 2 POOL
- P3 CLASS 3 POOL
- FL FLAT
- FA FALLS
- WATER DEPTH
- T1 TRANSECT

WCC2 AQUATIC HABITAT MAP

NOT TO SCALE

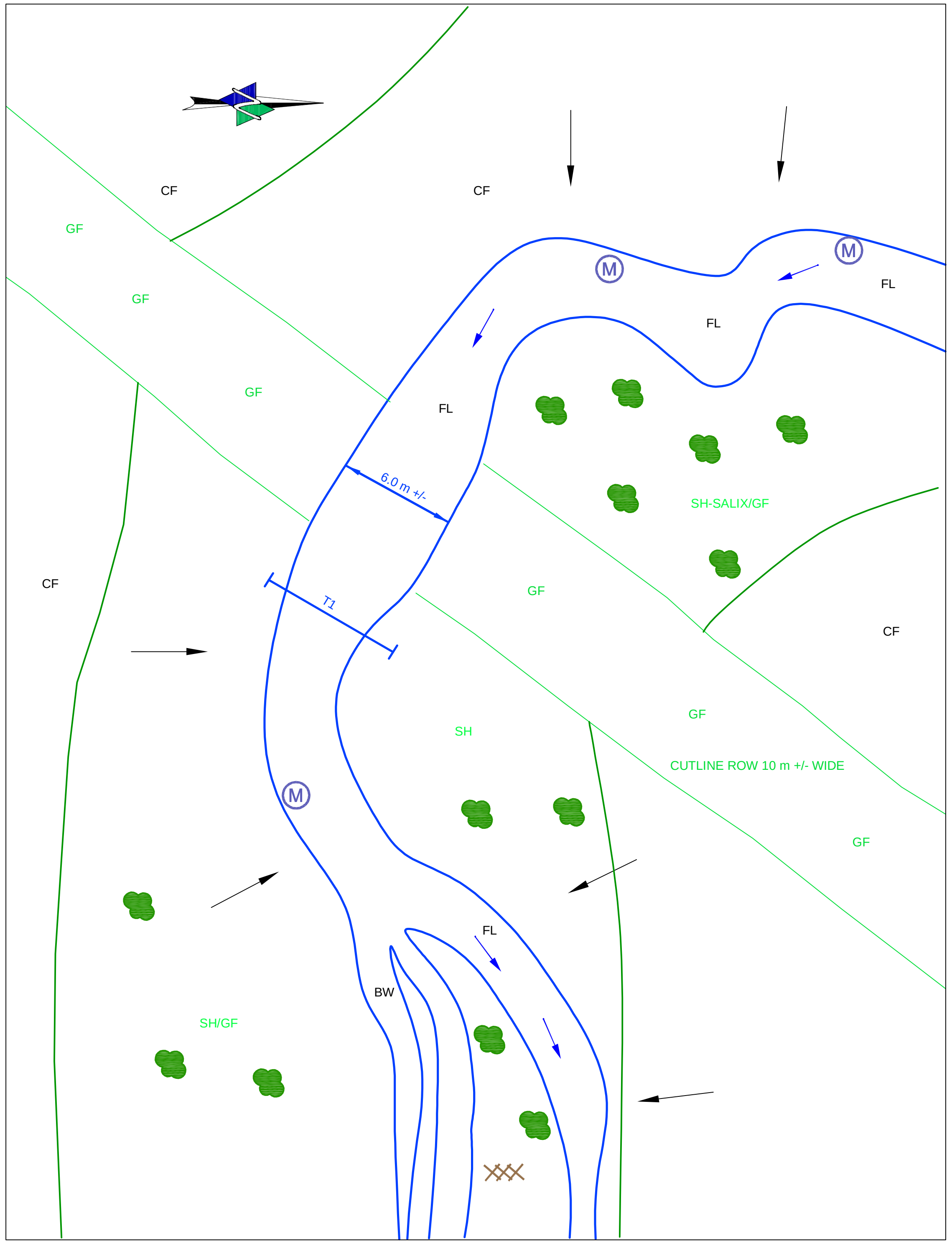


PHOTO 1. Aerial view of WCC2, an unnamed creek flowing out of Egg Lake.

PHOTO 2. View of unnamed creek upstream from WCC2.

PHOTO 3. View of unnamed creek downstream from WCC2.

WCC2 (Christina River tributary)
WCC2 was located in the Christina River watershed, and exhibited an irregular, meandering pattern. The watercourse was located in a mature coniferous forest and was bordered by shrubs, willows and grasses. The study area consisted of flat habitat with slow flowing water. There was some braiding of the stream present in the upstream area of the study area, and beaver activity led to the creation of small backwater areas. The substrate was composed largely of organic fines, which is common to other watercourses in the area. The watercourse provided moderate rearing, spawning, and feeding habitat potential for forage fish species and low habitat potential for large bodied/sport fish. Overwintering habitat potential is unknown because WCC2 was not visited in the winter season.

WCC2 SURFACE WATER QUALITY DATA

Sampling Date	Water Depth (m)	Discharge (m^3/s)	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (µS/cm)	pH (units)	Turbidity (NTU)
Feb-06	--	--	--	--	--	--	--
5-Aug-05	0.98	7.62	17.71	6.81	64	6.18	33.37
29-Sep-05	1.00	0.93	6.89	11.91	74	7.90	--
5-May-06	0.65	0.21	10.47	9.87	40	6.46	20.65

Note(s):
'--' = not sampled

WCC2 FISHERIES COLLECTION DATA

Sampling Season	Angling		Minnow Trap		Electrofishing	
	Fish Captured	Effort (h)	Fish Captured	Effort (h)	Fish Captured	Effort (s)
Winter	N/A	N/A	N/A	N/A	N/A	N/A
Spring	0	0.50	49 BRST	4.30	0	65
Summer	--	--	0	2.08	--	--
Fall	--	--	6 FTMN 5 BRST	3.27	--	--
Total	**0**	**0.50**	**54 BRST** **6 FTMN**	**9.65**	**0**	**65**

Note(s):
N/A = not surveyed; '--' = method not used during this survey
BRST = Brook Stickleback, FTMN = Fathead Minnow

WCC2 HABITAT POTENTIAL RANKING

Fish Habitat Potential	Large Bodied/Sport Fish	Forage Fish
Overwintering	nil*	nil*
Spawning	low	moderate
Rearing	low	moderate
Feeding	low	moderate

Note(s):
nil* = no habitat observed

Title:
CORNER STUDY AREA, WCC2, WATERCOURSE DATA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: GI	Revision Date: JUNE 7, 07	
File: 4455-HABITAT-07-WC		
Drawn by: BSW	Checked: TJ	Fig. No.: 8.5-16

LEGEND

Ba	BARE GROUND
Bd	BEDROCK
Bo	BOULDER
L.Bo	LARGE BOULDER
Co	COBBLE
S.Co	SMALL COBBLE
L.Co	LARGE COBBLE
Gr	GRAVEL
S.Gr	SMALL GRAVEL
L.Gr	LARGE GRAVEL
	ESCARPMENT
Sa	SAND
Si	SILT
Or	ORGANIC MATERIAL
DP	DEBRIS PILE
BL	BEAVER LODGE
BD	BEAVER DAM
EM	EMERGENT MACROPHYTES
SM	SUBMERGENT MACROPHYTES
FM	FLOATING MACROPHYTES
IV	INSTREAM VEGETATION
TV	TERRESTIAL VEGETATION
	DEADFALL
RW	ROOTWAD
SH	SHRUB
MF	MIXEDWOOD FOREST
CF	CONIFEROUS FOREST
DF	DECIDUOUS FOREST
SE	SEDGES
GF	GRASS/FORBES
MO	MOSS
MT	MINNOW TRAP
UCB	UNDERCUT BANK
OHC	OVERHEAD COVER
OHV	OVERHANGING VEGETATION
ISC	INSTREAM COVER
INV	INUNDATED VEGETATION
USB	UNSTABLE BANK
BW	BACKWATER
IP	IMPOUNDMENT POND
SN	SNYE
CH	CHUTE
CA	CASCADE
	SHALLOW SLOPE
	MODERATE SLOPE
	MODERATELY STEEP SLOPE
	STEEP SLOPE
	FLOW DIRECTION
RA	RAPIDS
RF	RIFFLE
R1	CLASS 1 RUN
R2	CLASS 2 RUN
R3	CLASS 3 RUN
P1	CLASS 1 POOL
P2	CLASS 2 POOL
P3	CLASS 3 POOL
FL	FLAT
FA	FALLS
	WATER DEPTH
T1	TRANSECT

WCC3 AQUATIC HABITAT MAP

NOT TO SCALE

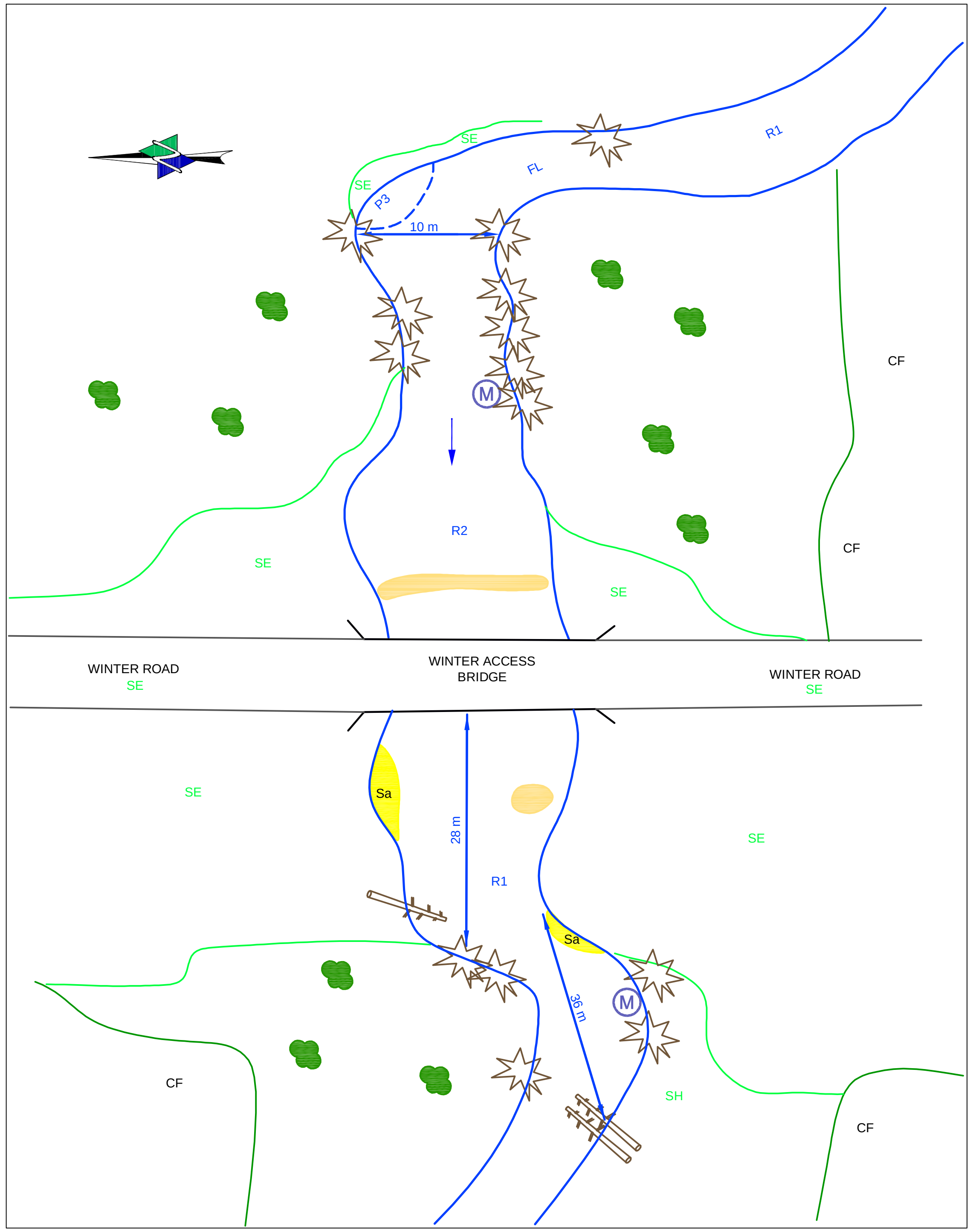


PHOTO 1. Aerial view of the WCC3 study site on an unnamed creek that drains Egg Lake into the Christina River.

PHOTO 2. Downstream view of the unnamed tributary from WCC3.

WCC3 (Christina River tributary)

WCC3 was located in the Christina River watershed, and the watercourse exhibited an irregular meander pattern. The watercourse was located in a mature coniferous forest area with shrubs and tall grasses creating an overhang of vegetation in many locations. Substrate was entirely composed of fines. At the crossing location habitat was a class 2 run (R2) habitat, while upstream and downstream habitat consisted of a class 1 run (R1) habitat with slower moving water. The water course provided low spawning habitat potential and low to moderate rearing and feeding habitat potential for large bodied/sport fish and moderate spawning, rearing and feeding habitat potential for forage fish species. Overwintering habitat potential was low due to the insufficient dissolved oxygen concentration beneath the ice.

PHOTO 3. Upstream view of the unnamed tributary from WCC3.

WCC3 FISHERIES COLLECTION DATA

Sampling Season	Angling		Minnow Trap		Electrofishing	
	Fish Captured	Effort (h)	Fish Captured	Effort (h)	Fish Captured	Effort (s)
Winter	--	--	0	1.25	--	--
Spring	--	--	16 BRST 1 LNSC	6.00	--	--
Summer	--	--	0	2.08	--	--
Fall	--	--	0	6.01	--	--
Total	--	--	**16 BRST 1 LNSC**	**15.34**	--	--

Note(s):
'--' = method not used during this survey

WCC3 SURFACE WATER QUALITY DATA

Sampling Date	Water Depth (m)	Discharge (m^3/s)	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (µS/cm)	pH (units)	Turbidity (NTU)
9-Feb-06	0.94	0.09	0.06	1.02	243	6.50	26.80
5-May-06	0.98	3.14	8.14	11.65	18	--	7.19
5-Aug-05	1.65	--	17.10	11.90	113	9.18	10.80
29-Sep-05	0.58	1.62	6.15	11.15	80	5.97	15.54

Note(s):
'--' = not sampled

WCC3 HABITAT POTENTIAL RANKING

Fish Habitat Potential	Large Bodied/Sport Fish	Forage Fish
Overwintering	low	low
Spawning	low	moderate
Rearing	low to moderate	moderate
Feeding	low to moderate	moderate

Title:

CORNER STUDY AREA, WCC3, WATERCOURSE DATA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: GI	Revision Date: JUNE 7, 07	
File: 4455-HABITAT-07-WC		
Drawn by: BSW	Checked: TJ	Fig. No.: 8.5-17

LEGEND

Ba	BARE GROUND
Bd	BEDROCK
Bo	BOULDER
L.Bo	LARGE BOULDER
Co	COBBLE
S.Co	SMALL COBBLE
L.Co	LARGE COBBLE
Gr	GRAVEL
S.Gr	SMALL GRAVEL
L.Gr	LARGE GRAVEL
	ESCARPMENT
Sa	SAND
Si	SILT
Or	ORGANIC MATERIAL
DP	DEBRIS PILE
BL	BEAVER LODGE
BD	BEAVER DAM
EM	EMERGENT MACROPHYTES
SM	SUBMERGENT MACROPHYTES
FM	FLOATING MACROPHYTES
IV	INSTREAM VEGETATION
TV	TERRESTIAL VEGETATION
	DEADFALL
RW	ROOTWAD
SH	SHRUB
MF	MIXEDWOOD FOREST
CF	CONIFEROUS FOREST
DF	DECIDUOUS FOREST
SE	SEDGES
GF	GRASS/FORBES
MO	MOSS
MT	MINNOW TRAP
UCB	UNDERCUT BANK
OHC	OVERHEAD COVER
OHV	OVERHANGING VEGETATION
ISC	INSTREAM COVER
INV	INUNDATED VEGETATION
USB	UNSTABLE BANK
BW	BACKWATER
IP	IMPOUNDMENT POND
SN	SNYE
CH	CHUTE
CA	CASCADE
	SHALLOW SLOPE
	MODERATE SLOPE
	MODERATELY STEEP SLOPE
	STEEP SLOPE
	FLOW DIRECTION
RA	RAPIDS
RF	RIFFLE
R1	CLASS 1 RUN
R2	CLASS 2 RUN
R3	CLASS 3 RUN
P1	CLASS 1 POOL
P2	CLASS 2 POOL
P3	CLASS 3 POOL
FL	FLAT
FA	FALLS
	WATER DEPTH
T1	TRANSECT

WCL1 AQUATIC HABITAT MAP

NOT TO SCALE

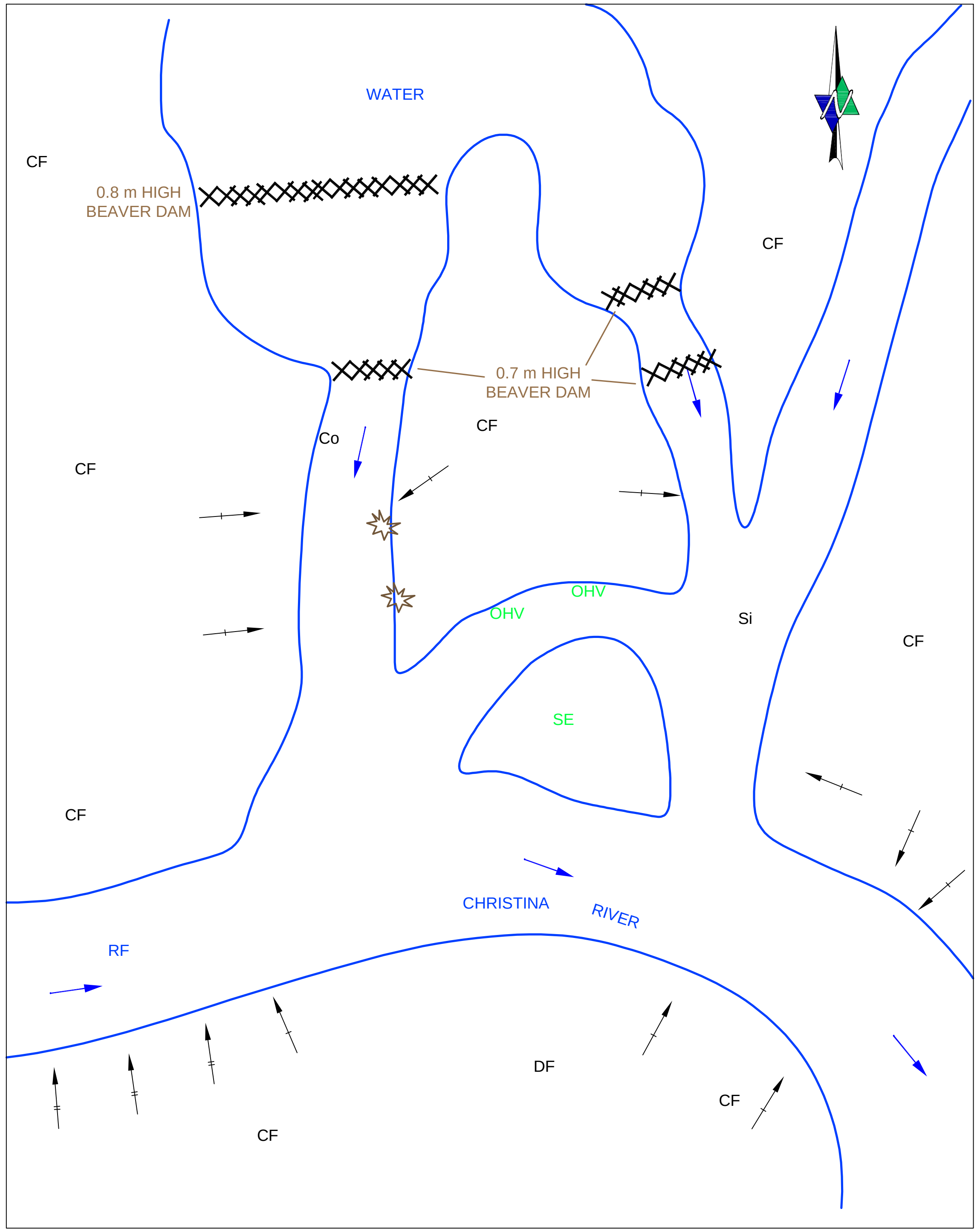


PHOTO 1. Aerial view of WCL1 located on the Christina River.

PHOTO 2. Upstream view of the Christina River from WCL1 showing beaver activity in the area.

WCL1 (Christina River)
WCL1 was located on the Christina River and exhibited an irregular meander pattern. The river was located in a mature coniferous forest, with grasses and willows bordering the watercourse. The habitat types in the study area included both run and riffle areas. Substrate was a mix of fines, gravel, cobble, and boulder, with the majority of the substrate in the form of cobble. The watercourse provided moderate to high spawning, rearing, and feeding habitat potential for both small and large bodied/sport fish with water quality, substrate and cover adequate for many fish species. Overwintering habitat could not be assessed as the site was not visited in the winter season.

PHOTO 3. Downstream view of the Christina River from WCL1.

WCL1 HABITAT POTENTIAL RANKING

Fish Habitat Potential	Large Bodied/Sport Fish	Forage Fish
Overwintering	--	--
Spawning	moderate to high	high
Rearing	moderate to high	high
Feeding	moderate to high	high

Note(s):
'--' = not sampled

WCL1 FISHERIES COLLECTION DATA

Sampling Season	Angling		Minnow Trap		Electrofishing	
	Fish Captured	Effort (h)	Fish Captured	Effort (h)	Fish Captured	Effort (s)
Winter	N/A	N/A	N/A	N/A	N/A	N/A
Spring	0	0.75	1 BRST	3.22	1 SPSH	615
Summer	--	--	--	--	--	--
Fall	--	--	0	4.50	--	--
Total	**0**	**0.75**	**1 BRST**	**7.72**	**1 SPSH**	**615**

Note(s):
N/A = not surveyed; '--' = method not used during this survey
BRST = Brook Stickleback, SPSH = Sportail Shiner

WCL1 SURFACE WATER QUALITY DATA

Sampling Date	Water Depth (m)	Discharge (m^3/s)	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (µS/cm)	pH (units)	Turbidity (NTU)
Feb-06	--	--	--	--	--	--	--
10-May-06	0.52	0.02	10.76	6.77	110	6.86	3.32
20-Aug-06	--	--	14.12	9.70	111	6.24	11.01
30-Sep-05	1.15	10.48	5.52	13.70	151	7.39	17.06

Note(s):
'--' = not sampled

Title:
LEISMER STUDY AREA, WCL1, WATERCOURSE DATA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: GI	Revision Date: JUNE 7, 07
File: 4455-HABITAT-07-WC	

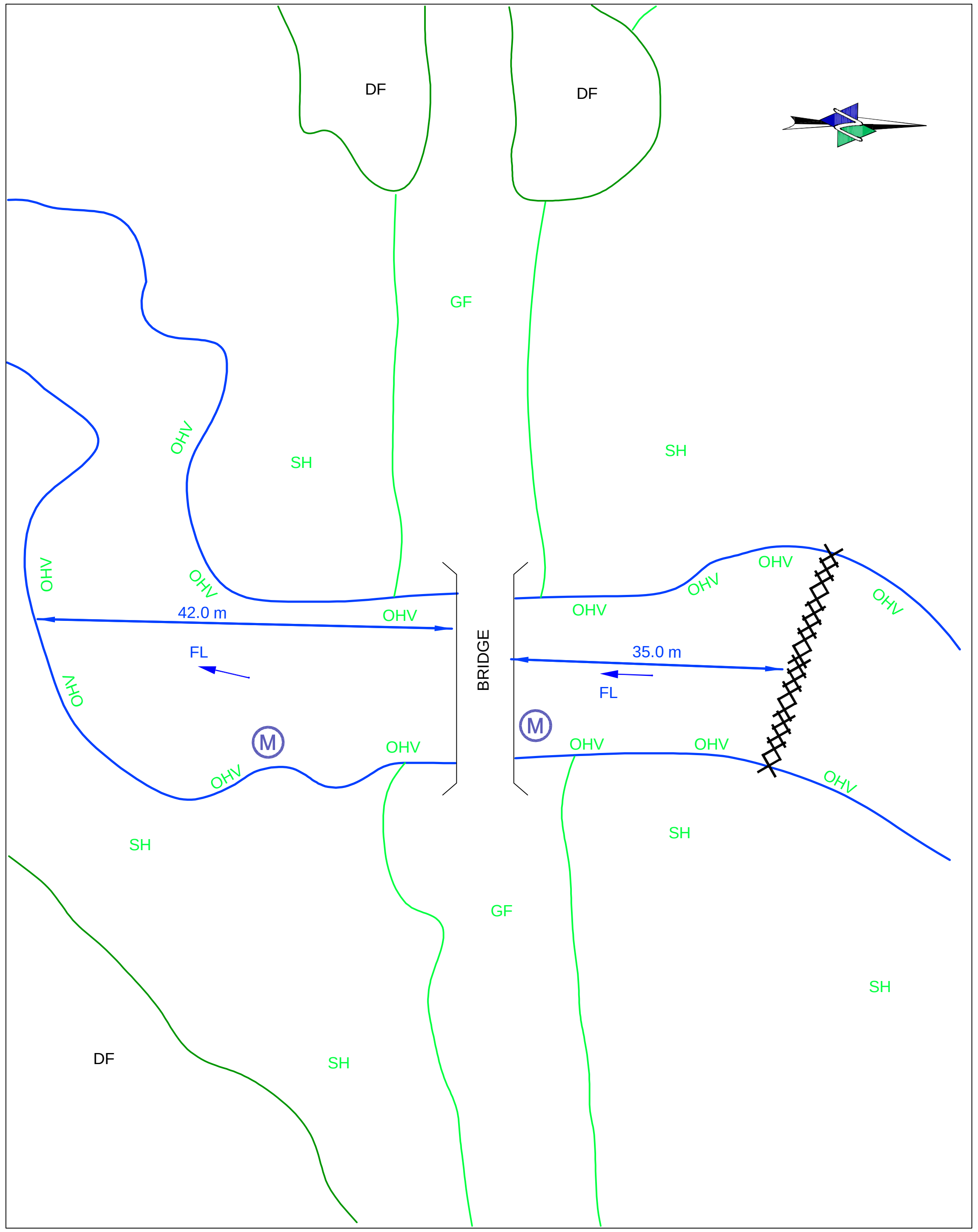
Drawn by: BSW	Checked: TJ	Fig. No.: 8.5-18

LEGEND

- Ba BARE GROUND
- Bd BEDROCK
- Bo BOULDER
- L.Bo LARGE BOULDER
- Co COBBLE
- S.Co SMALL COBBLE
- L.Co LARGE COBBLE
- Gr GRAVEL
- S.Gr SMALL GRAVEL
- L.Gr LARGE GRAVEL
- ESCARPMENT
- Sa SAND
- Si SILT
- Or ORGANIC MATERIAL
- DP DEBRIS PILE
- BL BEAVER LODGE
- BD BEAVER DAM
- EM EMERGENT MACROPHYTES
- SM SUBMERGENT MACROPHYTES
- FM FLOATING MACROPHYTES
- IV INSTREAM VEGETATION
- TV TERRESTIAL VEGETATION
- DEADFALL
- RW ROOTWAD
- SH SHRUB
- MF MIXEDWOOD FOREST
- CF CONIFEROUS FOREST
- DF DECIDUOUS FOREST
- SE SEDGES
- GF GRASS/FORBES
- MO MOSS
- MT MINNOW TRAP
- UCB UNDERCUT BANK
- OHC OVERHEAD COVER
- OHV OVERHANGING VEGETATION
- ISC INSTREAM COVER
- INV INUNDATED VEGETATION
- USB UNSTABLE BANK
- BW BACKWATER
- IP IMPOUNDMENT POND
- SN SNYE
- CH CHUTE
- CA CASCADE
- SHALLOW SLOPE
- MODERATE SLOPE
- MODERATELY STEEP SLOPE
- STEEP SLOPE
- FLOW DIRECTION
- RA RAPIDS
- RF RIFFLE
- R1 CLASS 1 RUN
- R2 CLASS 2 RUN
- R3 CLASS 3 RUN
- P1 CLASS 1 POOL
- P2 CLASS 2 POOL
- P3 CLASS 3 POOL
- FL FLAT
- FA FALLS
- WATER DEPTH
- T1 TRANSECT

WCL2 AQUATIC HABITAT MAP

NOT TO SCALE



WCL2 SURFACE WATER QUALITY DATA

Sampling Date	Water Depth (m)	Discharge (m^3/s)	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (µS/cm)	pH (units)	Turbidity (NTU)
8-Feb-06	1.20	0.00	0.14	11.30	352	6.59	127.50
6-May-06	1.76	1.47	6.54	10.02	50	7.61	7.04
8-Aug-06	--	--	14.50	9.80	140	9.30	11.12
28-Sep-05	1.42	0.23	4.99	11.10	107	6.67	12.07

Note(s):
'--' = not sampled

PHOTO 1. Aerial view of WCL2 located on an unnamed tributary to the Christina River.

PHOTO 2. View downstream from WCL2.

WCL2 (Christina River tributary)
WCL2 was located in the Christina River watershed and exhibited an irregular meander pattern. The watercourse was located in a mature coniferous forest dominated by pine and spruce species. The watercourse was bordered by tall grasses, forbes and shrubs. Within the study reach, the habitat consisted of run areas, with one shallow riffle located upstream of a beaver dam. Substrate was composed entirely of organic fines. The watercourse provided moderate rearing, spawning, feeding, and overwintering habitat potential for forage fish species, and low potential for large bodied/sport fish species.

PHOTO3. View of beaver activity upstream from WCL2.

WCL2 HABITAT POTENTIAL RANKING

Fish Habitat Potential	Large Bodied/Sport Fish	Forage Fish
Overwintering	low	moderate
Spawning	low	moderate
Rearing	low	moderate
Feeding	low	moderate

WCL2 FISHERIES COLLECTION DATA

Sampling Season	Angling		Minnow Trap		Electrofishing	
	Fish Captured	Effort (h)	Fish Captured	Effort (h)	Fish Captured	Effort (s)
Winter	--	--	1 BRST	0.88	--	--
Spring	--	--	1 BRST	4.20	12 BRST 6 PRDC	314
Summer	--	--	2 BRST	2.58	--	--
Fall	--	--	3 BRST	4.00	--	--
Total	--	--	**7 BRST**	**11.66**	**12 BRST 6 PRDC**	**314**

Note(s):
'--' = method not used during this survey
BRST = Brook Stickleback, PRDC = Pearl Dace

Title:

LEISMER STUDY AREA, WCL2, WATERCOURSE DATA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: GI	Revision Date: JUNE 7, 07
File: 4455-HABITAT-07-WC	

Drawn by: BSW	Checked: TJ	Fig. No.: 8.5-19

*PLOT 1:1=11x17 (L)

F:\4455 NAOSC\Drafting\2007\4455-HABITAT-07-WC.dwg - WCL2 - Jun. 15, 2007 11:06am - bwheeler

LEGEND

- Ba BARE GROUND
- Bd BEDROCK
- Bo BOULDER
- L.Bo LARGE BOULDER
- Co COBBLE
- S.Co SMALL COBBLE
- L.Co LARGE COBBLE
- Gr GRAVEL
- S.Gr SMALL GRAVEL
- L.Gr LARGE GRAVEL
- ESCARPMENT
- Sa SAND
- Si SILT
- Or ORGANIC MATERIAL
- DP DEBRIS PILE
- BL BEAVER LODGE
- BD BEAVER DAM
- EM EMERGENT MACROPHYTES
- SM SUBMERGENT MACROPHYTES
- FM FLOATING MACROPHYTES
- IV INSTREAM VEGETATION
- TV TERRESTIAL VEGETATION
- DEADFALL
- RW ROOTWAD
- SH SHRUB
- MF MIXEDWOOD FOREST
- CF CONIFEROUS FOREST
- DF DECIDUOUS FOREST
- SE SEDGES
- GF GRASS/FORBES
- MO MOSS
- MT MINNOW TRAP
- UCB UNDERCUT BANK
- OHC OVERHEAD COVER
- OHV OVERHANGING VEGETATION
- ISC INSTREAM COVER
- INV INUNDATED VEGETATION
- USB UNSTABLE BANK
- BW BACKWATER
- IP IMPOUNDMENT POND
- SN SNYE
- CH CHUTE
- CA CASCADE
- SHALLOW SLOPE
- MODERATE SLOPE
- MODERATELY STEEP SLOPE
- STEEP SLOPE
- FLOW DIRECTION
- RA RAPIDS
- RF RIFFLE
- R1 CLASS 1 RUN
- R2 CLASS 2 RUN
- R3 CLASS 3 RUN
- P1 CLASS 1 POOL
- P2 CLASS 2 POOL
- P3 CLASS 3 POOL
- FL FLAT
- FA FALLS
- WATER DEPTH
- T1 TRANSECT

WCL3 AQUATIC HABITAT MAP

NOT TO SCALE

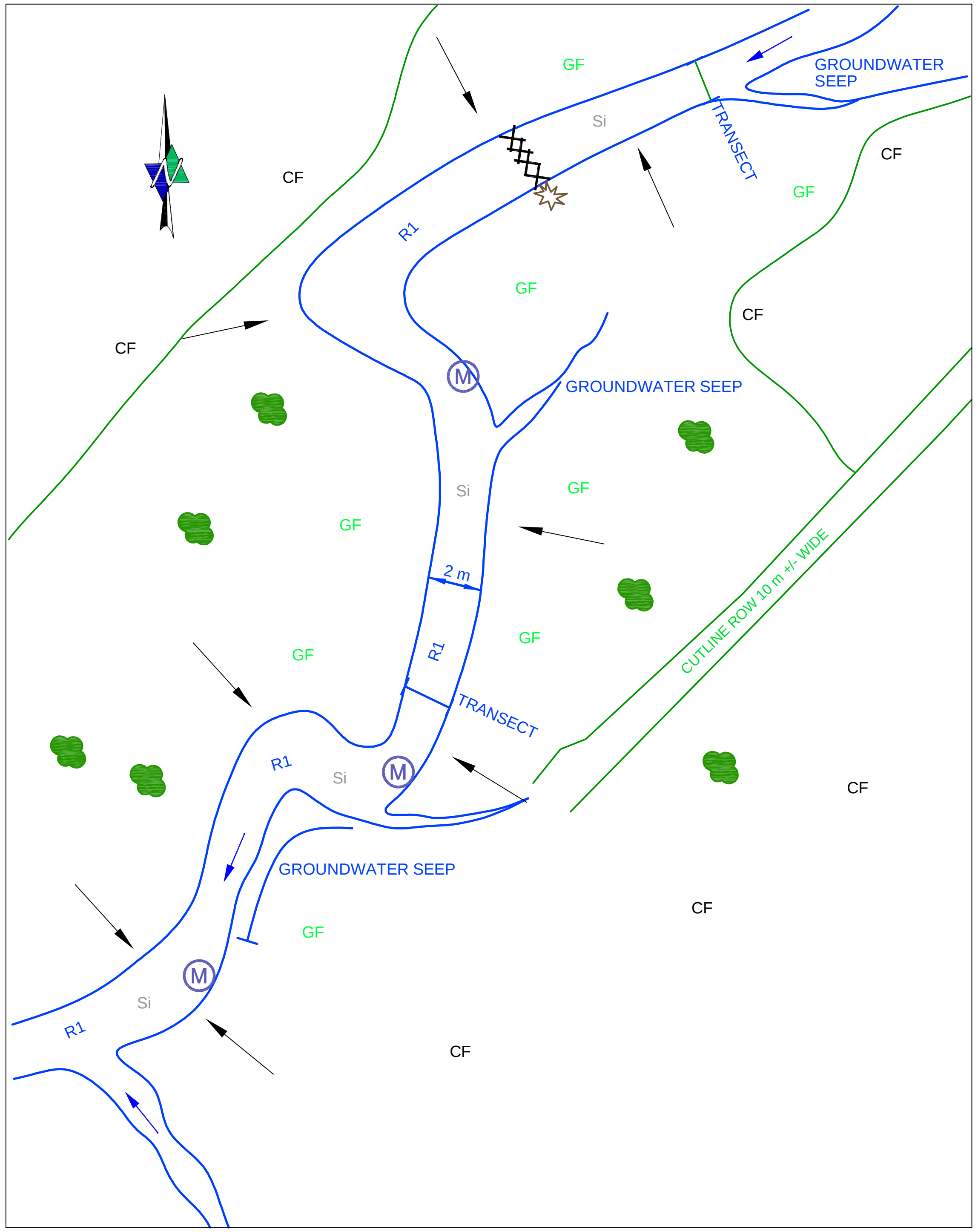


PHOTO 1. Aerial view of WCL3 located on an unnamed tributary to the Christina River.

PHOTO 2. View downstream from WCL3.

WCL3 (House River tributary)

WCL3 was located in the Christina River watershed and exhibited an irregular meander pattern. The watercourse was located in a coniferous forest ecosystem, with tall grasses and forbes growing along the watercourse border. The stretch of watercourse studied was composed of class 1 run (R1) habitat, and the substrate was composed largely of fines, with some small cobble and gravel. The watercourse provided moderate spawning, rearing, and feeding habitat potential for forage fish species, and low habitat potential for large bodied/sport fish species. The presence or absence of overwintering habitat could not be determined because this study site was not visited in the winter season.

WCL3 HABITAT POTENTIAL RANKING

Fish Habitat Potential	Large Bodied/Sport Fish	Forage Fish
Overwintering	--	--
Spawning	low	moderate
Rearing	low	moderate
Feeding	low	moderate

Note(s):
'--' = not sampled

PHOTO 3. View upstream of WCL3 showing signs of recent beaver activity.

WCL3 FISHERIES COLLECTION DATA

Sampling Season	Angling		Minnow Trap		Electrofishing	
	Fish Captured	Effort (h)	Fish Captured	Effort (h)	Fish Captured	Effort (s)
Winter	N/A	N/A	N/A	N/A	N/A	N/A
Spring	--	--	2 BRST	5.95	25 BRST	623
Summer	--	--	--	--	--	--
Fall	--	--	--	--	--	--
Total	--	--	**2 BRST**	**5.95**	**25 BRST**	**623**

Note(s):
N/A = not surveyed; '--' = method not used during this survey
BRST = Brook Stickleback

WCL3 SURFACE WATER QUALITY DATA

Sampling Date	Water Depth (m)	Discharge (m^3/s)	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (µS/cm)	pH (units)	Turbidity (NTU)
Feb-06	--	--	--	--	--	--	--
10-May-06	0.32	0.12	8.40	9.40	65	6.70	5.21
20-Aug-06	--	--	15.19	6.39	122	6.43	13.47

Note(s):
'--' = not sampled

Title:

LEISMER STUDY AREA, WCL3, WATERCOURSE DATA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: GI	Revision Date: JUNE 7, 07	
File: 4455-HABITAT-07-WC		
Drawn by: BSW	Checked: TJ	Fig. No.: 8.5-20

LEGEND

Ba BARE GROUND
Bd BEDROCK
Bo BOULDER
L.Bo LARGE BOULDER
Co COBBLE
S.Co SMALL COBBLE
L.Co LARGE COBBLE
Gr GRAVEL
S.Gr SMALL GRAVEL
L.Gr LARGE GRAVEL

ESCARPMENT
Sa SAND
Si SILT
Or ORGANIC MATERIAL
DP DEBRIS PILE
BL BEAVER LODGE
BD BEAVER DAM
EM EMERGENT MACROPHYTES
SM SUBMERGENT MACROPHYTES
FM FLOATING MACROPHYTES
IV INSTREAM VEGETATION
TV TERRESTIAL VEGETATION
DEADFALL
RW ROOTWAD
SH SHRUB

MF MIXEDWOOD FOREST
CF CONIFEROUS FOREST
DF DECIDUOUS FOREST
SE SEDGES
GF GRASS/FORBES
MO MOSS

MT MINNOW TRAP

UCB UNDERCUT BANK
OHC OVERHEAD COVER
OHV OVERHANGING VEGETATION
ISC INSTREAM COVER
INV INUNDATED VEGETATION

USB UNSTABLE BANK

BW BACKWATER
IP IMPOUNDMENT POND
SN SNYE
CH CHUTE
CA CASCADE

SHALLOW SLOPE
MODERATE SLOPE
MODERATELY STEEP SLOPE
STEEP SLOPE
FLOW DIRECTION

RA RAPIDS
RF RIFFLE
R1 CLASS 1 RUN
R2 CLASS 2 RUN
R3 CLASS 3 RUN
P1 CLASS 1 POOL
P2 CLASS 2 POOL
P3 CLASS 3 POOL
FL FLAT
FA FALLS

WATER DEPTH

T1 TRANSECT

WCL4 AQUATIC HABITAT MAP

NOT TO SCALE

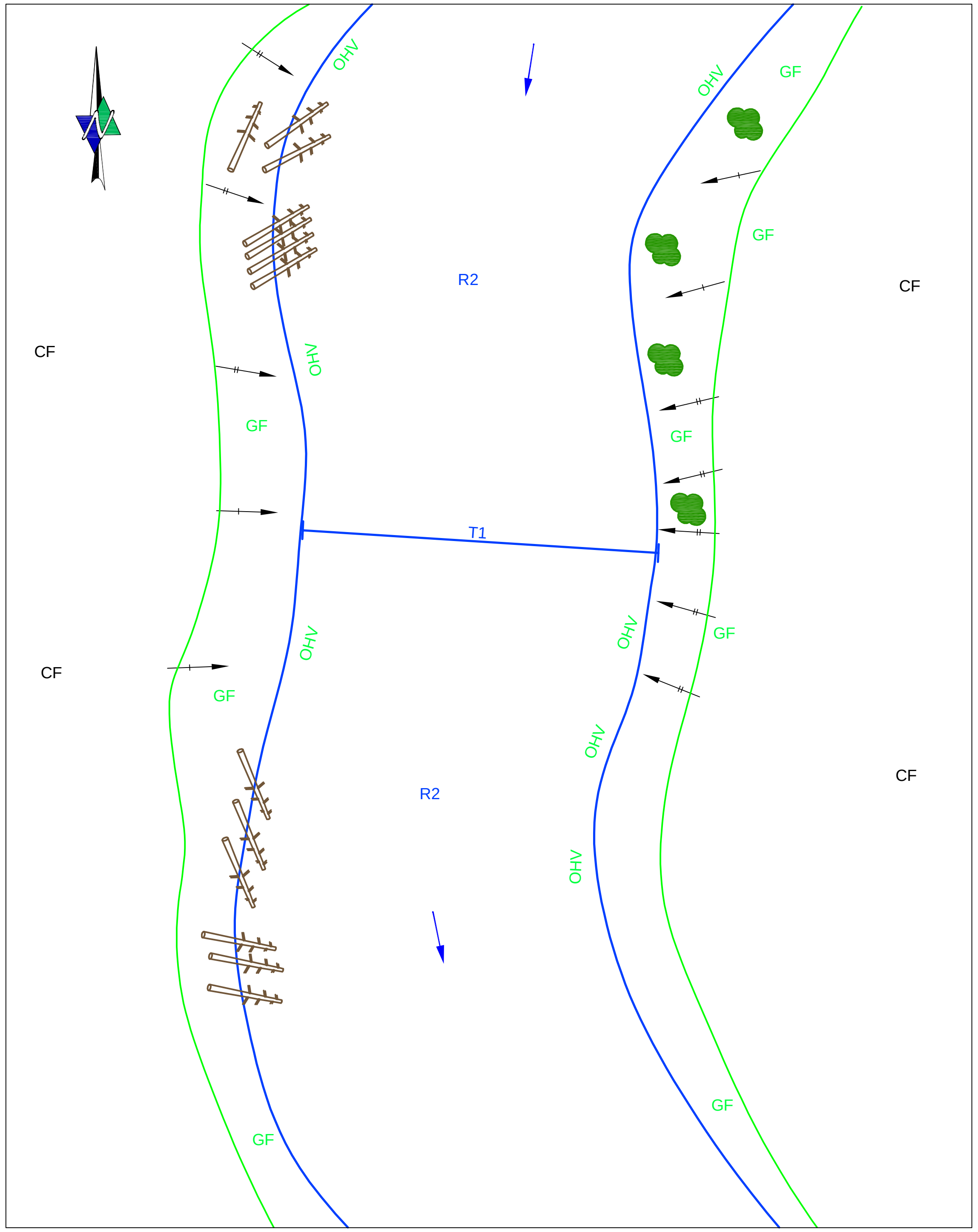


PHOTO 1. Aerial view of the Christina River at WCL4.

PHOTO 2. Upstream view of the Christina River from WCL4.

WCL4 (Christina River)

WCL4 was located on the Christina River, on an oxbow of the river. The watercourse ran through a mature coniferous forest dominated by white pine and trembling aspen and was bordered by grasses and shrubs. The habitat present was class 2 run (R2) and substrate consisted of fines, cobble and gravel. The watercourse at WCL4 provided moderate rearing, spawning, and feeding habitat potential for forage fish species and low to moderate habitat potential for large bodied/sport fish species. Overwintering potential was moderate for forage fish species, but low for large bodied/sport fish species due to shallow water depth below the ice.

PHOTO 3. Downstream view of the Christina River from WCL4.

WCL4 HABITAT POTENTIAL RANKING

Fish Habitat Potential	Large Bodied/Sport Fish	Forage Fish
Overwintering	low	moderate
Spawning	low to moderate	moderate
Rearing	low to moderate	moderate
Feeding	low to moderate	moderate

WCL4 FISHERIES COLLECTION DATA

Sampling Season	Angling		Minnow Trap		Electrofishing	
	Fish Captured	Effort (h)	Fish Captured	Effort (h)	Fish Captured	Effort (s)
Winter	--	--	0	1.08	--	--
Spring	--	--	0	3.83	--	--
Summer	--	--	18 LNSC 11 LKCH	3.03	--	--
Fall	--	--	0	5.02	--	--
Total	--	--	**18 LNSC** **11 LKCH**	**12.96**		--

Note(s):
'--' = method not used during this survey
LNSC = Longnose Sucker, LKCH = Lake Chub

WCL4 SURFACE WATER QUALITY DATA

Sampling Date	Water Depth (m)	Discharge (m^3/s)	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (µS/cm)	pH (units)	Turbidity (NTU)
9-Feb-06	0.30	0.02	0.06	12.77	443	6.70	21.15
6-May-06	1.03	8.96	7.55	11.65	60	7.28	9.73
5-Aug-05	1.20	5.58	15.90	11.50	117	9.21	12.80
20-Aug-06	--	--	15.01	10.02	110	6.79	7.53
29-Sep-05	0.56	4.36	5.46	12.60	160	7.62	15.04

Note(s):
'--' = not sampled

Title:

LEISMER STUDY AREA, WCL4, WATERCOURSE DATA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: GI	Revision Date: JUNE 7, 07

File: 4455-HABITAT-07-WC

Drawn by: BSW	Checked: TJ	Fig. No.: 8.5-21

LEGEND

Ba	BARE GROUND	
Bd	BEDROCK	
Bo	BOULDER	
L.Bo	LARGE BOULDER	
Co	COBBLE	
S.Co	SMALL COBBLE	
L.Co	LARGE COBBLE	
Gr	GRAVEL	
S.Gr	SMALL GRAVEL	
L.Gr	LARGE GRAVEL	
	ESCARPMENT	
Sa	SAND	
Si	SILT	
Or	ORGANIC MATERIAL	
DP	DEBRIS PILE	
BL	BEAVER LODGE	
BD	BEAVER DAM	
EM	EMERGENT MACROPHYTES	
SM	SUBMERGENT MACROPHYTES	
FM	FLOATING MACROPHYTES	
IV	INSTREAM VEGETATION	
TV	TERRESTIAL VEGETATION	
	DEADFALL	
RW	ROOTWAD	
SH	SHRUB	
MF	MIXEDWOOD FOREST	
CF	CONIFEROUS FOREST	
DF	DECIDUOUS FOREST	
SE	SEDGES	
GF	GRASS/FORBES	
MO	MOSS	
MT	MINNOW TRAP	
UCB	UNDERCUT BANK	
OHC	OVERHEAD COVER	
OHV	OVERHANGING VEGETATION	
ISC	INSTREAM COVER	
INV	INUNDATED VEGETATION	
USB	UNSTABLE BANK	
BW	BACKWATER	
IP	IMPOUNDMENT POND	
SN	SNYE	
CH	CHUTE	
CA	CASCADE	
	SHALLOW SLOPE	
	MODERATE SLOPE	
	MODERATELY STEEP SLOPE	
	STEEP SLOPE	
	FLOW DIRECTION	
RA	RAPIDS	
RF	RIFFLE	
R1	CLASS 1 RUN	
R2	CLASS 2 RUN	
R3	CLASS 3 RUN	
P1	CLASS 1 POOL	
P2	CLASS 2 POOL	
P3	CLASS 3 POOL	
FL	FLAT	
FA	FALLS	
	WATER DEPTH	
T1	TRANSECT	

WCL5 AQUATIC HABITAT MAP

NOT TO SCALE

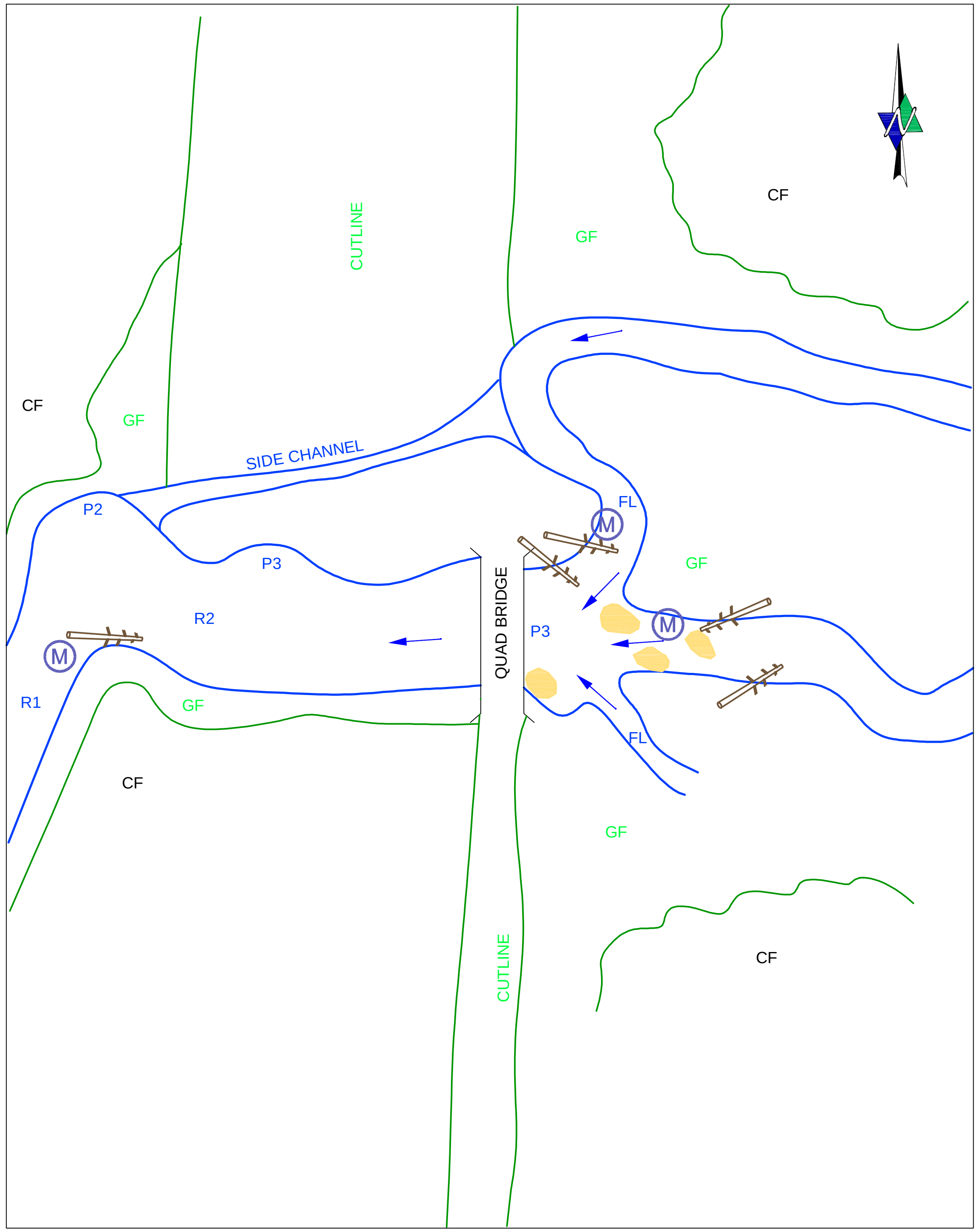


PHOTO 1. Aerial view of WCL5 located on Waddell Creek.

PHOTO 2. View downstream of WCL5 on Waddell Creek.

WCL5 (Waddell Creek)
WCL5 was located in the Christina River watershed on Waddell Creek, which followed an irregular meander pattern. The creek ran through a mature coniferous forest and the borders of the creek were vegetated with willows and grasses which provided some overhanging vegetation in the downstream reaches of the study area. Upstream of the WCL5 site a beaver dam complex caused channel braiding and a created pool habitat. When the channel braids met the habitat was a class 2 run (R2), and farther downstream was class 1 run (R1) habitat. The substrate was composed predominantly of fines with some gravel. The watercourse provided moderate spawning, rearing and feeding habitat potential for forage fish species, low spawning, and moderate rearing and feeding habitat potential for large bodied/sport fish species. Overwintering habitat was low for both forage and large bodied/sport fish species due to shallow water depth below the ice.

PHOTO 3. Typical riparian vegetation along the Waddell Creek at WCL5.

WCL5 HABITAT POTENTIAL RANKING

Fish Habitat Potential	Large Bodied/Sport Fish	Forage Fish
Overwintering	low	low
Spawning	low	moderate
Rearing	moderate	moderate
Feeding	moderate	moderate

WCL5 FISHERIES COLLECTION DATA

Sampling Season	Angling		Minnow Trap		Electrofishing	
	Fish Captured	Effort (h)	Fish Captured	Effort (h)	Fish Captured	Effort (s)
Winter	--	--	0	1.17	--	--
Spring	--	--	--	--	--	--
Summer	--	--	5 BRST	3.32	--	--
Fall	--	--	0	2.77	--	--
Total	**--**	**--**	**5 BRST**	**7.26**	**--**	**--**

Note(s):
'--' = method not used during this survey
BRST = Brook Stickleback

WCL5 SURFACE WATER QUALITY DATA

Sampling Date	Water Depth (m)	Discharge (m^3/s)	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (µS/cm)	pH (units)	Turbidity (NTU)
8-Feb-06	0.12	0.02	0.08	10.68	348	6.50	47.53
6-May-06	0.49	0.68	7.48	11.73	110	7.80	2.80
6-Aug-05	0.59	0.38	15.38	8.89	169	7.26	1.54
28-Sep-05	0.39	0.10	5.47	12.60	177	7.14	3.64

Title:
LEISMER STUDY AREA, WCL5, WATERCOURSE DATA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: GI	Revision Date: JUNE 7, 07	
File: 4455-HABITAT-07-WC		
Drawn by: BSW	Checked: TJ	Fig. No.: 8.5-22

*PLOT 1:1=11X17 (L)
F:\4455 NAOSC\Drafting\2007\4455-HABITAT-07-Wc.dwg - WCL5 - Jun. 15, 2007 11:08am - bwheeler

LEGEND

Ba BARE GROUND
Bd BEDROCK
Bo BOULDER
L.Bo LARGE BOULDER
Co COBBLE
S.Co SMALL COBBLE
L.Co LARGE COBBLE
Gr GRAVEL
S.Gr SMALL GRAVEL
L.Gr LARGE GRAVEL

ESCARPMENT

Sa SAND
Si SILT
Or ORGANIC MATERIAL
DP DEBRIS PILE
BL BEAVER LODGE
BD BEAVER DAM
EM EMERGENT MACROPHYTES
SM SUBMERGENT MACROPHYTES
FM FLOATING MACROPHYTES
IV INSTREAM VEGETATION
TV TERRESTIAL VEGETATION

DEADFALL

RW ROOTWAD
SH SHRUB

MF MIXEDWOOD FOREST
CF CONIFEROUS FOREST
DF DECIDUOUS FOREST
SE SEDGES
GF GRASS/FORBES
MO MOSS

MT MINNOW TRAP

UCB UNDERCUT BANK
OHC OVERHEAD COVER
OHV OVERHANGING VEGETATION
ISC INSTREAM COVER
INV INUNDATED VEGETATION

USB UNSTABLE BANK

BW BACKWATER
IP IMPOUNDMENT POND
SN SNYE
CH CHUTE
CA CASCADE

SHALLOW SLOPE
MODERATE SLOPE
MODERATELY STEEP SLOPE
STEEP SLOPE
FLOW DIRECTION

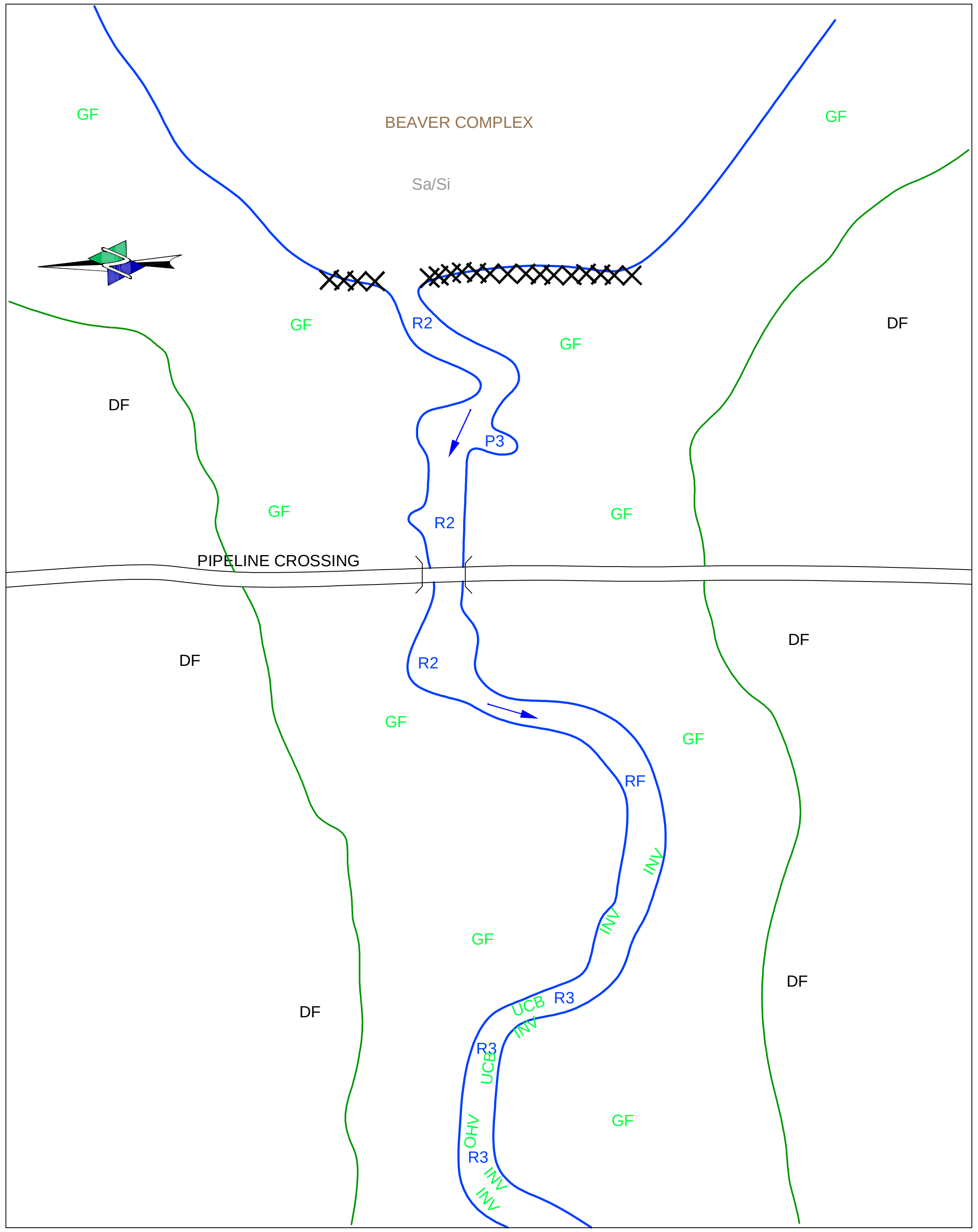
RA RAPIDS
RF RIFFLE
R1 CLASS 1 RUN
R2 CLASS 2 RUN
R3 CLASS 3 RUN
P1 CLASS 1 POOL
P2 CLASS 2 POOL
P3 CLASS 3 POOL
FL FLAT
FA FALLS

WATER DEPTH

T1 TRANSECT

WCL6 AQUATIC HABITAT MAP

NOT TO SCALE



WCL6 SURFACE WATER QUALITY DATA

Sampling Date	Water Depth (m)	Discharge (m^3/s)	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (µS/cm)	pH (units)	Turbidity (NTU)
8-Feb-06	0.31	0.00	0.70	0.83	742	6.53	56.61
6-May-06	0.50	0.47	6.55	14.00	131	7.59	1.92
6-Aug-05	1.10	0.53	14.10	8.67	224	9.22	2.54
20-Aug-06	--	--	15.00	8.33	281	7.19	2.08
28-Sep-05	--	--	3.73	10.42	227	7.89	2.46

Note(s):
'--' = not sampled

PHOTO 1. Aerial view of an unnamed tributary to the Christina River at WCL6.

PHOTO 2. View upstream of WCL6.

WCL6 (Christina River tributary)
WCL6 was located in the Christina River watershed and exhibited an irregular meander pattern. The watercourse was located in a coniferous forest and was bordered with grasses and willows. A large beaver complex in the upstream reaches of the study area led to the creation of pools. As the water exited the beaver complex, the habit alternated between riffle and class 1, 2 and 3 run (R1, R2, R3) areas. The substrate was composed of sand and silt fines. The watercourse provided moderate spawning, rearing, and feeding habitat potential for forage fish species and low spawning, and moderate rearing and feeding habitat potential for large bodied/sport fish species. Overwintering habitat potential was nil to low for large bodied/sport fish species, and low for forage fish species due to low dissolved oxygen concentrations and shallow water depth below ice.

PHOTO 3. Downstream view of the unnamed tributary at WCL6.

WCL6 HABITAT POTENTIAL RANKING

Fish Habitat Potential	Large Bodied/Sport Fish	Forage Fish
Overwintering	nil* to low	low
Spawning	low	moderate
Rearing	moderate	moderate
Feeding	moderate	moderate

nil* = no habitat observed

WCL6 FISHERIES COLLECTION DATA

Sampling Season	Angling		Minnow Trap		Electrofishing	
	Fish Captured	Effort (h)	Fish Captured	Effort (h)	Fish Captured	Effort (s)
Winter	--	--	--	--	--	--
Spring	--	--	0	6.00	--	--
Summer	--	--	0	2.82	--	--
Fall	--	--	2 BRST	4.30	--	--
Total	--	--	**2 BRST**	**13.12**	--	--

Note(s):
'--' = method not used during this survey
BRST = Brook Stickleback

Title:

LEISMER STUDY AREA, WCL6, WATERCOURSE DATA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: GI	Revision Date: JUNE 7, 07	
File: 4455-HABITAT-07-WC		
Drawn by: BSW	Checked: TJ	Fig. No.: 8.5-23

LEGEND

Ba	BARE GROUND
Bd	BEDROCK
Bo	BOULDER
L.Bo	LARGE BOULDER
Co	COBBLE
S.Co	SMALL COBBLE
L.Co	LARGE COBBLE
Gr	GRAVEL
S.Gr	SMALL GRAVEL
L.Gr	LARGE GRAVEL
	ESCARPMENT
Sa	SAND
Si	SILT
Or	ORGANIC MATERIAL
DP	DEBRIS PILE
BL	BEAVER LODGE
BD	BEAVER DAM
EM	EMERGENT MACROPHYTES
SM	SUBMERGENT MACROPHYTES
FM	FLOATING MACROPHYTES
IV	INSTREAM VEGETATION
TV	TERRESTIAL VEGETATION
	DEADFALL
RW	ROOTWAD
SH	SHRUB
MF	MIXEDWOOD FOREST
CF	CONIFEROUS FOREST
DF	DECIDUOUS FOREST
SE	SEDGES
GF	GRASS/FORBES
MO	MOSS
MT	MINNOW TRAP
UCB	UNDERCUT BANK
OHC	OVERHEAD COVER
OHV	OVERHANGING VEGETATION
ISC	INSTREAM COVER
INV	INUNDATED VEGETATION
USB	UNSTABLE BANK
BW	BACKWATER
IP	IMPOUNDMENT POND
SN	SNYE
CH	CHUTE
CA	CASCADE
	SHALLOW SLOPE
	MODERATE SLOPE
	MODERATELY STEEP SLOPE
	STEEP SLOPE
	FLOW DIRECTION
RA	RAPIDS
RF	RIFFLE
R1	CLASS 1 RUN
R2	CLASS 2 RUN
R3	CLASS 3 RUN
P1	CLASS 1 POOL
P2	CLASS 2 POOL
P3	CLASS 3 POOL
FL	FLAT
FA	FALLS
	WATER DEPTH
T1	TRANSECT

WCL7 AQUATIC HABITAT MAP

NOT TO SCALE

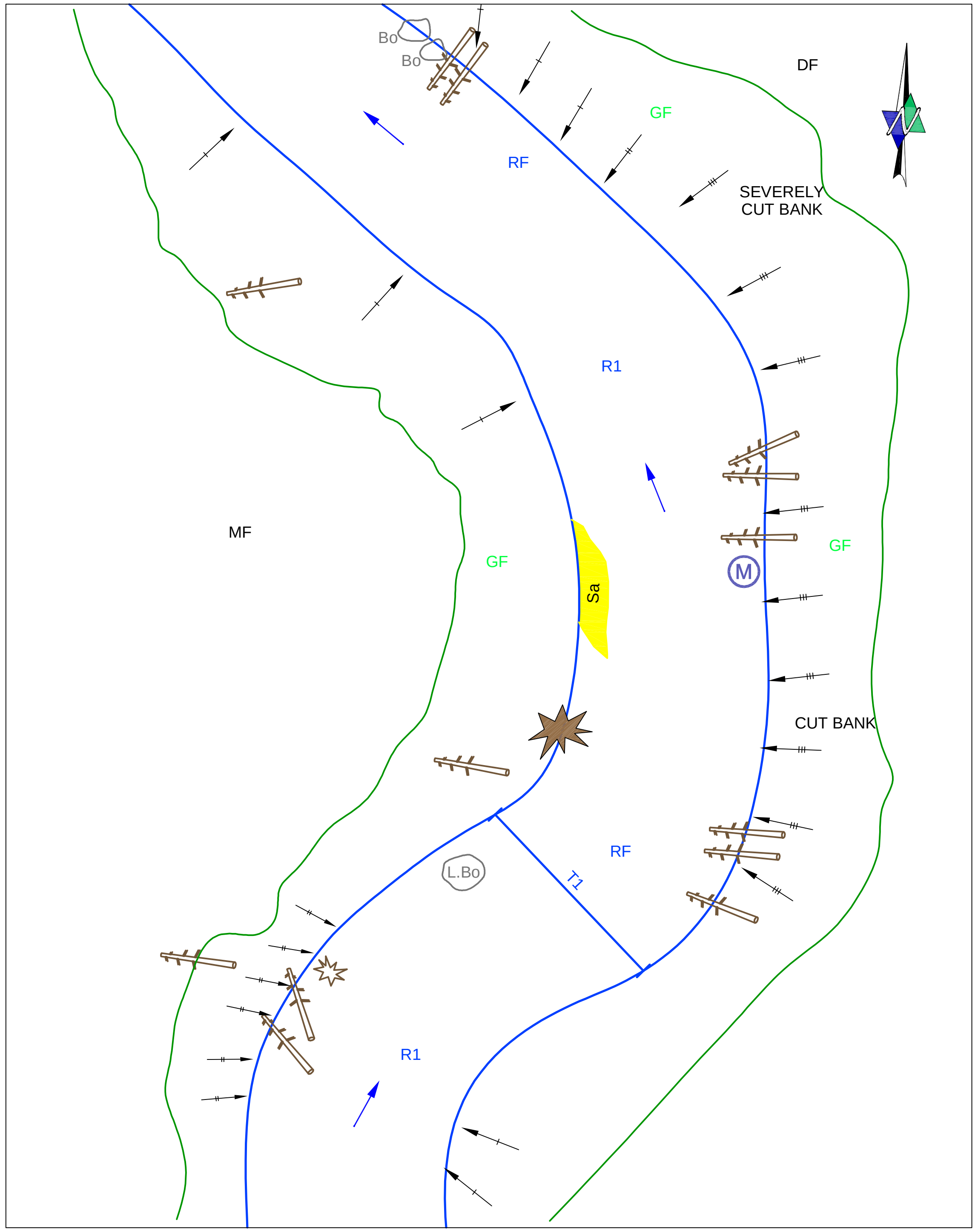


PHOTO 1. Aerial view of the Christina River at WCL7.

PHOTO 2. View looking downstream on the Christina River from WCL7.

WCL7 (Christina River)

WCL7 was located on the Christina River along a stretch that exhibited a gentle meander pattern. The river flowed through a mature mixed forest and the watercourse was bordered by spruce, pine and trembling aspen. The left downstream bank was steeply cut, while the right downstream bank had a more gradual slope. The vegetation along both banks provided little overhanging vegetation. The habitat present alternated from R1 to riffle areas. The substrate was largely composed of fines and cobble with lesser amounts of gravel and small boulders. The watercourse provided high spawning, rearing and feeding habitat potential for forage fish species and moderate habitat potential for large bodied/sport fish species. Overwintering habitat potential could not be determined because the WCL7 site was not visited during the winter season.

PHOTO 3. Upstream view on the Christina River from WCL7.

WCL7 FISHERIES COLLECTION DATA

Sampling Season	Angling		Minnow Trap		Electrofishing	
	Fish Captured	Effort (h)	Fish Captured	Effort (h)	Fish Captured	Effort (s)
Winter	N/A	N/A	N/A	N/A	N/A	N/A
Spring	0	0.5	0	6.12	–	--
Summer	--	–	1 PRDC	2.65	–	--
Fall	--	–	--	--	23 ARGR 3 LNSC 2 WHSC 2 SPSH	1954
Total	**0**	**0.5**	**1 PRDC**	**8.77**	**23 ARGR 3 LNSC 2 WHSC 2 SPSH**	**1954**

Note(s):
N/A = not surveyed; '–' = method not used during this survey
LNSC = Longnose Sucker, WHSC = White Sucker, SPSH = Spottail Shiner, ARGR = Arctic Grayling

WCL7 SURFACE WATER QUALITY DATA

Sampling Date	Water Depth (m)	Discharge (m^3/s)	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (µS/cm)	pH (units)	Turbidity (NTU)
Feb-06	--	--	--	--	--	--	--
7-May-06	0.82	11.18	8.21	11.80	73	8.40	19.76
5-Aug-05	--	--	15.92	10.33	75	6.57	--
29-Sep-05	0.59	6.37	6.10	15.30	231	9.60	16.80

Note(s):
'--' = not sampled

WCL7 HABITAT POTENTIAL RANKING

Fish Habitat Potential	Large Bodied/Sport Fish	Forage Fish
Overwintering	--	--
Spawning	moderate	high
Rearing	moderate	high
Feeding	moderate	high

Note(s):
'--' = not sampled

Title:

LEISMER STUDY AREA, WCL7, WATERCOURSE DATA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: GI	Revision Date: JUNE 7, 07	
File: 4455-HABITAT-07-WC		
Drawn by: BSW	Checked: TJ	Fig. No.: 8.5-24

LEGEND

Ba BARE GROUND
Bd BEDROCK
Bo BOULDER
L.Bo LARGE BOULDER
Co COBBLE
S.Co SMALL COBBLE
L.Co LARGE COBBLE
Gr GRAVEL
S.Gr SMALL GRAVEL
L.Gr LARGE GRAVEL

ESCARPMENT

Sa SAND
Si SILT
Or ORGANIC MATERIAL
DP DEBRIS PILE
BL BEAVER LODGE
BD BEAVER DAM
EM EMERGENT MACROPHYTES
SM SUBMERGENT MACROPHYTES
FM FLOATING MACROPHYTES
IV INSTREAM VEGETATION
TV TERRESTIAL VEGETATION
DEADFALL
RW ROOTWAD
SH SHRUB

MF MIXEDWOOD FOREST
CF CONIFEROUS FOREST
DF DECIDUOUS FOREST
SE SEDGES
GF GRASS/FORBES
MO MOSS

MT MINNOW TRAP

UCB UNDERCUT BANK
OHC OVERHEAD COVER
OHV OVERHANGING VEGETATION
ISC INSTREAM COVER
INV INUNDATED VEGETATION

USB UNSTABLE BANK

BW BACKWATER
IP IMPOUNDMENT POND
SN SNYE
CH CHUTE
CA CASCADE

SHALLOW SLOPE
MODERATE SLOPE
MODERATELY STEEP SLOPE
STEEP SLOPE
FLOW DIRECTION

RA RAPIDS
RF RIFFLE
R1 CLASS 1 RUN
R2 CLASS 2 RUN
R3 CLASS 3 RUN
P1 CLASS 1 POOL
P2 CLASS 2 POOL
P3 CLASS 3 POOL
FL FLAT
FA FALLS

WATER DEPTH
T1 TRANSECT

WCL8 AQUATIC HABITAT MAP

NOT TO SCALE

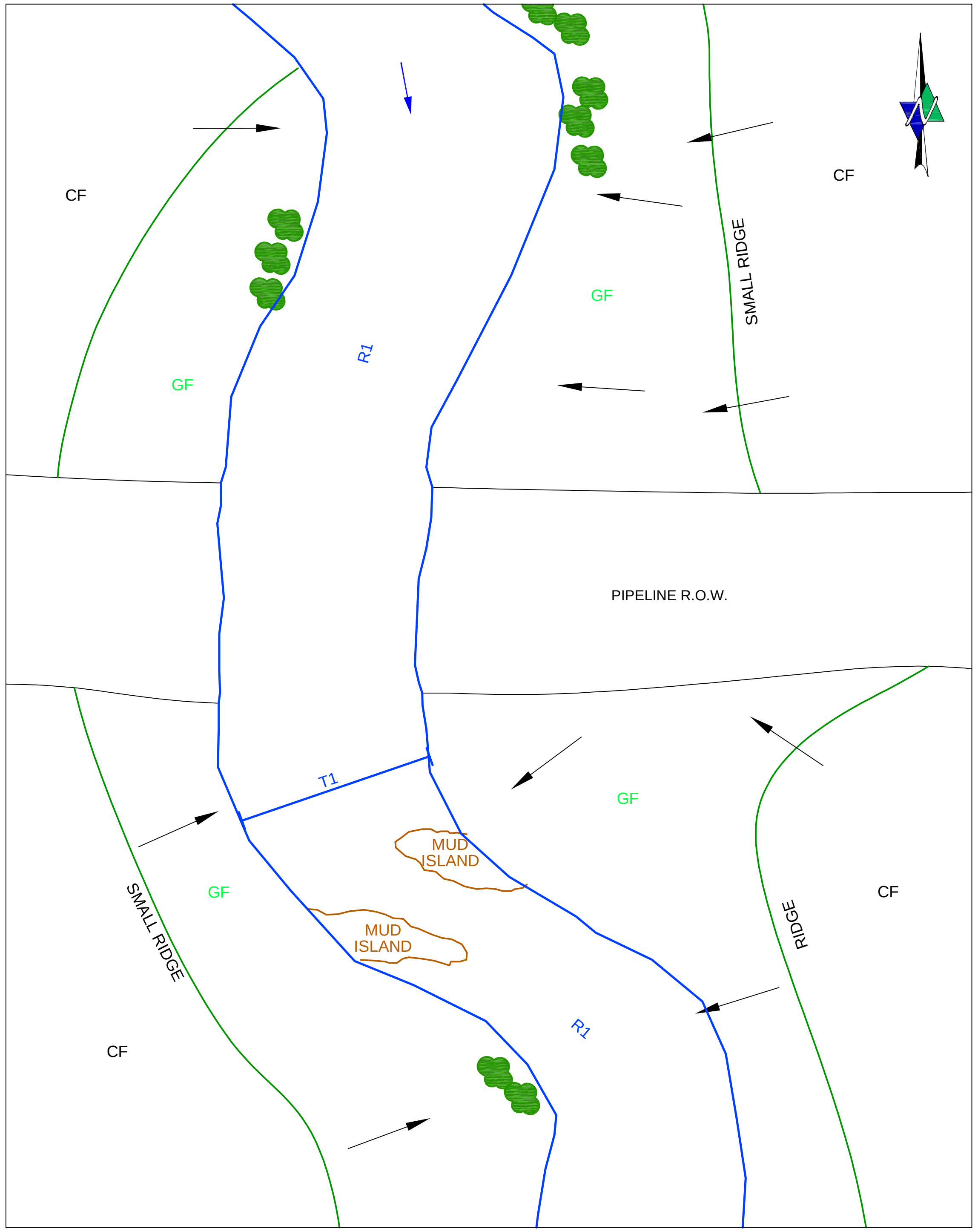


PHOTO 1. Aerial view of an unnamed tributary to the Christina River at WCL8.

PHOTO 2. Downstream view of the tributary from WCL8.

WCL8 (Christina River tributary)
WCL8 was located in the Christina River watershed and the watercourse exhibited an irregular meander pattern. The watercourse was located in a coniferous forest stand dominated by pine and black spruce. The vegetation bordering the watercourse was dominated by willows, grasses and shrubs providing a small amount of overhanging vegetation cover. The habitat along the study reach was a class 1 run (R1) with a small riffle near the downstream edge of the study area. The substrate was composed entirely of organic fines. The watercourse provided moderate spawning, rearing and feeding habitat potential for forage fish species and low habitat potential for large bodied/sport fish species. Overwintering habitat potential could not be determined as WCL8 was not visited in the winter season.

PHOTO 3. Upstream view of the tributary from WCL8.

WCL8 HABITAT POTENTIAL RANKING

Fish Habitat Potential	Large Bodied/Sport Fish	Forage Fish
Overwintering	--	--
Spawning	low	moderate
Rearing	low	moderate
Feeding	low	moderate

Note(s):
'--' = not sampled

WCL8 FISHERIES COLLECTION DATA

Sampling Season	Angling		Minnow Trap		Electrofishing	
	Fish Captured	Effort (h)	Fish Captured	Effort (h)	Fish Captured	Effort (s)
Winter	N/A	N/A	N/A	N/A	N/A	N/A
Spring	--	--	0	4.50	--	--
Summer	--	--	1 BRST	3.00	--	--
Fall	--	--	1 FTMN	1.88	--	--
Total	--	--	**1 BRST 1 FTMN**	**9.38**	--	--

Note(s):
N/A = not surveyed; '--' = method not used during this survey
BRST = Brook Stickleback, FTMN = Fathead Minnow

WCL8 SURFACE WATER QUALITY DATA

Sampling Date	Water Depth (m)	Discharge (m^3/s)	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (µS/cm)	pH (units)	Turbidity (NTU)
Feb-06	--	--	--	--	--	--	--
6-May-06	1.07	0.56	8.47	9.97	96	6.23	4.06
5-Aug-05	1.04	2.35	14.10	8.93	144	9.25	3.11
20-Aug-06	--	--	15.65	8.82	147	7.32	2.24
29-Sep-05	0.65	0.28	4.84	12.40	143	7.06	4.33

Note(s):
'--' = not sampled

Title:
LEISMER STUDY AREA, WCL8, WATERCOURSE DATA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: GI	Revision Date: JUNE 7, 07	
File: 4455-HABITAT-07-WC		
Drawn by: BSW	Checked: TJ	Fig. No.: 8.5-25

LEGEND

Ba	BARE GROUND	
Bd	BEDROCK	
Bo	BOULDER	
L.Bo	LARGE BOULDER	
Co	COBBLE	
S.Co	SMALL COBBLE	
L.Co	LARGE COBBLE	
Gr	GRAVEL	
S.Gr	SMALL GRAVEL	
L.Gr	LARGE GRAVEL	
	ESCARPMENT	
Sa	SAND	
Si	SILT	
Or	ORGANIC MATERIAL	
DP	DEBRIS PILE	
BL	BEAVER LODGE	
BD	BEAVER DAM	
EM	EMERGENT MACROPHYTES	
SM	SUBMERGENT MACROPHYTES	
FM	FLOATING MACROPHYTES	
IV	INSTREAM VEGETATION	
TV	TERRESTIAL VEGETATION	
	DEADFALL	
RW	ROOTWAD	
SH	SHRUB	
MF	MIXEDWOOD FOREST	
CF	CONIFEROUS FOREST	
DF	DECIDUOUS FOREST	
SE	SEDGES	
GF	GRASS/FORBES	
MO	MOSS	
MT	MINNOW TRAP	
UCB	UNDERCUT BANK	
OHC	OVERHEAD COVER	
OHV	OVERHANGING VEGETATION	
ISC	INSTREAM COVER	
INV	INUNDATED VEGETATION	
USB	UNSTABLE BANK	
BW	BACKWATER	
IP	IMPOUNDMENT POND	
SN	SNYE	
CH	CHUTE	
CA	CASCADE	
	SHALLOW SLOPE	
	MODERATE SLOPE	
	MODERATELY STEEP SLOPE	
	STEEP SLOPE	
	FLOW DIRECTION	
RA	RAPIDS	
RF	RIFFLE	
R1	CLASS 1 RUN	
R2	CLASS 2 RUN	
R3	CLASS 3 RUN	
P1	CLASS 1 POOL	
P2	CLASS 2 POOL	
P3	CLASS 3 POOL	
FL	FLAT	
FA	FALLS	
	WATER DEPTH	
T1	TRANSECT	

WCL9 AQUATIC HABITAT MAP

NOT TO SCALE

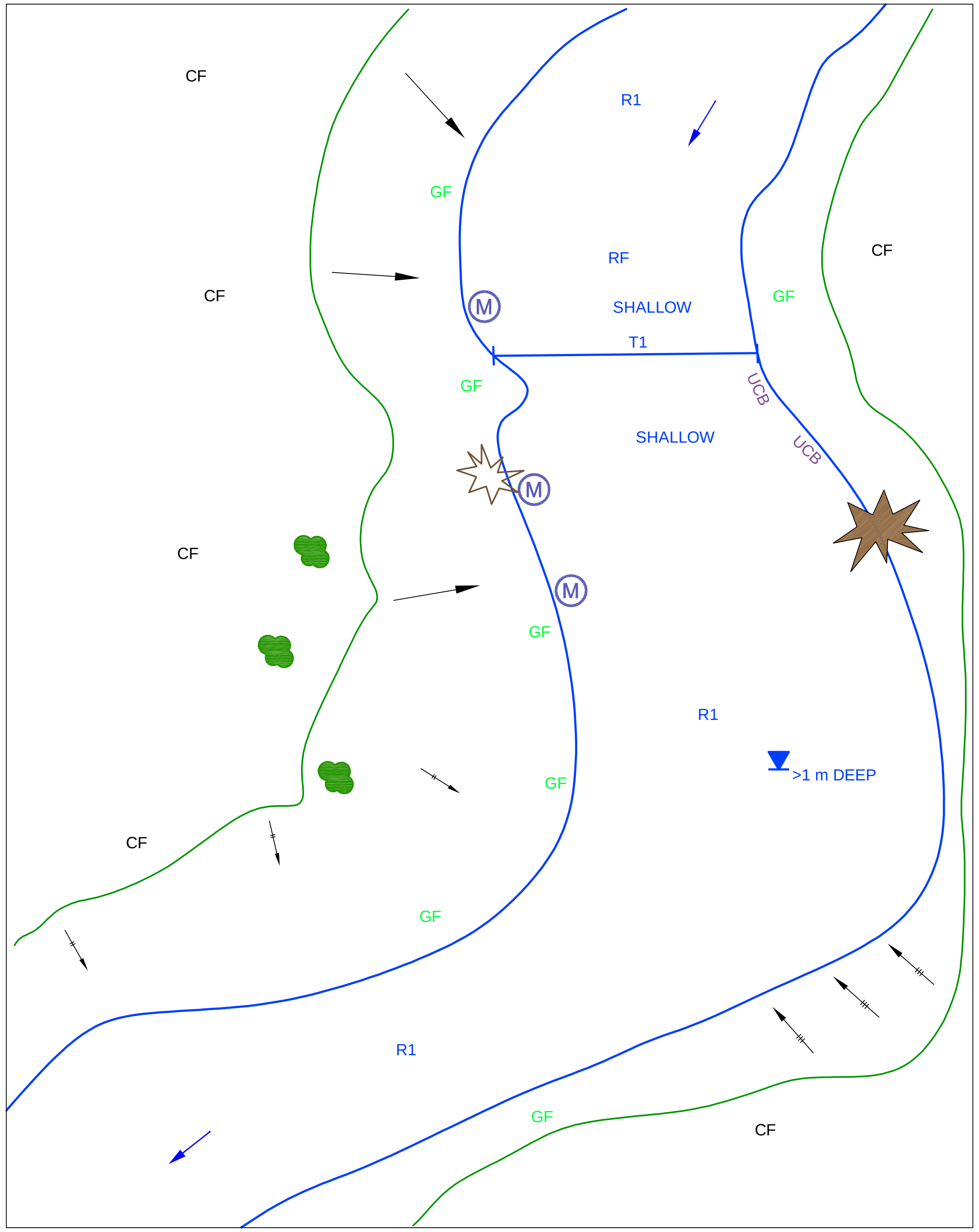


PHOTO 1. Aerial view of the Christina River at WCL9.

PHOTO 2. Upstream view of the Christina River from WCL9.

WCL9 (Christina River)
WCL9 was located on the Christina River and exhibited a gentle meander pattern. The river ran through a coniferous forest ecosystem dominated by spruce and aspen. The riverine habitat consisted of run (R1) habitat areas combined with some shallow riffle habitat. There was evidence of beaver activity in the area. Substrate was composed of fines, gravel and cobble, with some small boulders. The watercourse provided high spawning, rearing and feeding habitat potential for forage fish species, and moderate habitat potential for large bodied/sport fish species. Overwintering habitat was low for both forage and large bodied/sport fish species due to low dissolved oxygen concentrations and shallow water depth beneath the ice.

PHOTO 3. Downstream view of the Christina River from WCL9.

WCL9 HABITAT POTENTIAL RANKING

Fish Habitat Potential	Large Bodied/Sport Fish	Forage Fish
Overwintering	low	low
Spawning	moderate	high
Rearing	moderate	high
Feeding	moderate	high

WCL9 FISHERIES COLLECTION DATA

Sampling Season	Angling		Minnow Trap		Electrofishing	
	Fish Captured	Effort (h)	Fish Captured	Effort (h)	Fish Captured	Effort (s)
Winter	--	--	0	1.00	--	--
Spring	1 ARGR	1.5	0	8.82	--	--
Summer	--	--	0	2.22	--	--
Fall	--	--	0	2.38	--	--
Total	**1 ARGR**	**1.5**	**0**	**14.42**	**--**	**--**

Note(s):
'--' = method not used during this survey
ARGR = Arctic Grayling

WCL9 SURFACE WATER QUALITY DATA

Sampling Date	Water Depth (m)	Discharge (m^3/s)	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (µS/cm)	pH (units)	Turbidity (NTU)
10-Feb-06	0.75	0.00	0.02	2.47	443	6.62	26.17
7-May-06	0.77	11.82	10.52	12.10	73	7.59	14.45
4-Aug-05	1.1	--	16.67	8.73	71	6.88	10.53
20-Aug-06	--	--	16.09	9.86	94	7.38	11.83
28-Sep-05	0.74	5.13	4.93	11.10	162	7.6	14.52

Note(s):
'--' = not sampled

Title:

LEISMER STUDY AREA, WCL9, WATERCOURSE DATA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: GI	Revision Date: JUNE 7, 07
File: 4455-HABITAT-07-WC	

Drawn by:	Checked:	Fig. No.:
BSW	TJ	8.5-26

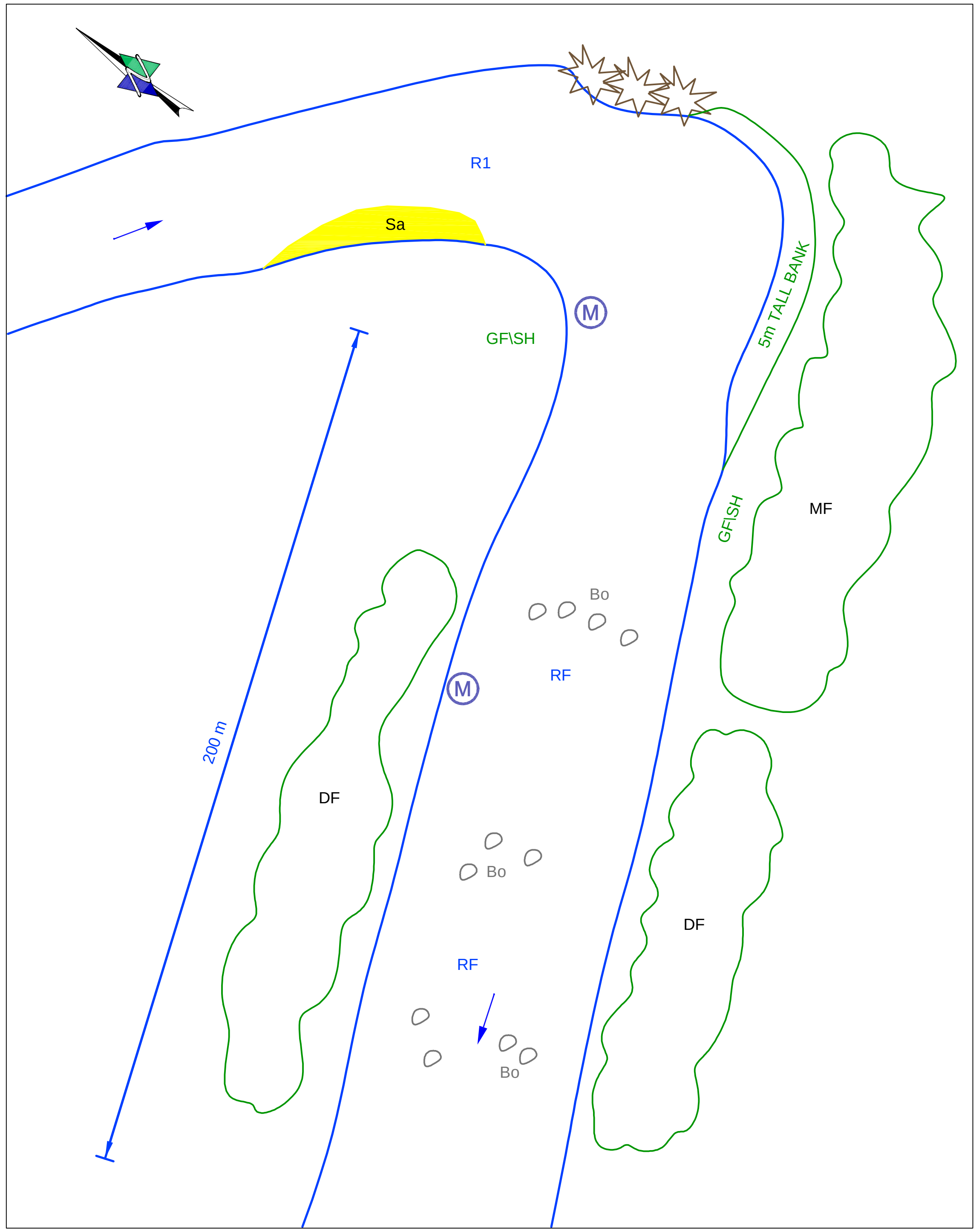
*PLOT 1:1=11X17 (L)
F:\4455 NAOSC\Drafting\2007\4455-HABITAT-07-WC.dwg - WCL9 - Jun 15, 2007 11:10am - bwheeler

LEGEND

Ba BARE GROUND
Bd BEDROCK
Bo BOULDER
L.Bo LARGE BOULDER
Co COBBLE
S.Co SMALL COBBLE
L.Co LARGE COBBLE
Gr GRAVEL
S.Gr SMALL GRAVEL
L.Gr LARGE GRAVEL
ESCARPMENT
Sa SAND
Si SILT
Or ORGANIC MATERIAL
DP DEBRIS PILE
BL BEAVER LODGE
BD BEAVER DAM
EM EMERGENT MACROPHYTES
SM SUBMERGENT MACROPHYTES
FM FLOATING MACROPHYTES
IV INSTREAM VEGETATION
TV TERRESTIAL VEGETATION
DEADFALL
RW ROOTWAD
SH SHRUB
MF MIXEDWOOD FOREST
CF CONIFEROUS FOREST
DF DECIDUOUS FOREST
SE SEDGES
GF GRASS/FORBES
MO MOSS
MT MINNOW TRAP
UCB UNDERCUT BANK
OHC OVERHEAD COVER
OHV OVERHANGING VEGETATION
ISC INSTREAM COVER
INV INUNDATED VEGETATION
USB UNSTABLE BANK
BW BACKWATER
IP IMPOUNDMENT POND
SN SNYE
CH CHUTE
CA CASCADE
SHALLOW SLOPE
MODERATE SLOPE
MODERATELY STEEP SLOPE
STEEP SLOPE
FLOW DIRECTION
RA RAPIDS
RF RIFFLE
R1 CLASS 1 RUN
R2 CLASS 2 RUN
R3 CLASS 3 RUN
P1 CLASS 1 POOL
P2 CLASS 2 POOL
P3 CLASS 3 POOL
FL FLAT
FA FALLS
WATER DEPTH
T1 TRANSECT

WCL10 AQUATIC HABITAT MAP

NOT TO SCALE



WCL10 SURFACE WATER QUALITY DATA

Sampling Date	Water Depth (m)	Discharge (m^3/s)	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (µS/cm)	pH (units)	Turbidity (NTU)
Feb-06	--	--	--	--	--	--	--
7-May-06	0.97	2.46	11.16	11.43	90	6.59	13.48
4-Aug-05	1.00	22.56	16.08	8.97	77	7.03	16.76
28-Sep-05	0.55	2.34	5.20	6.95	242	9.60	17.10

Note(s):
'--' = not sampled

PHOTO 1. View of the Christina River at WCL10 from the top of the ridge on the left downstream bank.

PHOTO 2. Upstream view of the Christina River from WCL10.

WCL10 (Christina River)
WCL10 was located on the Christina River on an oxbow section of the river. The watercourse was situated in a coniferous forest area and the banks of the river were vegetated with willows. The habitat present in this stretch of river consisted of alternating class 1 (R1) run, class 2 (R2) run and riffle habitat. Substrate was composed of gravel, cobble and boulder. The watercourse provided high spawning, rearing, and feeding habitat potential for forage fish species, and moderate habitat potential for large bodied/sport fish species. Overwintering habitat potential could not be assessed because WCL10 was not visited in the winter season.

WCL10 HABITAT POTENTIAL RANKING

Fish Habitat Potential	Large Bodied/Sport Fish	Forage Fish
Overwintering	--	--
Spawning	moderate	high
Rearing	moderate	high
Feeding	moderate	high

Note(s):
'--' = not sampled

PHOTO 3. Downstream view of the Christina River from WCL10.

WCL10 FISHERIES COLLECTION DATA

Sampling Season	Angling		Minnow Trap		Electrofishing	
	Fish Captured	Effort (h)	Fish Captured	Effort (h)	Fish Captured	Effort (s)
Winter	N/A	N/A	N/A	N/A	N/A	N/A
Spring	0	1.5	--	--	--	--
Summer	--	--	0	2.72	--	--
Fall	--	--	--	--	26 ARGR 5 LNSC 1 SPSH 5 WHSC	2531
Total	**0**	**1.5**	**0**	**2.72**	**26 ARGR 5 LNSC 1 SPSH 5 WHSC**	**2531**

Note(s):
N/A = not surveyed; '--' = method not used during this survey
ARGR = Arctic Grayling, LNSC = Longnose Sucker, WHSC = White Sucker, SPSH = Spottail Shiner

Title:

LEISMER STUDY AREA, WCL10, WATERCOURSE DATA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: GI	Revision Date: JUNE 7, 07

File: 4455-HABITAT-07-WC

Drawn by: BSW	Checked: TJ	Fig. No.: 8.5-27

LEGEND

- Ba BARE GROUND
- Bd BEDROCK
- Bo BOULDER
- L.Bo LARGE BOULDER
- Co COBBLE
- S.Co SMALL COBBLE
- L.Co LARGE COBBLE
- Gr GRAVEL
- S.Gr SMALL GRAVEL
- L.Gr LARGE GRAVEL
- ESCARPMENT
- Sa SAND
- Si SILT
- Or ORGANIC MATERIAL
- DP DEBRIS PILE
- BL BEAVER LODGE
- BD BEAVER DAM
- EM EMERGENT MACROPHYTES
- SM SUBMERGENT MACROPHYTES
- FM FLOATING MACROPHYTES
- IV INSTREAM VEGETATION
- TV TERRESTIAL VEGETATION
- DEADFALL
- RW ROOTWAD
- SH SHRUB
- MF MIXEDWOOD FOREST
- CF CONIFEROUS FOREST
- DF DECIDUOUS FOREST
- SE SEDGES
- GF GRASS/FORBES
- MO MOSS
- MT MINNOW TRAP
- UCB UNDERCUT BANK
- OHC OVERHEAD COVER
- OHV OVERHANGING VEGETATION
- ISC INSTREAM COVER
- INV INUNDATED VEGETATION
- USB UNSTABLE BANK
- BW BACKWATER
- IP IMPOUNDMENT POND
- SN SNYE
- CH CHUTE
- CA CASCADE
- SHALLOW SLOPE
- MODERATE SLOPE
- MODERATELY STEEP SLOPE
- STEEP SLOPE
- FLOW DIRECTION
- RA RAPIDS
- RF RIFFLE
- R1 CLASS 1 RUN
- R2 CLASS 2 RUN
- R3 CLASS 3 RUN
- P1 CLASS 1 POOL
- P2 CLASS 2 POOL
- P3 CLASS 3 POOL
- FL FLAT
- FA FALLS
- WATER DEPTH
- T1 TRANSECT

WCL11 AQUATIC HABITAT MAP

NOT TO SCALE

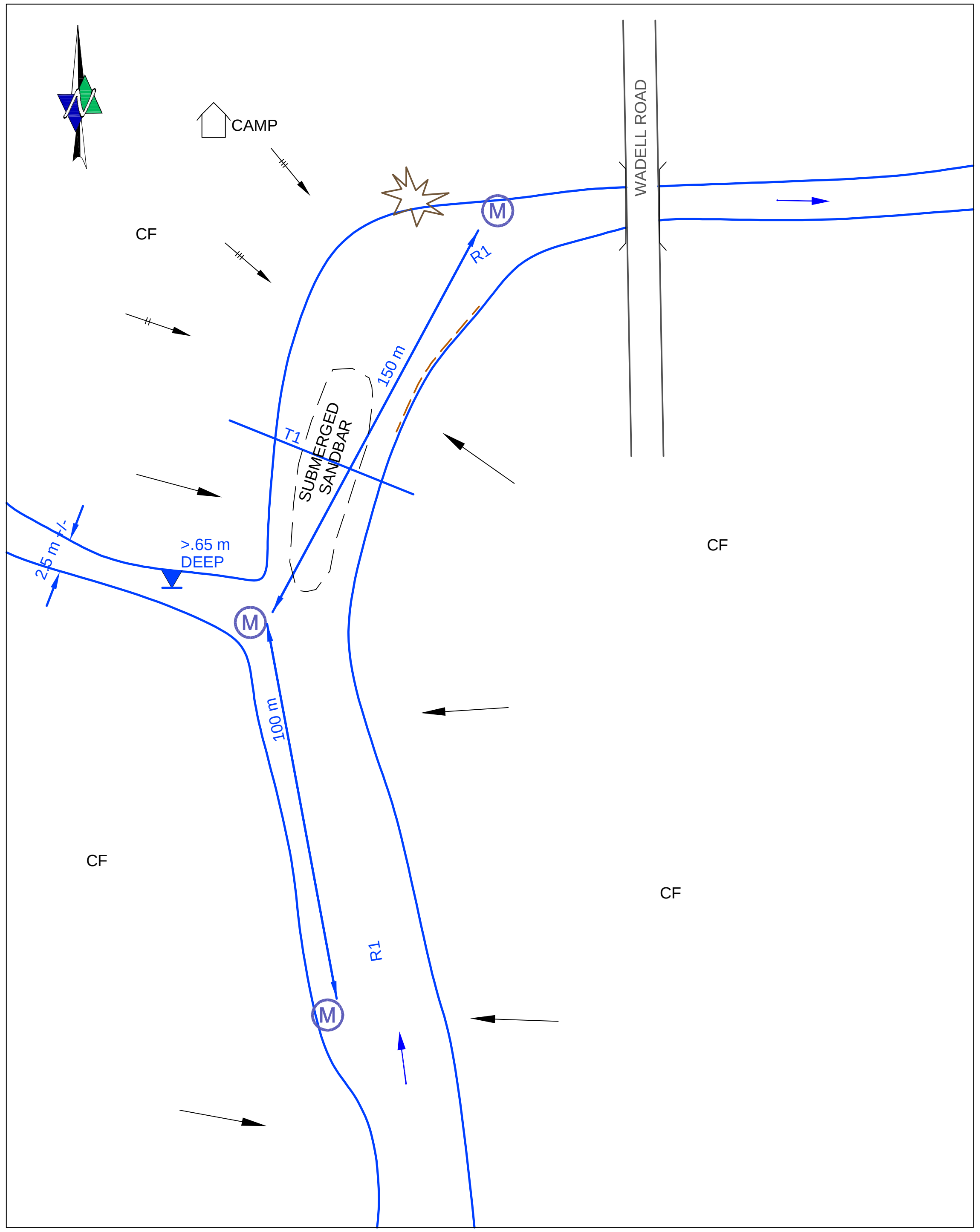


PHOTO 1. View of the Christina River at WCL11 looking directly across to the right downstream bank, displaying typical riparian vegetation found in the area.

PHOTO 2. Upstream view of the Christina River from WCL11.

PHOTO 3. View of the Christina River downstream of WCL11.

WCL11 (Christina River)

WCL11 was located on the Christina River on a stretch of river with an irregular meander pattern. This section of the Christina River ran through a coniferous forest area including jackpine and spruce. The watercourse was bordered by cottonwood and willow. The habitat present in the area was smooth, slow-moving class 1 run habitat. The substrate was composed of fines and small gravel at the study site and there were some cobble and small boulders present upstream and downstream. The watercourse provided high spawning, rearing and feeding habitat potential for forage fish species and moderate habitat potential for large bodied/sport fish species. Overwintering habitat potential was moderate for forage fish and low for large bodied/sport fish species due to low dissolved oxygen concentration and shallow water depth below the ice.

WCL11 SURFACE WATER QUALITY DATA

Sampling Date	Water Depth (m)	Discharge (m^3/s)	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (µS/cm)	pH (units)	Turbidity (NTU)
7-Feb-06	0.56	5.06	0.04	5.84	422	6.60	15.98
3-May-06	--	--	5.80	10.62	137	5.95	13.02
3-Aug-05	--	--	16.30	9.83	136.6	9.39	22.90
27-Sep-05	1.15	10.37	7.50	14.30	197	7.60	--

Note(s):
'--' = not sampled

WCL11 FISHERIES COLLECTION DATA

Sampling Season	Angling		Minnow Trap		Electrofishing	
	Fish Captured	Effort (h)	Fish Captured	Effort (h)	Fish Captured	Effort (s)
Winter	--	--	0	19.17	--	--
Spring	0	0.5	0	6.08	0	351
Summer	--	--	--	--	--	--
Fall	--	--	1 BRST 2 LNSC	4.07	11 WHSC 20 LNSC 12 ARGR 1 LKCH 1 GOLD 4 TRPR 1 BURB	2244
Total	**0**	**0.5**	**1 BRST 2 LNSC**	**29.32**	**11 WHSC 20 LNSC 12 ARGR 1 LKCH 1 GOLD 4 TRPR 1 BURB**	**2595**

Note(s):
'--' = method not used during this survey
BURB = Burbot, GOLD = Goldeye, LKCH = Lake Chub, TRPR = Trout Perch, LNSC = Longnose Sucker, WHSC = White Sucker, ARGR = Arctic Grayling

WCL11 HABITAT POTENTIAL RANKING

Fish Habitat Potential	Large Bodied/Sport Fish	Forage Fish
Overwintering	low	moderate
Spawning	moderate	high
Rearing	moderate	high
Feeding	moderate	high

Title:
LEISMER STUDY AREA, WCL11, WATERCOURSE DATA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: GI	Revision Date: JUNE 7, 07
File: 4455-HABITAT-07-WC	
Drawn by: BSW	Checked: TJ	Fig. No.: 8.5-28

LEGEND

Ba BARE GROUND
Bd BEDROCK
Bo BOULDER
L.Bo LARGE BOULDER
Co COBBLE
S.Co SMALL COBBLE
L.Co LARGE COBBLE
Gr GRAVEL
S.Gr SMALL GRAVEL
L.Gr LARGE GRAVEL

ESCARPMENT
Sa SAND
Si SILT
Or ORGANIC MATERIAL
DP DEBRIS PILE
BL BEAVER LODGE
BD BEAVER DAM
EM EMERGENT MACROPHYTES
SM SUBMERGENT MACROPHYTES
FM FLOATING MACROPHYTES
IV INSTREAM VEGETATION
TV TERRESTIAL VEGETATION
DEADFALL
RW ROOTWAD
SH SHRUB

MF MIXEDWOOD FOREST
CF CONIFEROUS FOREST
DF DECIDUOUS FOREST
SE SEDGES
GF GRASS/FORBES
MO MOSS

MT MINNOW TRAP

UCB UNDERCUT BANK
OHC OVERHEAD COVER
OHV OVERHANGING VEGETATION
ISC INSTREAM COVER
INV INUNDATED VEGETATION

USB UNSTABLE BANK

BW BACKWATER
IP IMPOUNDMENT POND
SN SNYE
CH CHUTE
CA CASCADE

SHALLOW SLOPE
MODERATE SLOPE
MODERATELY STEEP SLOPE
STEEP SLOPE
FLOW DIRECTION

RA RAPIDS
RF RIFFLE
R1 CLASS 1 RUN
R2 CLASS 2 RUN
R3 CLASS 3 RUN
P1 CLASS 1 POOL
P2 CLASS 2 POOL
P3 CLASS 3 POOL
FL FLAT
FA FALLS

WATER DEPTH

T1 TRANSECT

WCL12 AQUATIC HABITAT MAP

NOT TO SCALE

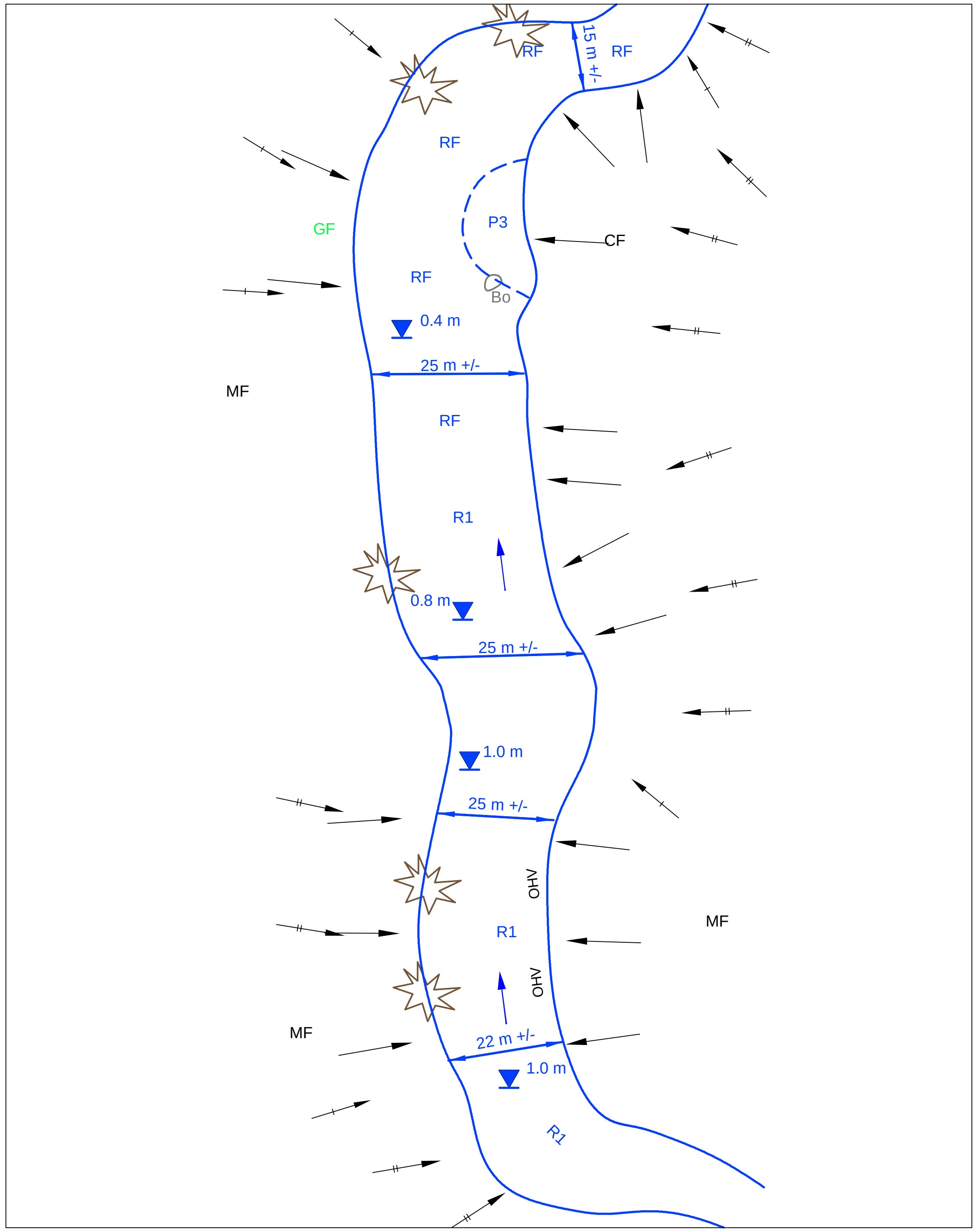


PHOTO 1. Aerial view of an unnamed tributary to the Christina River at WCL12.

PHOTO 2. Upstream view of the watercourse from WCL12.

WCL12 (Christina River tributary)
WCL12 was located in the Christina River watershed. The watercourse is located in a mixed wood forest dominated by tamarack. Some beaver activity was noted near the study area. The habitat in the area was generally class 1 run (R1) in the upstream reaches of the study area and riffle in the area downstream. The substrate present in the study reach included fines, small gravel, cobble and small boulders. The watercourse provided high spawning, rearing and feeding habitat potential for forage fish species and moderate habitat potential for large bodied/sport fish species. Overwintering habitat potential was moderate for forage fish species, and low for large bodied/sport fish species due to shallow water depth below the ice.

PHOTO 3. Downstream view of the watercourse from WCL12.

WCL12 HABITAT POTENTIAL RANKING

Fish Habitat Potential	Large Bodied/Sport Fish	Forage Fish
Overwintering	low	moderate
Spawning	moderate	high
Rearing	moderate	high
Feeding	moderate	high

WCL12 FISHERIES COLLECTION DATA

Sampling Season	Angling		Minnow Trap		Electrofishing	
	Fish Captured	Effort (h)	Fish Captured	Effort (h)	Fish Captured	Effort (s)
Winter	--	--	0	1.16	--	--
Spring	--	--	0	5.00	--	--
Summer	--	--	0	1.97	--	--
Fall	--	--	--	--	9 ARGR 1 BURB 1 LKCH	1839
Total	--	--	**0**	**8.13**	**9 ARGR 1 BURB 1 LKCH**	**1839**

Note(s):
'--' = method not used during this survey
ARGR = Arctic Grayling, BURB = Burbot, LKCH = Lake Chub

WCL12 SURFACE WATER QUALITY DATA

Sampling Date	Water Depth (m)	Discharge (m^3/s)	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (µS/cm)	pH (units)	Turbidity (NTU)
11-Feb-06	1.00	0.10	0.00	6.46	326	6.76	17.18
7-May-06	0.67	12.12	7.82	10.87	93	6.30	7.94
4-Aug-05	2.20	15.51	15.50	7.25	94	6.65	13.56
28-Sep-05	0.40	2.02	5.20	12.30	307	9.60	10.10

Title:

LEISMER STUDY AREA, WCL12, WATERCOURSE DATA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: GI	Revision Date: JUNE 7, 07	
File: 4455-HABITAT-07-WC		
Drawn by: BSW	Checked: TJ	Fig. No.: 8.5-29

LEGEND

Ba BARE GROUND
Bd BEDROCK
Bo BOULDER
L.Bo LARGE BOULDER
Co COBBLE
S.Co SMALL COBBLE
L.Co LARGE COBBLE
Gr GRAVEL
S.Gr SMALL GRAVEL
L.Gr LARGE GRAVEL

ESCARPMENT

Sa SAND
Si SILT
Or ORGANIC MATERIAL
DP DEBRIS PILE
BL BEAVER LODGE
BD BEAVER DAM
EM EMERGENT MACROPHYTES
SM SUBMERGENT MACROPHYTES
FM FLOATING MACROPHYTES
IV INSTREAM VEGETATION
TV TERRESTIAL VEGETATION

DEADFALL

RW ROOTWAD
SH SHRUB

MF MIXEDWOOD FOREST
CF CONIFEROUS FOREST
DF DECIDUOUS FOREST
SE SEDGES
GF GRASS/FORBES
MO MOSS

MT MINNOW TRAP

UCB UNDERCUT BANK
OHC OVERHEAD COVER
OHV OVERHANGING VEGETATION
ISC INSTREAM COVER
INV INUNDATED VEGETATION

USB UNSTABLE BANK

BW BACKWATER
IP IMPOUNDMENT POND
SN SNYE
CH CHUTE
CA CASCADE

SHALLOW SLOPE
MODERATE SLOPE
MODERATELY STEEP SLOPE
STEEP SLOPE
FLOW DIRECTION

RA RAPIDS
RF RIFFLE
R1 CLASS 1 RUN
R2 CLASS 2 RUN
R3 CLASS 3 RUN
P1 CLASS 1 POOL
P2 CLASS 2 POOL
P3 CLASS 3 POOL
FL FLAT
FA FALLS

WATER DEPTH

T1 TRANSECT

WCL13 AQUATIC HABITAT MAP

NOT TO SCALE

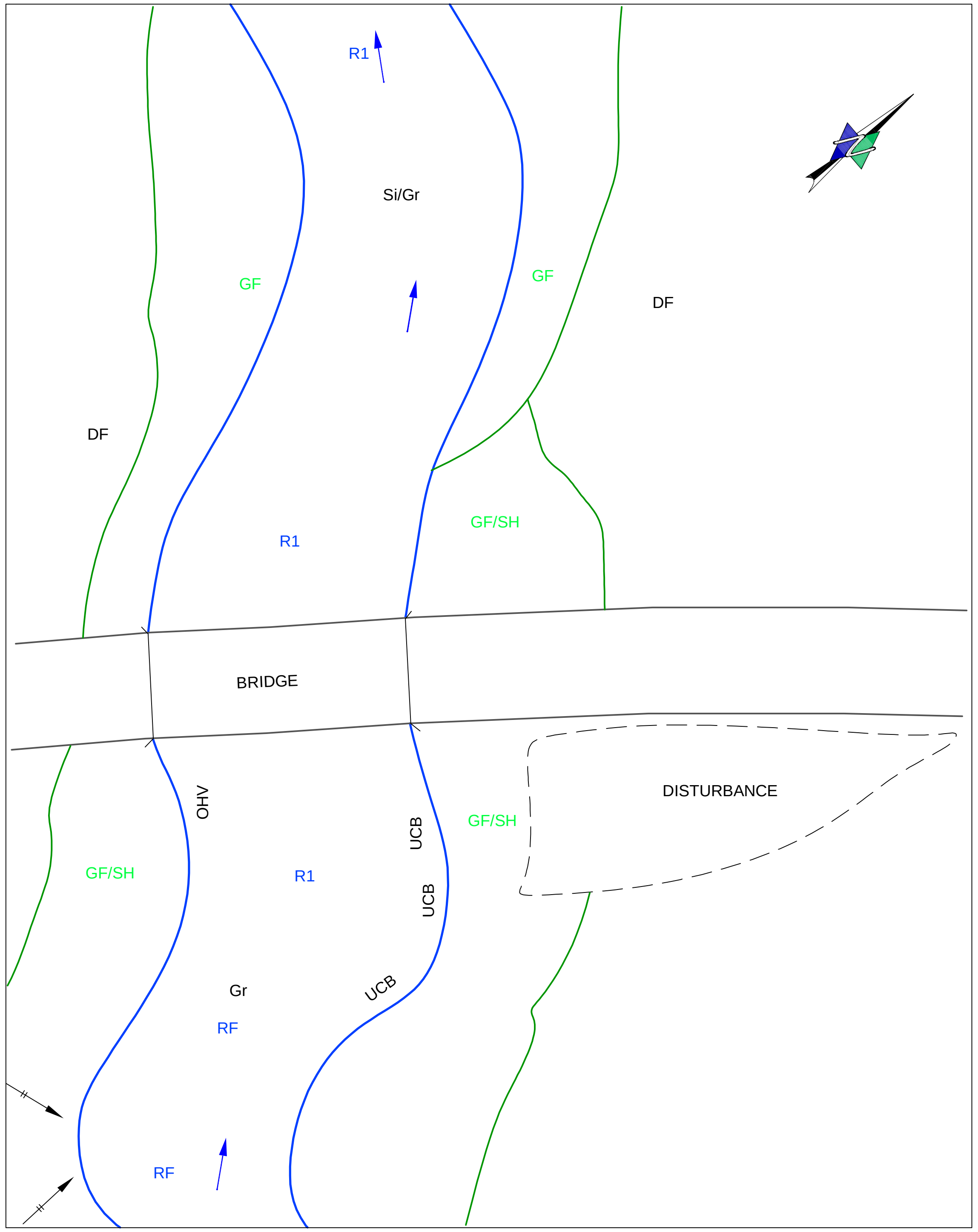


PHOTO 1. Downstream view of the May River from WCL13.

PHOTO 2. Upstream view of the May River from WCL13.

PHOTO 3. View of the bridge crossing on the May River at WCL13.

WCL13 (May River)

WCL13 was located in the Christina River watershed on the May River, which follows an irregular meandering pattern. The river was located in a mature coniferous forest and was bordered by grass and willows. WCL13 was near a road crossing and much of the area has been disturbed. The habitat present includes both class 1 (R1) runs and some riffle habitat in the upstream reaches of the study area. Substrate was composed of both fines and small gravel. The watercourse provided moderate spawning, rearing and feeding habitat potential for forage fish species and low habitat potential for large bodied/sport fish species. Overwintering habitat potential was moderate for forage fish and low for large bodied/sport fish species due to shallow water depth beneath the ice and low flow conditions.

WCL13 FISHERIES COLLECTION DATA

Sampling Season	Angling		Minnow Trap		Electrofishing	
	Fish Captured	Effort (h)	Fish Captured	Effort (h)	Fish Captured	Effort (s)
Winter	--	--	0	16.67	--	--
Spring	0	1.5	0	5.00	--	--
Summer	--	--	--	--	--	--
Fall	--	--	--	--	--	--
Total	**0**	**1.5**	**0**	**21.67**	**--**	**--**

Note(s):
'--' = method not used during this survey

WCL13 SURFACE WATER QUALITY DATA

Sampling Date	Water Depth (m)	Discharge (m^3/s)	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (µS/cm)	pH (units)	Turbidity (NTU)
7-Feb-06	0.52	0.00	0.83	6.60	314	6.67	10.91
3-May-06	1.12	9.15	6.73	12.87	91	6.85	5.77
20-Aug-06	--	--	17.59	9.79	102	7.59	2.77

Note(s):
'--' = method not used during this survey

WCL13 HABITAT POTENTIAL RANKING

Fish Habitat Potential	Large Bodied/Sport Fish	Forage Fish
Overwintering	low	moderate
Spawning	low	moderate
Rearing	low	moderate
Feeding	low	moderate

Title:

LEISMER STUDY AREA, WCL13, WATERCOURSE DATA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: GI	Revision Date: JUNE 7, 07
File: 4455-HABITAT-07-WC	

Drawn by: BSW	Checked: TJ	Fig. No.: 8.5-30

*PLOT 1:1=11X17 (L)

LEGEND

- Ba BARE GROUND
- Bd BEDROCK
- Bo BOULDER
- L.Bo LARGE BOULDER
- Co COBBLE
- S.Co SMALL COBBLE
- L.Co LARGE COBBLE
- Gr GRAVEL
- S.Gr SMALL GRAVEL
- L.Gr LARGE GRAVEL
- ESCARPMENT
- Sa SAND
- Si SILT
- Or ORGANIC MATERIAL
- DP DEBRIS PILE
- BL BEAVER LODGE
- BD BEAVER DAM
- EM EMERGENT MACROPHYTES
- SM SUBMERGENT MACROPHYTES
- FM FLOATING MACROPHYTES
- IV INSTREAM VEGETATION
- TV TERRESTIAL VEGETATION
- DEADFALL
- RW ROOTWAD
- SH SHRUB
- MF MIXEDWOOD FOREST
- CF CONIFEROUS FOREST
- DF DECIDUOUS FOREST
- SE SEDGES
- GF GRASS/FORBES
- MO MOSS
- MT MINNOW TRAP
- UCB UNDERCUT BANK
- OHC OVERHEAD COVER
- OHV OVERHANGING VEGETATION
- ISC INSTREAM COVER
- INV INUNDATED VEGETATION
- USB UNSTABLE BANK
- BW BACKWATER
- IP IMPOUNDMENT POND
- SN SNYE
- CH CHUTE
- CA CASCADE
- SHALLOW SLOPE
- MODERATE SLOPE
- MODERATELY STEEP SLOPE
- STEEP SLOPE
- FLOW DIRECTION
- RA RAPIDS
- RF RIFFLE
- R1 CLASS 1 RUN
- R2 CLASS 2 RUN
- R3 CLASS 3 RUN
- P1 CLASS 1 POOL
- P2 CLASS 2 POOL
- P3 CLASS 3 POOL
- FL FLAT
- FA FALLS
- WATER DEPTH
- T1 TRANSECT

WCL14 AQUATIC HABITAT MAP

NOT TO SCALE

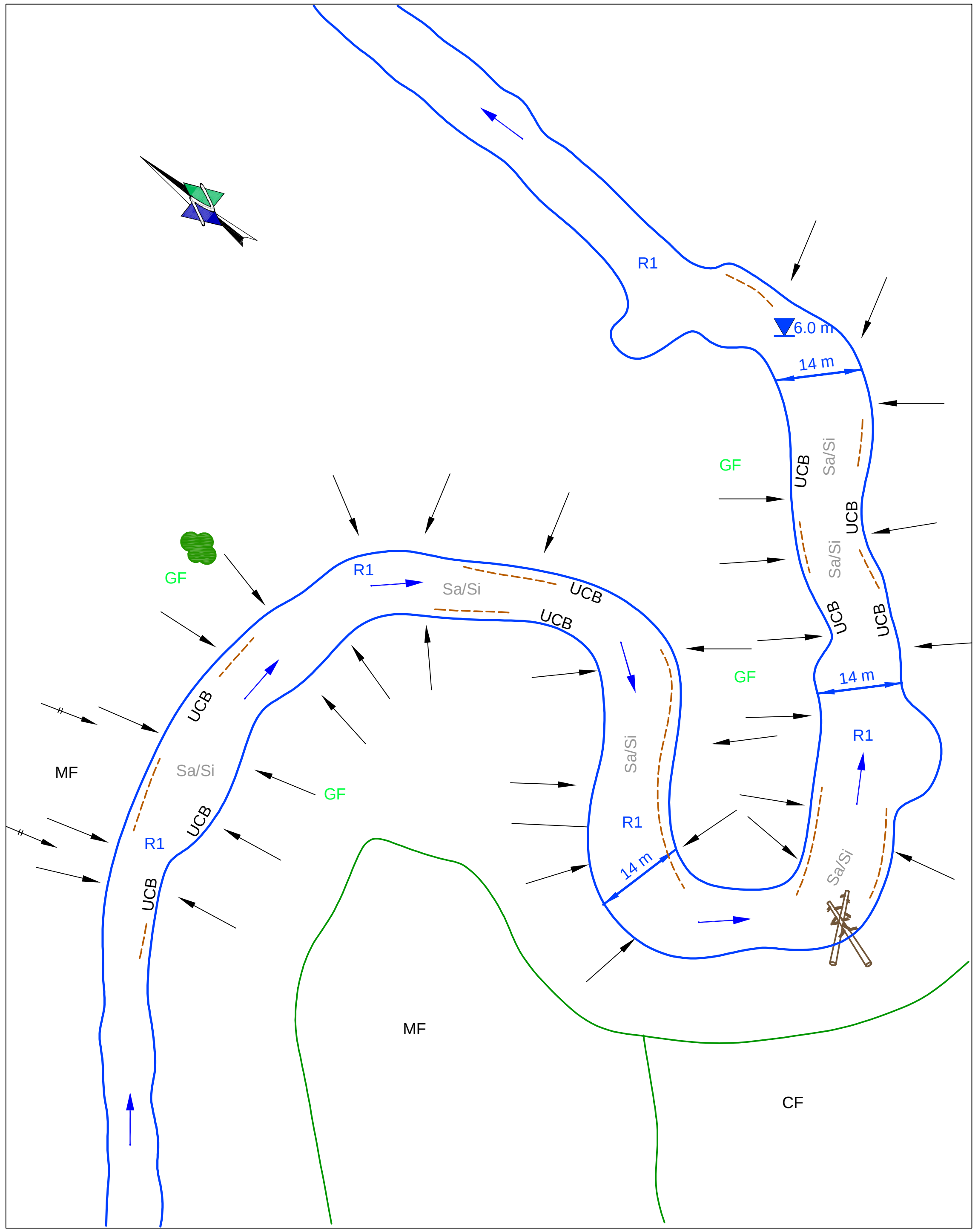


PHOTO 1. Aerial view of an unnamed tributary to the Christina River from WCL14.

PHOTO 2. View of the left downstream bank from WCL14.

PHOTO 3. Downstream view of the watercourse from WCL14.

WCL14 (Christina River tributary)

WCL14 was located in a watercourse that connects Base Lake to the Christina River. The watercourse follows an irregular meander pattern through an old growth coniferous forest area. The habitat present in the study reach consisted entirely of class 1 (R1) run habitat with substrate composed entirely of sand and silica fines. The watercourse provided moderate spawning, rearing and feeding habitat potential for both forage and large bodied/sport fish species. Overwintering potential could not be assessed because WCL14 was not visited in the winter season.

WCL14 FISHERIES COLLECTION DATA

Sampling Season	Angling		Minnow Trap		Electrofishing	
	Fish Captured	Effort (h)	Fish Captured	Effort (h)	Fish Captured	Effort (s)
Winter	N/A	N/A	N/A	N/A	N/A	N/A
Spring	0	1.5	0	4.00	--	--
Summer	--	--	1 PRDC	2.22	--	--
Fall	--	--	--	--	--	--
Total	**0**	**1.5**	**1 PRDC**	**6.22**	**--**	**--**

Note(s):
N/A = not surveyed; '--' = method not used during this survey
PRDC = Pearl Dace

WCL14 SURFACE WATER QUALITY DATA

Sampling Date	Water Depth (m)	Discharge (m^3/s)	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (µS/cm)	pH (units)	Turbidity (NTU)
Feb-06	--	--	--	--	--	--	--
7-May-06	1.02	0.76	7.76	10.97	90	6.15	15.72
8-Aug-05	1.00	5.58	15.90	10.20	159	9.32	21.30
30-Sep-05	--	--	6.74	12.27	168	7.65	--

Note(s):
'--' = not sampled

WCL14 HABITAT POTENTIAL RANKING

Fish Habitat Potential	Large Bodied/Sport Fish	Forage Fish
Overwintering	--	--
Spawning	moderate	moderate
Rearing	moderate	moderate
Feeding	moderate	moderate

Note(s):
'--' = not sampled

Title: **LEISMER STUDY AREA, WCL14, WATERCOURSE DATA**	NORTH AMERICAN OIL SANDS CORPORATION	
	Approved: GI	Revision Date: JUNE 7, 07
	File: 4455-HABITAT-07-WC	
	Drawn by: BSW / Checked: TJ	Fig. No.: 8.5-31

F:\4455 NAOSC\Drafting\2007\4455-HABITAT-07-WC.dwg - WCL14 - Jun. 15, 2007 11:13am - bwheeler

PHOTO 1. Aerial view of the Christina River at WCL15.

PHOTO 2. View of Christina River shoreline at WCL15

PHOTO 3. Downstream view of the Christina River from WCL15.

WCL15 HABITAT POTENTIAL RANKING

Fish Habitat Potential	Large Bodied/Sport Fish	Forage Fish
Overwintering	--	--
Spawning	low to moderate	moderate
Rearing	low to moderate	moderate
Feeding	low to moderate	moderate

Note(s):
'--' = not sampled

WCL15 SURFACE WATER QUALITY DATA

Sampling Date	Water Depth (m)	Discharge (m^3/s)	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (µS/cm)	pH (units)	Turbidity (NTU)
Feb-06	--	--	--	--	--	--	--
10-May-06	--	--	--	--	--	--	--
5-Aug-05	1.00	12.02	16.38	9.40	66	6.31	8.95
30-Sep-05	--	--	--	--	--	--	--

Note(s):
'--' = not sampled

WCL15 FISHERIES COLLECTION DATA

Sampling Season	Angling		Minnow Trap		Electrofishing	
	Fish Captured	Effort (h)	Fish Captured	Effort (h)	Fish Captured	Effort (s)
Winter	N/A	N/A	N/A	N/A	N/A	N/A
Spring	--	--	--	--	--	--
Summer	--	--	0	2.47	--	--
Fall	--	--	--	--	--	--
Total	**0**	**0**	**0**	**2.47**	**0**	**615**

Note(s):
N/A = not surveyed; '--' = method not used during this survey

Title:

LEISMER STUDY AREA, WCL15, WATERCOURSE DATA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: GI	Revision Date: JUNE 7, 07
File: 4455-HABITAT-07-WC	
Drawn by: BSW	Checked: TJ
Fig. No.: 8.5-32	

*PLOT 1:1=Letter (P)

F:\4455 NAOSC\Drafting\2007\4455-HABITAT-07-Wc.dwg - WCL15 - Jun. 15, 2007 11:17am - bwheeler

LEGEND

Ba BARE GROUND
Bd BEDROCK
Bo BOULDER
L.Bo LARGE BOULDER
Co COBBLE
S.Co SMALL COBBLE
L.Co LARGE COBBLE
Gr GRAVEL
S.Gr SMALL GRAVEL
L.Gr LARGE GRAVEL

ESCARPMENT

Sa SAND
Si SILT
Or ORGANIC MATERIAL
DP DEBRIS PILE
BL BEAVER LODGE
BD BEAVER DAM
EM EMERGENT MACROPHYTES
SM SUBMERGENT MACROPHYTES
FM FLOATING MACROPHYTES
IV INSTREAM VEGETATION
TV TERRESTIAL VEGETATION

DEADFALL

RW ROOTWAD
SH SHRUB

MF MIXEDWOOD FOREST
CF CONIFEROUS FOREST
DF DECIDUOUS FOREST
SE SEDGES
GF GRASS/FORBES
MO MOSS

MT MINNOW TRAP

UCB UNDERCUT BANK
OHC OVERHEAD COVER
OHV OVERHANGING VEGETATION
ISC INSTREAM COVER
INV INUNDATED VEGETATION

USB UNSTABLE BANK

BW BACKWATER
IP IMPOUNDMENT POND
SN SNYE
CH CHUTE
CA CASCADE

SHALLOW SLOPE
MODERATE SLOPE
MODERATELY STEEP SLOPE
STEEP SLOPE
FLOW DIRECTION

RA RAPIDS
RF RIFFLE
R1 CLASS 1 RUN
R2 CLASS 2 RUN
R3 CLASS 3 RUN
P1 CLASS 1 POOL
P2 CLASS 2 POOL
P3 CLASS 3 POOL
FL FLAT
FA FALLS

WATER DEPTH

T1 TRANSECT

LH1 AQUATIC HABITAT MAP

NOT TO SCALE

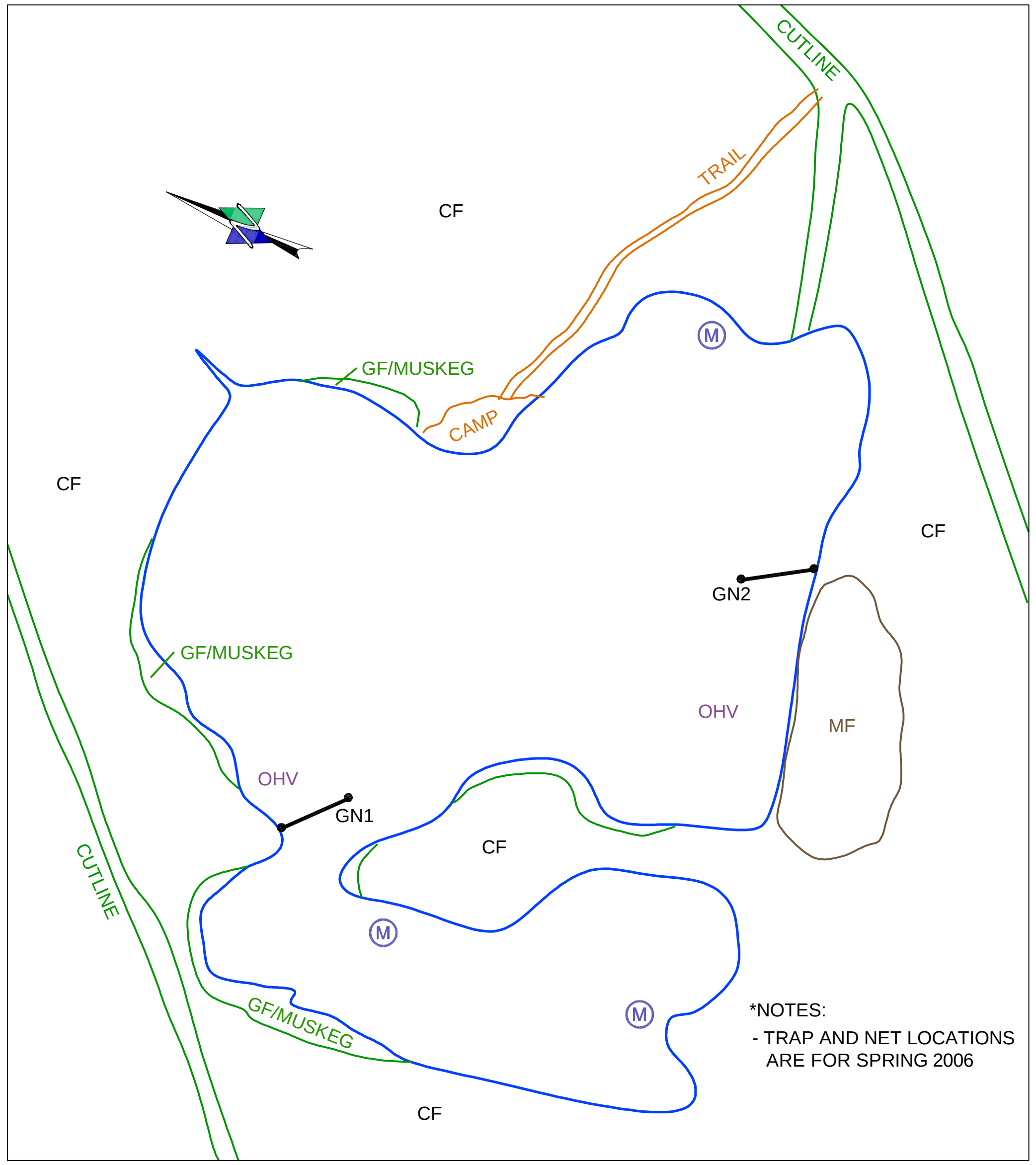


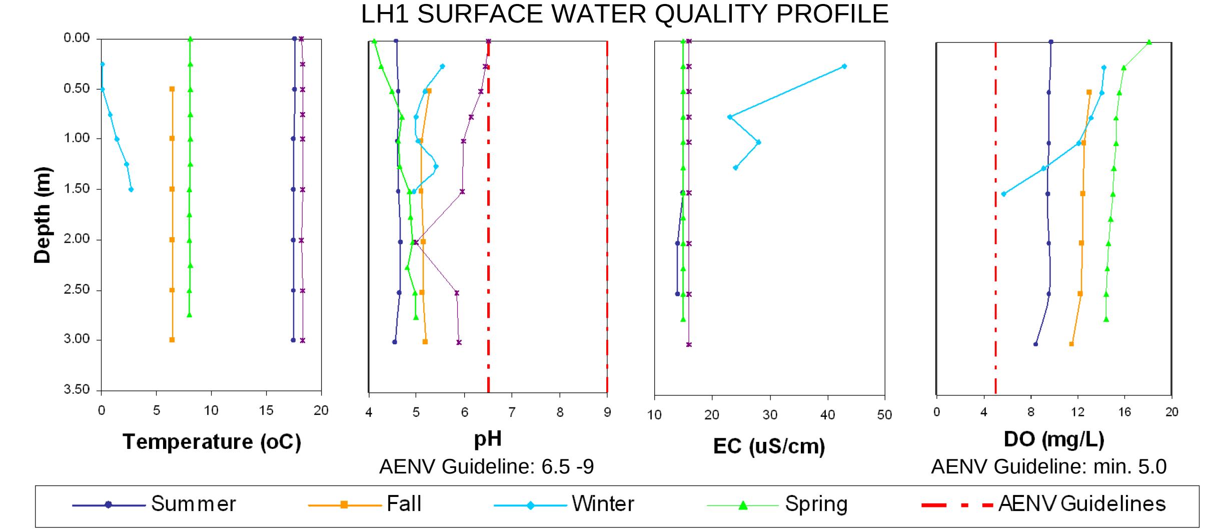
PHOTO 1. Aerial view of unnamed waterbody LH1.

PHOTO 2. Northwest inlet of unnamed waterbody LH1.

Unnamed Waterbody LH1
LH1 is located in the Hangingstone River watershed and drains into Hangingstone River through a northwest outlet. The waterbody surface area was approximately 1.8 km² and observed depths were approximately 3 m. The euphotic zone extended to the bottom of the waterbody (secchi depth x = 1.94 m) and turbidity was low (x = 2.08 NTU). Vegetation surrounding the waterbody consisted primarily of coniferous black spruce forest with aspen and willow and grasses in shoreline areas. The shoreline of the lake was comprised of grasses, sedges, forbs with some isolated sections of cobble and bolder. Substrate consisted of silt and sand, and aquatic vegetation was present in the form of aquatic grasses, sedges and water lilies. Based on depths, DO levels and the capture of forage fish, overwintering potential for sport and forage fish was high. Spawning rearing and feeding potential for forage fish and sport fish species was moderate to high. Although the observed pH was below guidelines, it is likely this waterbody could support fish species more resilient to slightly acidic conditions such as northern pike and brook stickleback.

PHOTO 3. Brook stickleback (*Culaea inconstans*) from waterbody LH1 (February 2006).

LH1 SURFACE WATER QUALITY PROFILE



AENV, 1999
CCME, 2002

LH1 FISHERIES COLLECTION DATA

Sampling Season	Angling: Fish Captured	Angling: Effort (h)	Minnow Trap: Fish Captured	Minnow Trap: Effort (h)	Gill Nets: Fish Captured	Gill Nets: Effort (h)
Winter	–	–	2 BRST	76.15	0	20.6
Spring	–	–	228 BRST	88.58	246 WHSC 210 PRDC	54.72
Summer	–	–	1 BRST	2.75	22 WHSC	4.58
Fall	–	–	2 BRST	10	124 WHSC 6 SPSH	95.75
Total	**–**	**–**	**233 BRST**	**177.48**	**396 WHSC 210 PRDC 6 SPSH**	**175.65**

Note(s):
'–' = method not used during this survey
BRST = Brook Stickleback, PRDC = Pearl Dace, SPSH = Spottail Shiner, WHSC = White Sucker

LH1 HABITAT POTENTIAL RANKING

Fish Habitat Potential	Large Bodied/Sport Fish	Forage Fish
Overwintering	high	high
Spawning	moderate-high	high
Rearing	moderate-high	high
Feeding	high	high

Title:

HANGINGSTONE STUDY AREA, LH1, WATERBODY DATA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: GI	Revision Date: JUNE 7, 07
File: 4455-HABITAT-07-WB	
Drawn by: BSW	Checked: TJ
Fig. No.: 8.5-33	

LEGEND

Ba	BARE GROUND
Bd	BEDROCK
Bo	BOULDER
L.Bo	LARGE BOULDER
Co	COBBLE
S.Co	SMALL COBBLE
L.Co	LARGE COBBLE
Gr	GRAVEL
S.Gr	SMALL GRAVEL
L.Gr	LARGE GRAVEL
	ESCARPMENT
Sa	SAND
Si	SILT
Or	ORGANIC MATERIAL
DP	DEBRIS PILE
BL	BEAVER LODGE
BD	BEAVER DAM
EM	EMERGENT MACROPHYTES
SM	SUBMERGENT MACROPHYTES
FM	FLOATING MACROPHYTES
IV	INSTREAM VEGETATION
TV	TERRESTIAL VEGETATION
	DEADFALL
RW	ROOTWAD
SH	SHRUB
MF	MIXEDWOOD FOREST
CF	CONIFEROUS FOREST
DF	DECIDUOUS FOREST
SE	SEDGES
GF	GRASS/FORBES
MO	MOSS
MT	MINNOW TRAP
UCB	UNDERCUT BANK
OHC	OVERHEAD COVER
OHV	OVERHANGING VEGETATION
ISC	INSTREAM COVER
INV	INUNDATED VEGETATION
USB	UNSTABLE BANK
BW	BACKWATER
IP	IMPOUNDMENT POND
SN	SNYE
CH	CHUTE
CA	CASCADE
	SHALLOW SLOPE
	MODERATE SLOPE
	MODERATELY STEEP SLOPE
	STEEP SLOPE
	FLOW DIRECTION
RA	RAPIDS
RF	RIFFLE
R1	CLASS 1 RUN
R2	CLASS 2 RUN
R3	CLASS 3 RUN
P1	CLASS 1 POOL
P2	CLASS 2 POOL
P3	CLASS 3 POOL
FL	FLAT
FA	FALLS
	WATER DEPTH
T1	TRANSECT

LH2 AQUATIC HABITAT MAP

NOT TO SCALE

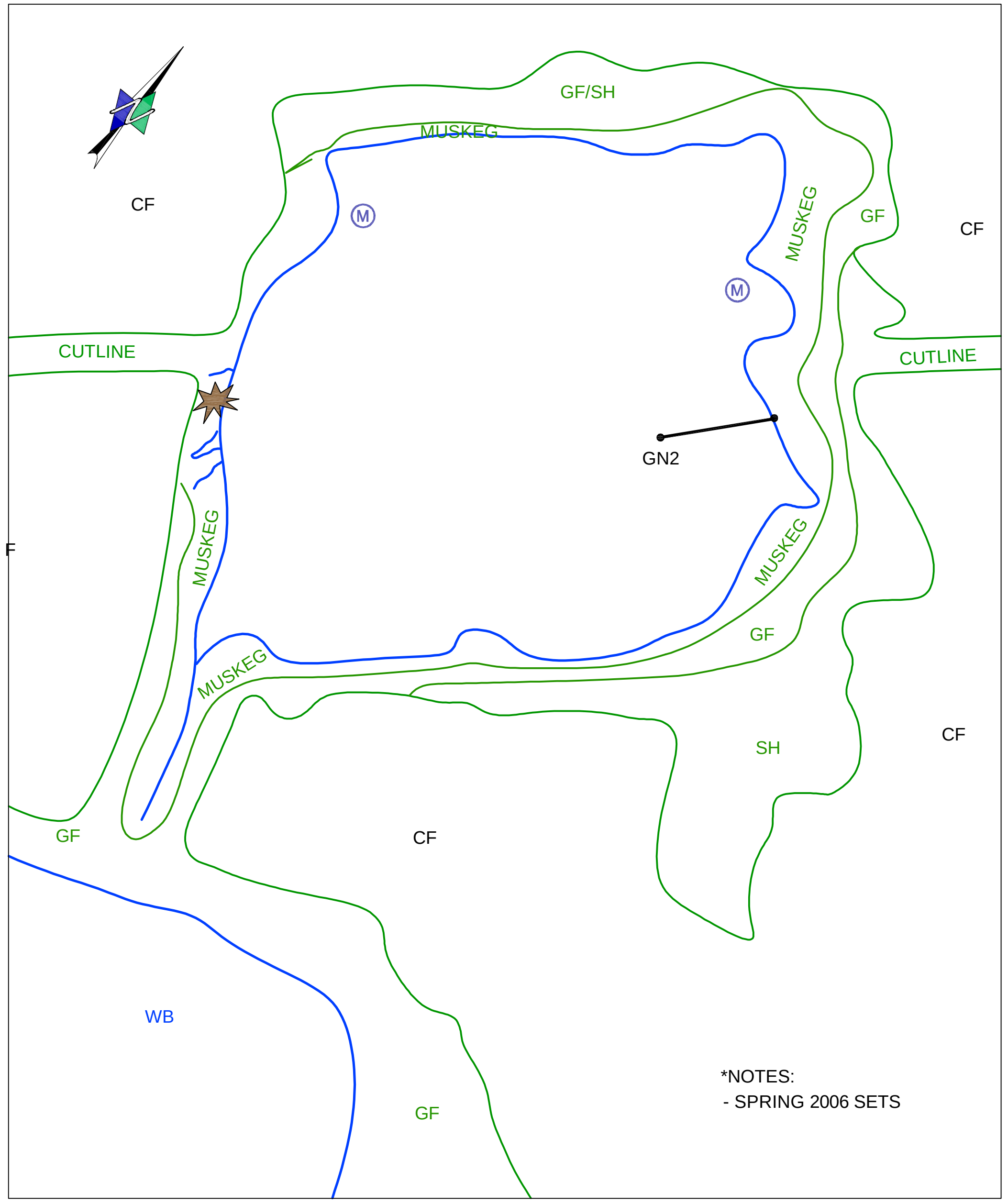


PHOTO 1. Aerial view of unnamed waterbody LH2 (Foreground).

PHOTO 2. View from shore of unnamed waterbody LH2.

Unnamed Waterbody LH2

LH2 is located in the Hangingstone watershed and drains via another smaller waterbody into Hangingstone River. In spring 2006, the southern outlet was blocked by an old beaver dam and the channel was not defined downstream of this obstruction. Surface area was approximately 2.2 km² and observed depth was about 1.6 m. The euphotic zone extended to the floor of the waterbody (secchi x = 0.53 m) and turbidity was low (x = 2.7 NTUs). Riparian vegetation was comprised of grass, forb and shrubs, flanked by coniferous black spruce forest. Substrate was predominantly silty organic fines and supported several patches of emergent aquatic vegetation. Overwintering potential was limited by water depth and not assessed. Spawning and rearing potential for sport fish was moderate to high based on the spring capture of ripe northern pike. Sport fish feeding habitat potential was high due to the presence of forage fish. Spawning, rearing and feeding habitat potential was ranked as high for forage fish as evidenced by the capture of stickleback and pearl dace in the summer and spring seasons.

LH2 HABITAT POTENTIAL RANKING

Fish Habitat Potential	Large Bodied/Sport Fish	Forage Fish
Overwintering	--	--
Spawning	moderate-high	high
Rearing	moderate-high	high
Feeding	high	high

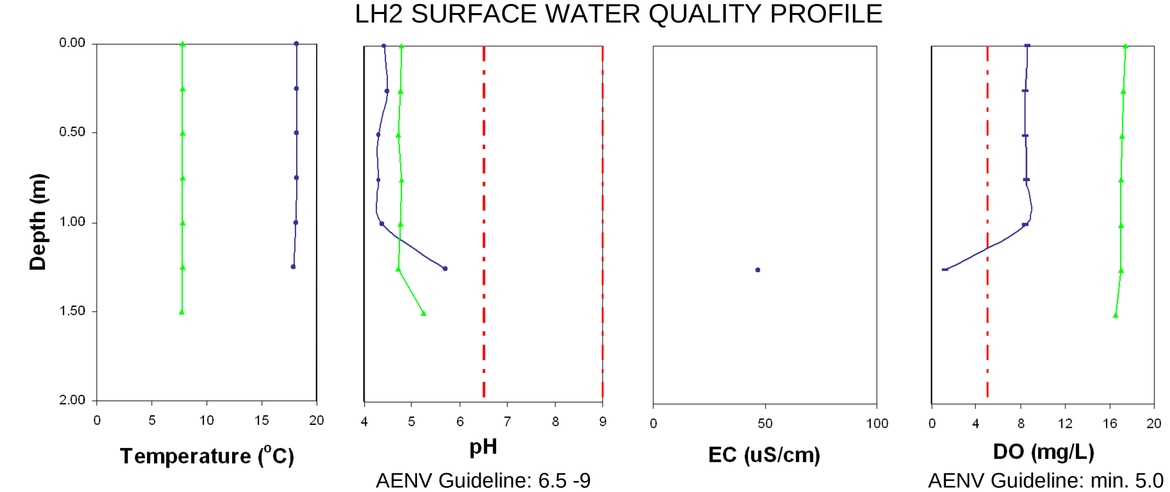
Note(s):
'--' = not sampled

LH2 FISHERIES COLLECTION DATA

Sampling Season	Angling		Minnow Trap		Gill Nets	
	Fish Captured	Effort (h)	Fish Captured	Effort (h)	Fish Captured	Effort (h)
Winter	N/A	N/A	N/A	N/A	N/A	N/A
Spring	--	--	160 BRST	37.2	3 NRPK	19.03
Summer	--	--	35 BRST 1 PRDC	9.35	0	4.22
Fall	N/A	N/A	N/A	N/A	N/A	N/A
Total	**--**	**--**	**195 BRST 1 PRDC**	**46.55**	**3 NRPK**	**23.25**

Note(s):
N/A = not sampled; '--' = method not used during this survey
BRST = Brook Stickleback, NRPK = Northern Pike, PRDC = Pearl Dace

LH2 SURFACE WATER QUALITY PROFILE



AENV, 1999
CCME, 2002

Title:	NORTH AMERICAN OIL SANDS CORPORATION	
HANGINGSTONE STUDY AREA, LH2, WATERBODY DATA	Approved: GI	Revision Date: JUNE 7, 07
	File: 4455-HABITAT-07-WB	
	Drawn by: BSW	Checked: TJ	Fig. No.: 8.5-34

LEGEND

Ba BARE GROUND
Bd BEDROCK
Bo BOULDER
L.Bo LARGE BOULDER
Co COBBLE
S.Co SMALL COBBLE
L.Co LARGE COBBLE
Gr GRAVEL
S.Gr SMALL GRAVEL
L.Gr LARGE GRAVEL

ESCARPMENT
Sa SAND
Si SILT
Or ORGANIC MATERIAL
DP DEBRIS PILE
BL BEAVER LODGE
BD BEAVER DAM
EM EMERGENT MACROPHYTES
SM SUBMERGENT MACROPHYTES
FM FLOATING MACROPHYTES
IV INSTREAM VEGETATION
TV TERRESTIAL VEGETATION
DEADFALL
RW ROOTWAD
SH SHRUB

MF MIXEDWOOD FOREST
CF CONIFEROUS FOREST
DF DECIDUOUS FOREST
SE SEDGES
GF GRASS/FORBES
MO MOSS

MT MINNOW TRAP

UCB UNDERCUT BANK
OHC OVERHEAD COVER
OHV OVERHANGING VEGETATION
ISC INSTREAM COVER
INV INUNDATED VEGETATION

USB UNSTABLE BANK

BW BACKWATER
IP IMPOUNDMENT POND
SN SNYE
CH CHUTE
CA CASCADE

SHALLOW SLOPE
MODERATE SLOPE
MODERATELY STEEP SLOPE
STEEP SLOPE
FLOW DIRECTION

RA RAPIDS
RF RIFFLE
R1 CLASS 1 RUN
R2 CLASS 2 RUN
R3 CLASS 3 RUN
P1 CLASS 1 POOL
P2 CLASS 2 POOL
P3 CLASS 3 POOL
FL FLAT
FA FALLS

WATER DEPTH
T1 TRANSECT

LH3 AQUATIC HABITAT MAP

NOT TO SCALE

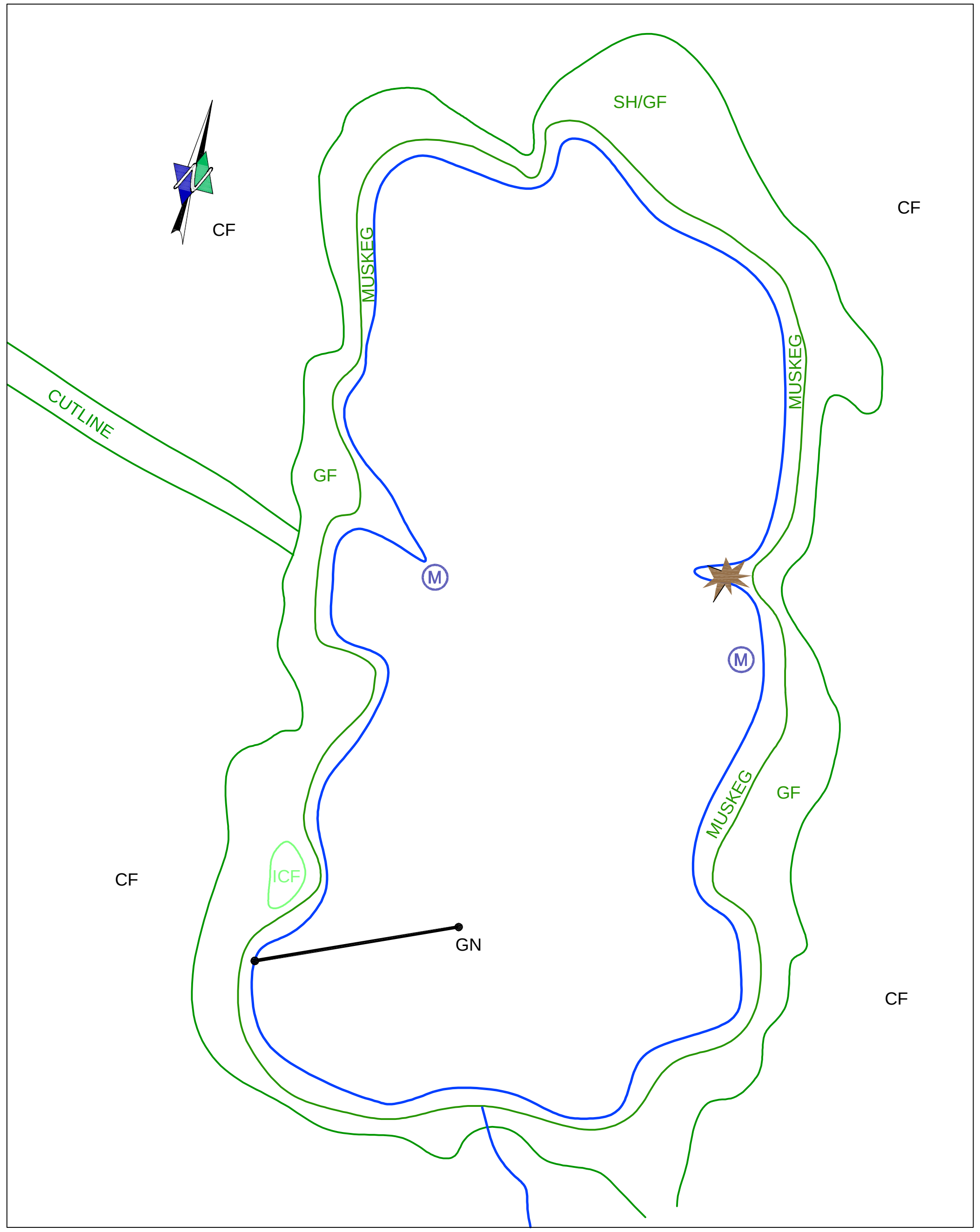


PHOTO 1. Aerial view of Soho Lake LH3.

PHOTO 2. South view from shore of Soho Lake LH3.

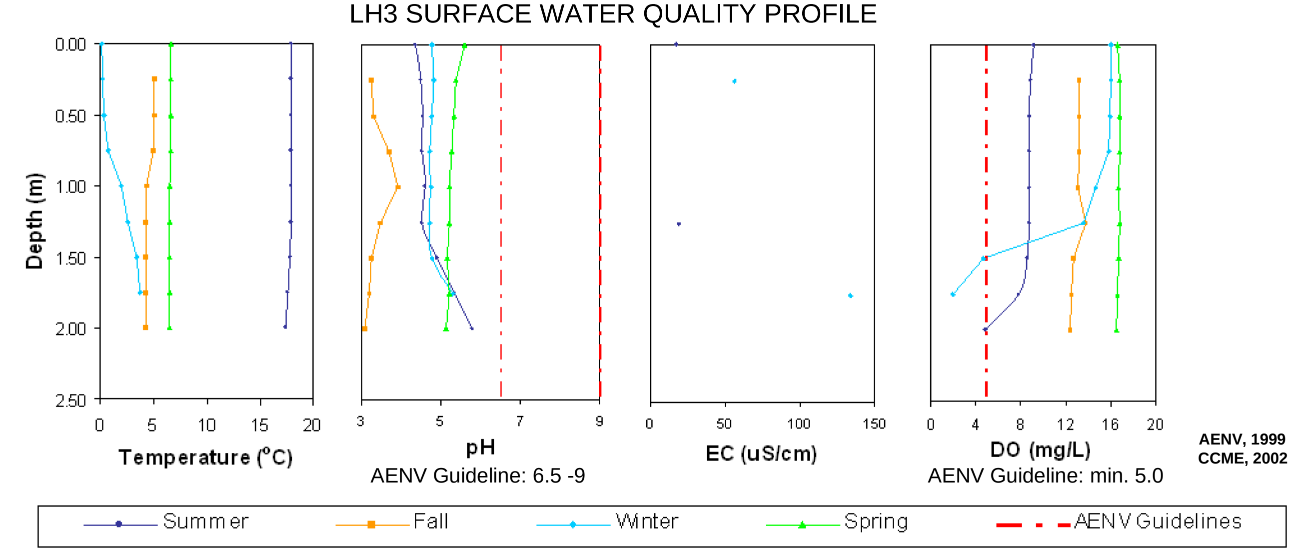
Soho Lake LH3

LH3, Soho Lake, is part of the Hangingstone watershed. No outlet or inlet was clearly defined and flow was likely reticulated through wetlands into Hangingstone River. Soho Lake had an approximate surface area of 0.2 km ^{2} and ranged in depth between 2 to 2.5 m. The euphotic zone extended the entire depth of the waterbody (secchi x = 1.03 m) and turbidity was low (x = 2.87 NTU). Black spruce forest surrounded the lake and shoreline vegetation included grass, forbs and shrubs and were overhanging in sections. Substrate was silty organic fines and supported patches of emergent aquatic vegetation. Potential for overwintering habitat was low for sport fish and moderate for forage fish based on adequate DO but shallow depth. Spawning, rearing and feeding potential were low for sport fish and moderate for forage fish to the capture of sticklebacks in their spawning season (spring). A beaver lodge was observed on the edge of the lake during summer, fall and spring surveys.

LH3 HABITAT POTENTIAL RANKING

Fish Habitat Potential	Large Bodied/Sport Fish	Forage Fish
Overwintering	low	moderate
Spawning	low	moderate
Rearing	low	moderate
Feeding	low	moderate

LH3 SURFACE WATER QUALITY PROFILE



LH3 FISHERIES COLLECTION DATA

Sampling Season	Angling		Minnow Trap		Gill Nets	
	Fish Captured	Effort (h)	Fish Captured	Effort (h)	Fish Captured	Effort (h)
Winter	0	125	0	53.85	0	18.05
Spring	--	--	126 BRST	48.13	0	24.17
Summer	--	--	0	7.85	0	4.5
Fall	--	--	2 BRST	1.75	0	5
Total	**0**	**125**	**128 BRST**	**111.58**	**0**	**51.72**

Note(s):
'--' = method not used during this survey
BRST = Brook Stickleback

Title:

HANGINGSTONE STUDY AREA, LH3, WATERBODY DATA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: GI	Revision Date: JUNE 7, 07
File: 4455-HABITAT-07-WB	

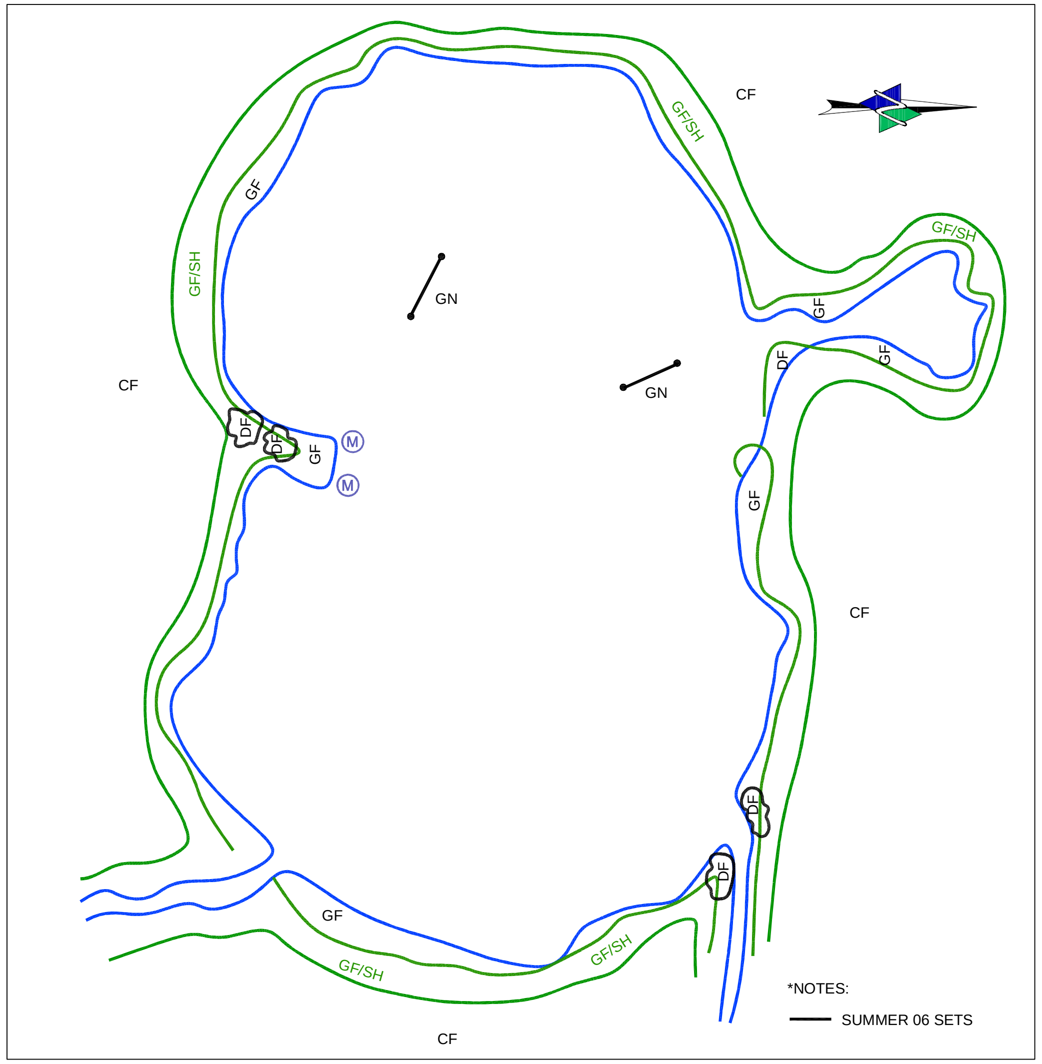
Drawn by: BSW	Checked: TJ	Fig. No.: 8.5-35

LEGEND

- Ba BARE GROUND
- Bd BEDROCK
- Bo BOULDER
- L.Bo LARGE BOULDER
- Co COBBLE
- S.Co SMALL COBBLE
- L.Co LARGE COBBLE
- Gr GRAVEL
- S.Gr SMALL GRAVEL
- L.Gr LARGE GRAVEL
- ESCARPMENT
- Sa SAND
- Si SILT
- Or ORGANIC MATERIAL
- DP DEBRIS PILE
- BL BEAVER LODGE
- BD BEAVER DAM
- EM EMERGENT MACROPHYTES
- SM SUBMERGENT MACROPHYTES
- FM FLOATING MACROPHYTES
- IV INSTREAM VEGETATION
- TV TERRESTIAL VEGETATION
- DEADFALL
- RW ROOTWAD
- SH SHRUB
- MF MIXEDWOOD FOREST
- CF CONIFEROUS FOREST
- DF DECIDUOUS FOREST
- SE SEDGES
- GF GRASS/FORBES
- MO MOSS
- MT MINNOW TRAP
- UCB UNDERCUT BANK
- OHC OVERHEAD COVER
- OHV OVERHANGING VEGETATION
- ISC INSTREAM COVER
- INV INUNDATED VEGETATION
- USB UNSTABLE BANK
- BW BACKWATER
- IP IMPOUNDMENT POND
- SN SNYE
- CH CHUTE
- CA CASCADE
- SHALLOW SLOPE
- MODERATE SLOPE
- MODERATELY STEEP SLOPE
- STEEP SLOPE
- FLOW DIRECTION
- RA RAPIDS
- RF RIFFLE
- R1 CLASS 1 RUN
- R2 CLASS 2 RUN
- R3 CLASS 3 RUN
- P1 CLASS 1 POOL
- P2 CLASS 2 POOL
- P3 CLASS 3 POOL
- FL FLAT
- FA FALLS
- WATER DEPTH
- T1 TRANSECT

LC1 AQUATIC HABITAT MAP

NOT TO SCALE



LC1 FISHERIES COLLECTION DATA

Sampling Season	Angling		Minnow Trap		Gill Nets	
	Fish Captured	Effort (h)	Fish Captured	Effort (h)	Fish Captured	Effort (h)
Winter	0	228.5	1 LKCH	24.75	--	--
Spring	--	--	318 BRST 5 PRDC	74.58	233 WHSC 76 PRDC 2 LNSC 1 NRPK	39.5
Summer	--	--	5 BRST	42.17	113 WHSC 26 LNSC 1 SPSH	40.42
Fall	--	--	6 SPSH 1 BRST	5.8	5 WHSC	9
Total	**0**	**228.5**	**324 BRST 1 LKCH 5 PRDC 6 SPSH**	**147.3**	**346 WHSC 76 PRDC 28 LNSC 1 NRPK 1 SPSH**	**88.92**

Note(s):
'--' = method not used during this survey
BRST = Brook Stickleback, LKCH = Lake Chub, LNSC = Longnose Sucker, NRPK = Northern Pike,
PRDC = Pearl Dace, SPSH = Spottail Shiner, WHSC = White Sucker

PHOTO 1. Aerial view of Egg Lake, LC1.

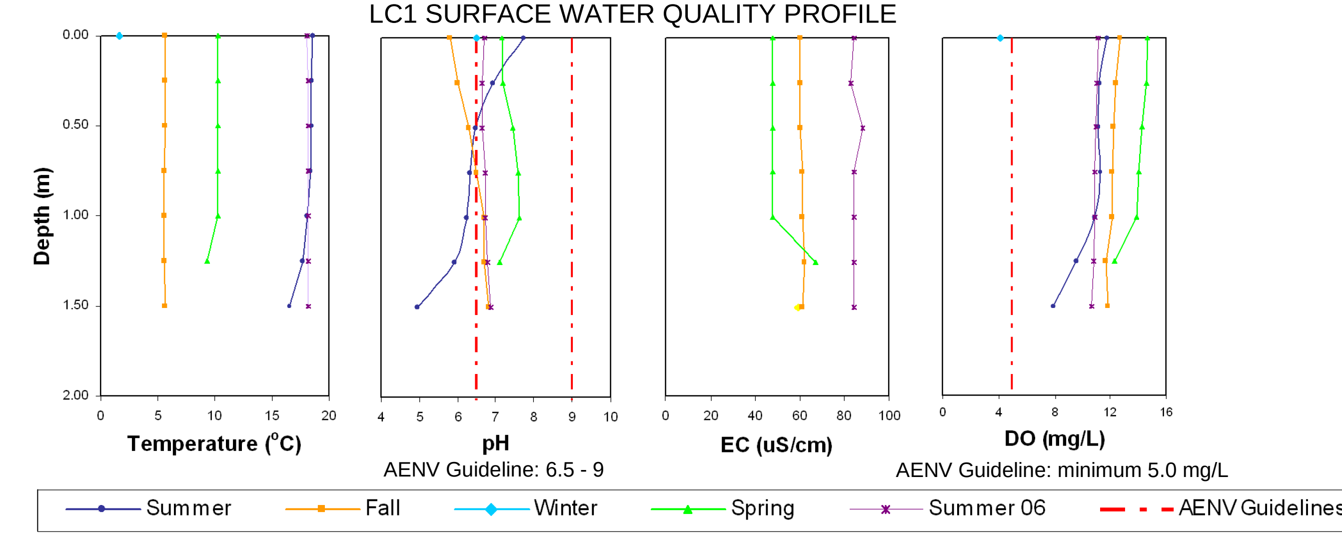
PHOTO 2. Northeast inlet of Egg Lake, LC1.

Egg Lake, Waterbody LC1

Egg Lake is situated in the Christina watershed and drains into the Christina River through a southeast outlet of moderate flow (0.23 m/s). LC1 was approximately 8.3 km² and was uniform and shallow with observed depths between 1.5 to 2 m. The euphotic zone spanned the entire lake depth (secchi x = 0.41 m) and turbidity was moderate compared with the other waterbodies (x = 37.63 NTU). Riparian vegetation consisted of black spruce bog and larch fen with patches of aspen, willow and birch. Shoreline vegetation included grass, shrubs and sedge with sections of sand and cobble. Substrate was predominantly silt with some sand and submerged and floating aquatic vegetation was common throughout the lake. Overwintering potential was low for sport fish due to limited depth and low DO, and moderate for forage fish based on the capture of lake chub. Spawning, rearing and feeding potential were high for sport and forage fish based on the capture of ripe suckers and suitable habitat. Five pelicans were observed on the lake in August 2005.

PHOTO 3. Lake chub (*Couesius plumbeus*) from Egg Lake LC1 (February 2006).

LC1 SURFACE WATER QUALITY PROFILE



LC1 HABITAT POTENTIAL RANKING

Fish Habitat Potential	Large Bodied/Sport Fish	Forage Fish
Overwintering	low	moderate
Spawning	high	high
Rearing	high	high
Feeding	high	high

Title:

CORNER STUDY AREA, LC1, WATERBODY DATA

NORTH AMERICAN OIL SANDS CORPORATION

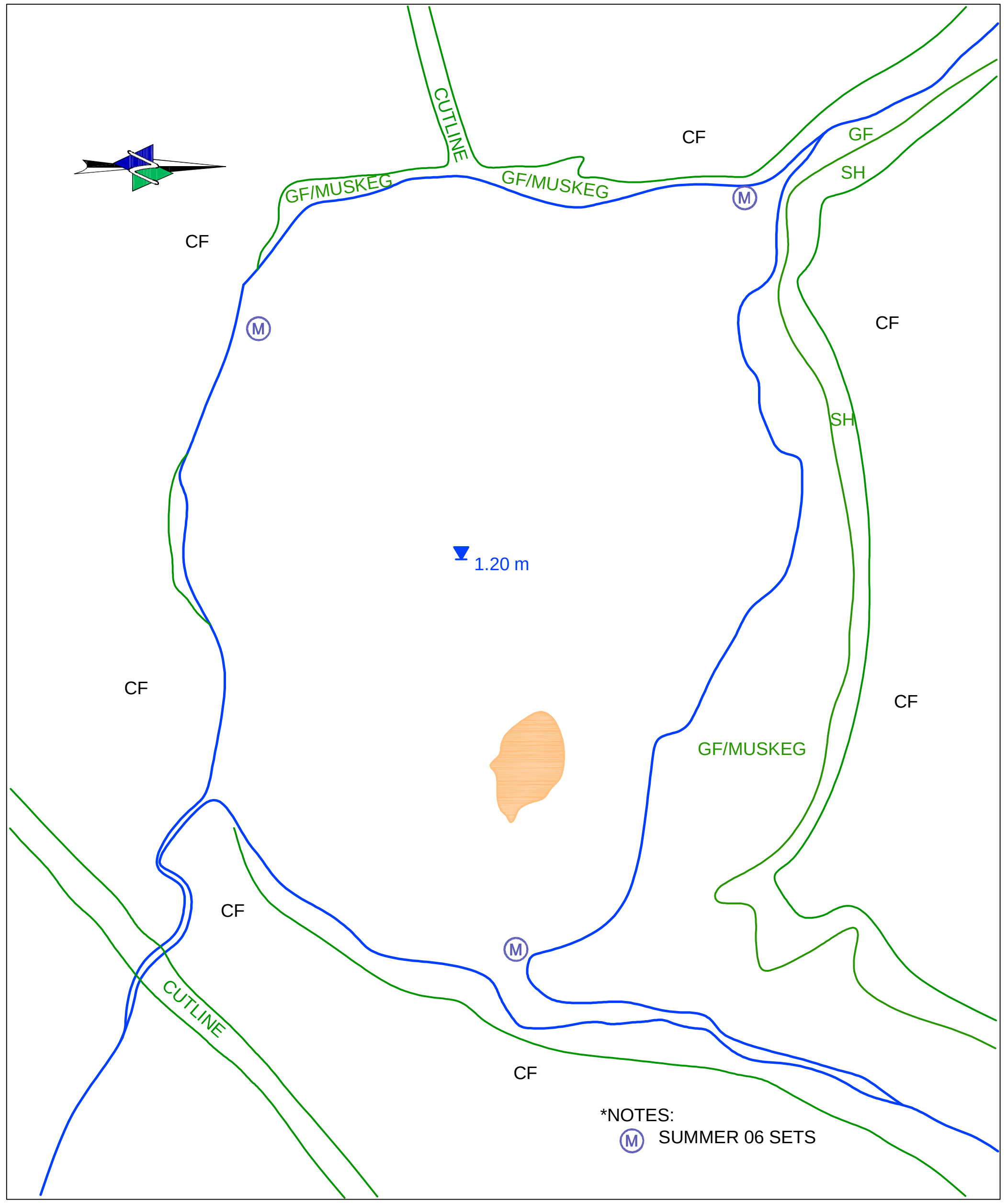
Approved: GI	Revision Date: JUNE 7, 07
File: 4455-HABITAT-07-WB	
Drawn by: BSW	Checked: TJ
Fig. No.: 8.5-36	

LEGEND

	Ba	BARE GROUND
	Bd	BEDROCK
	Bo	BOULDER
	L.Bo	LARGE BOULDER
	Co	COBBLE
	S.Co	SMALL COBBLE
	L.Co	LARGE COBBLE
	Gr	GRAVEL
	S.Gr	SMALL GRAVEL
	L.Gr	LARGE GRAVEL
		ESCARPMENT
	Sa	SAND
	Si	SILT
	Or	ORGANIC MATERIAL
	DP	DEBRIS PILE
	BL	BEAVER LODGE
	BD	BEAVER DAM
	EM	EMERGENT MACROPHYTES
	SM	SUBMERGENT MACROPHYTES
	FM	FLOATING MACROPHYTES
	IV	INSTREAM VEGETATION
	TV	TERRESTIAL VEGETATION
		DEADFALL
	RW	ROOTWAD
	SH	SHRUB
	MF	MIXEDWOOD FOREST
	CF	CONIFEROUS FOREST
	DF	DECIDUOUS FOREST
	SE	SEDGES
	GF	GRASS/FORBES
	MO	MOSS
	MT	MINNOW TRAP
	UCB	UNDERCUT BANK
	OHC	OVERHEAD COVER
	OHV	OVERHANGING VEGETATION
	ISC	INSTREAM COVER
	INV	INUNDATED VEGETATION
	USB	UNSTABLE BANK
	BW	BACKWATER
	IP	IMPOUNDMENT POND
	SN	SNYE
	CH	CHUTE
	CA	CASCADE
		SHALLOW SLOPE
		MODERATE SLOPE
		MODERATELY STEEP SLOPE
		STEEP SLOPE
		FLOW DIRECTION
	RA	RAPIDS
	RF	RIFFLE
	R1	CLASS 1 RUN
	R2	CLASS 2 RUN
	R3	CLASS 3 RUN
	P1	CLASS 1 POOL
	P2	CLASS 2 POOL
	P3	CLASS 3 POOL
	FL	FLAT
	FA	FALLS
		WATER DEPTH
	T1	TRANSECT

LC2 AQUATIC HABITAT MAP

NOT TO SCALE



LC2 FISH COLLECTION DATA

Sampling Season	Angling: Fish Captured	Angling: Effort (h)	Minnow Trap: Fish Captured	Minnow Trap: Effort (h)	Gill Nets: Fish Captured	Gill Nets: Effort (h)
Winter	N/A	N/A	N/A	N/A	N/A	N/A
Spring	--	--	49 BRST	76.45	0	25.67
Summer	--	--	8 BRST	6.5	56 WHSC 6 LNSC 2 SPSH	4.25
Fall	--	--	14 BRST	11.42	15 WHSC 3 LNSC	6.5
Total	**--**	**--**	**71 BRST**	**94.37**	**71 WHSC 9 LNSC 2 SPSH**	**36.42**

Note(s):
N/A = not sampled; '--' = method not used during this survey
BRST = Brook Stickleback, LNSC = Longnose Sucker, SPSH = Spottail Shiner, WHSC = White Sucker

PHOTO 1. Aerial view of unnamed waterbody LC2.

PHOTO 2. Northwest inlet of unnamed waterbody LC2.

Unnamed Waterbody LC2

LC2 is part of the Christina River watershed and drains into Christina River via a northwest outlet. Surface area was approximately 1.6 km² and depth was fairly uniform at 1.5 m. The euphotic zone extended the entire water column (secchi x = 0.87 m) and mean turbidity was low at 10.31 NTU. Surrounding vegetation consisted of hummocky grass and shrubs, flanked by black spruce bog with isolated patches of shrubby larch fen and overhanging deciduous stands. Substrate was silty fines. Submerged aquatic vegetation (coontail and potamagetons) covered most of the waterbody floor and a floating vegetation island about 20 to 45 m long comprised of sedge and shrubs was observed. Overwintering potential was not assessed due to shallow depth.

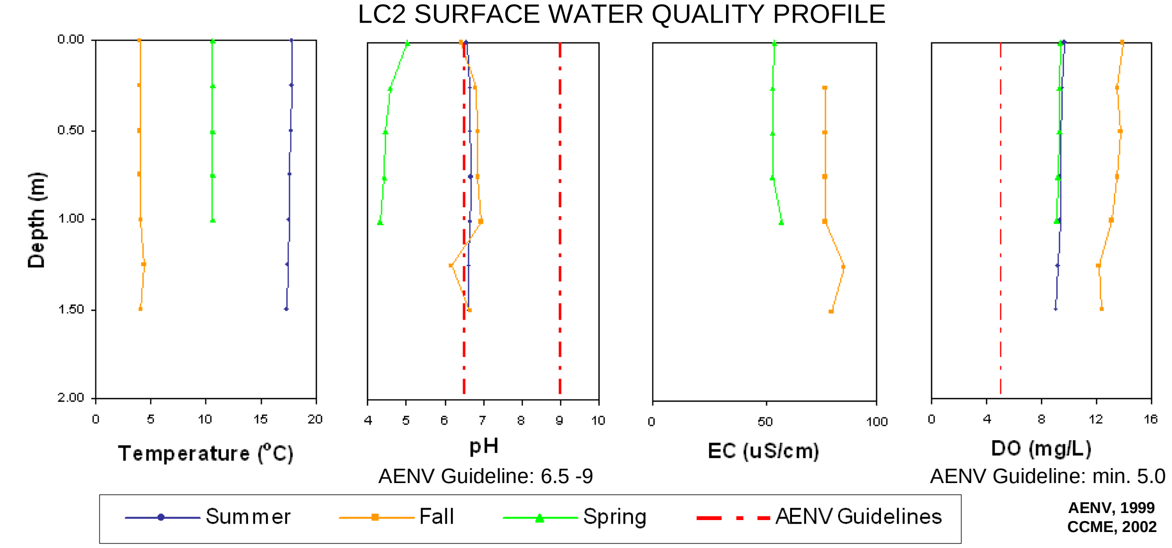
Potential for spawning habitat was low and high for sport fish and forage fish respectively. Rearing and feeding potential was high for both sport and forage fish. Incidental wildlife observations included moose, loons and a variety of waterfowl.

LC2 HABITAT POTENTIAL RANKING

Fish Habitat Potential	Large Bodied/Sport Fish	Forage Fish
Overwintering	--	--
Spawning	low	high
Rearing	high	high
Feeding	high	high

Note(s):
'--' = not sampled

LC2 SURFACE WATER QUALITY PROFILE



AENV, 1999
CCME, 2002

Title: **CORNER STUDY AREA, LC2, WATERBODY DATA**	NORTH AMERICAN OIL SANDS CORPORATION	
	Approved: GI	Revision Date: JUNE 7, 07
	File: 4455-HABITAT-07-WB	
	Drawn by: BSW	Checked: TJ	Fig. No.: 8.5-37

LEGEND

Ba BARE GROUND
Bd BEDROCK
Bo BOULDER
L.Bo LARGE BOULDER
Co COBBLE
S.Co SMALL COBBLE
L.Co LARGE COBBLE
Gr GRAVEL
S.Gr SMALL GRAVEL
L.Gr LARGE GRAVEL

ESCARPMENT
Sa SAND
Si SILT
Or ORGANIC MATERIAL
DP DEBRIS PILE
BL BEAVER LODGE
BD BEAVER DAM
EM EMERGENT MACROPHYTES
SM SUBMERGENT MACROPHYTES
FM FLOATING MACROPHYTES
IV INSTREAM VEGETATION
TV TERRESTIAL VEGETATION
DEADFALL
RW ROOTWAD
SH SHRUB

MF MIXEDWOOD FOREST
CF CONIFEROUS FOREST
DF DECIDUOUS FOREST
SE SEDGES
GF GRASS/FORBES
MO MOSS

MT MINNOW TRAP

UCB UNDERCUT BANK
OHC OVERHEAD COVER
OHV OVERHANGING VEGETATION
ISC INSTREAM COVER
INV INUNDATED VEGETATION

USB UNSTABLE BANK

BW BACKWATER
IP IMPOUNDMENT POND
SN SNYE
CH CHUTE
CA CASCADE

SHALLOW SLOPE
MODERATE SLOPE
MODERATELY STEEP SLOPE
STEEP SLOPE
FLOW DIRECTION

RA RAPIDS
RF RIFFLE
R1 CLASS 1 RUN
R2 CLASS 2 RUN
R3 CLASS 3 RUN
P1 CLASS 1 POOL
P2 CLASS 2 POOL
P3 CLASS 3 POOL
FL FLAT
FA FALLS

WATER DEPTH
T1 TRANSECT

LL1 AQUATIC HABITAT MAP

NOT TO SCALE

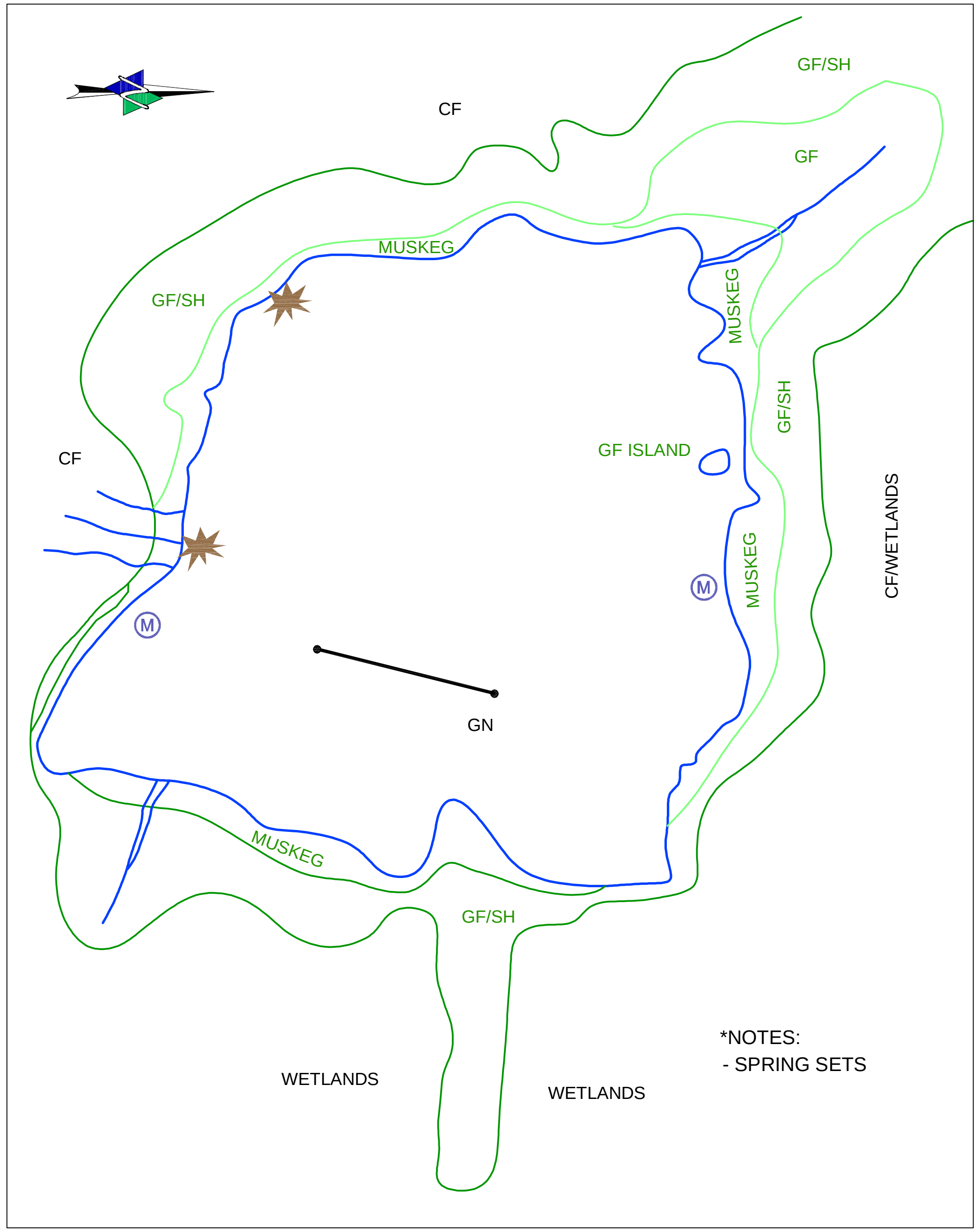


PHOTO 1. Aerial view of unnamed waterbody LL1.

PHOTO 2. South shore of unnamed waterbody LL1.

Unnamed Waterbody LL1

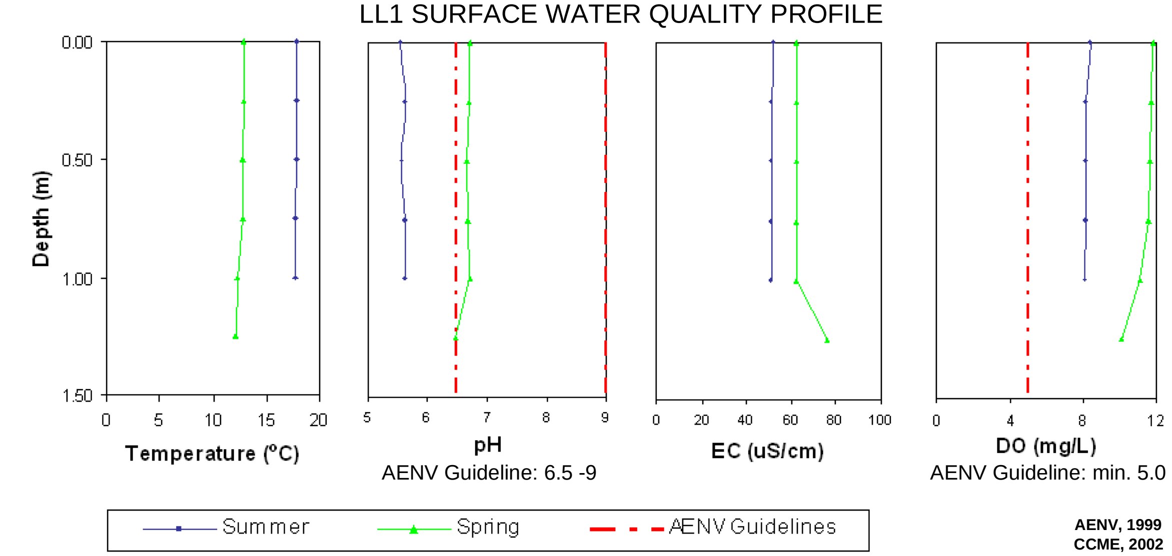
LL1 is part of the Christina River watershed and had no discernible inlet or outlet. Approximate surface area was 0.2 km^2 and observed depth ranged between 1 to 1.4 m. The euphotic zone extended to the waterbody floor (secchi x = 0.78 m) and turbidity was low at 1.67 NTU. Riparian vegetation was predominantly grass and shrubs flanked with black spruce bog and a large section of shrubby larch fen on the eastern shore. Substrate was silt and aquatic vegetation was prevalent throughout the waterbody with lily pads covering ~35-40% of the surface. Overwintering potential was not assessed due to shallow depth. The absence of an inlet and outlet and the lack of fish captured indicated extremely limited to non-existent potential for sport fish spawning, rearing and feeding habitat. Potential spawning, rearing and feeding habitat for forage fish was low based on limited watershed connectivity. Incidental wildlife observations included loon, grebe, mallard and other waterfowl. Two beaver lodges were present on the waterbody.

LL1 HABITAT POTENTIAL RANKING

Fish Habitat Potential	Large Bodied/Sport Fish	Forage Fish
Overwintering	--	--
Spawning	nil*	low
Rearing	nil*	low
Feeding	nil*	low

Note(s):
'--' = not sampled; nil* = no habitat observed

LL1 SURFACE WATER QUALITY PROFILE



AENV, 1999
CCME, 2002

LL1 FISHERIES COLLECTION DATA

Sampling Season	Angling		Minnow Trap		Electrofishing	
	Fish Captured	Effort (h)	Fish Captured	Effort (h)	Fish Captured	Effort (h)
Winter	N/A	N/A	N/A	N/A	N/A	N/A
Spring	--	--	0	45.08	0	22.5
Summer	--	--	0	1	--	--
Fall	N/A	N/A	N/A	N/A	N/A	N/A
Total	**0**	**0**	**0**	**46.08**	**0**	**22.5**

Note(s):
N/A = not sampled; '--' = method not used during this survey

Title:
LEISMER STUDY AREA, LL1, WATERBODY DATA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: GI	Revision Date: JUNE 7, 07	
File: 4455-HABITAT-07-WB		
Drawn by: BSW	Checked: TJ	Fig. No.: 8.5-38

LEGEND

Ba BARE GROUND
Bd BEDROCK
Bo BOULDER
L.Bo LARGE BOULDER
Co COBBLE
S.Co SMALL COBBLE
L.Co LARGE COBBLE
Gr GRAVEL
S.Gr SMALL GRAVEL
L.Gr LARGE GRAVEL

ESCARPMENT

Sa SAND
Si SILT
Or ORGANIC MATERIAL
DP DEBRIS PILE
BL BEAVER LODGE
BD BEAVER DAM
EM EMERGENT MACROPHYTES
SM SUBMERGENT MACROPHYTES
FM FLOATING MACROPHYTES
IV INSTREAM VEGETATION
TV TERRESTIAL VEGETATION
DEADFALL
RW ROOTWAD
SH SHRUB

MF MIXEDWOOD FOREST
CF CONIFEROUS FOREST
DF DECIDUOUS FOREST
SE SEDGES
GF GRASS/FORBES
MO MOSS

MT MINNOW TRAP

UCB UNDERCUT BANK
OHC OVERHEAD COVER
OHV OVERHANGING VEGETATION
ISC INSTREAM COVER
INV INUNDATED VEGETATION

USB UNSTABLE BANK

BW BACKWATER
IP IMPOUNDMENT POND
SN SNYE
CH CHUTE
CA CASCADE

SHALLOW SLOPE
MODERATE SLOPE
MODERATELY STEEP SLOPE
STEEP SLOPE
FLOW DIRECTION

RA RAPIDS
RF RIFFLE
R1 CLASS 1 RUN
R2 CLASS 2 RUN
R3 CLASS 3 RUN
P1 CLASS 1 POOL
P2 CLASS 2 POOL
P3 CLASS 3 POOL
FL FLAT
FA FALLS

WATER DEPTH
T1 TRANSECT

LL2 AQUATIC HABITAT MAP

NOT TO SCALE

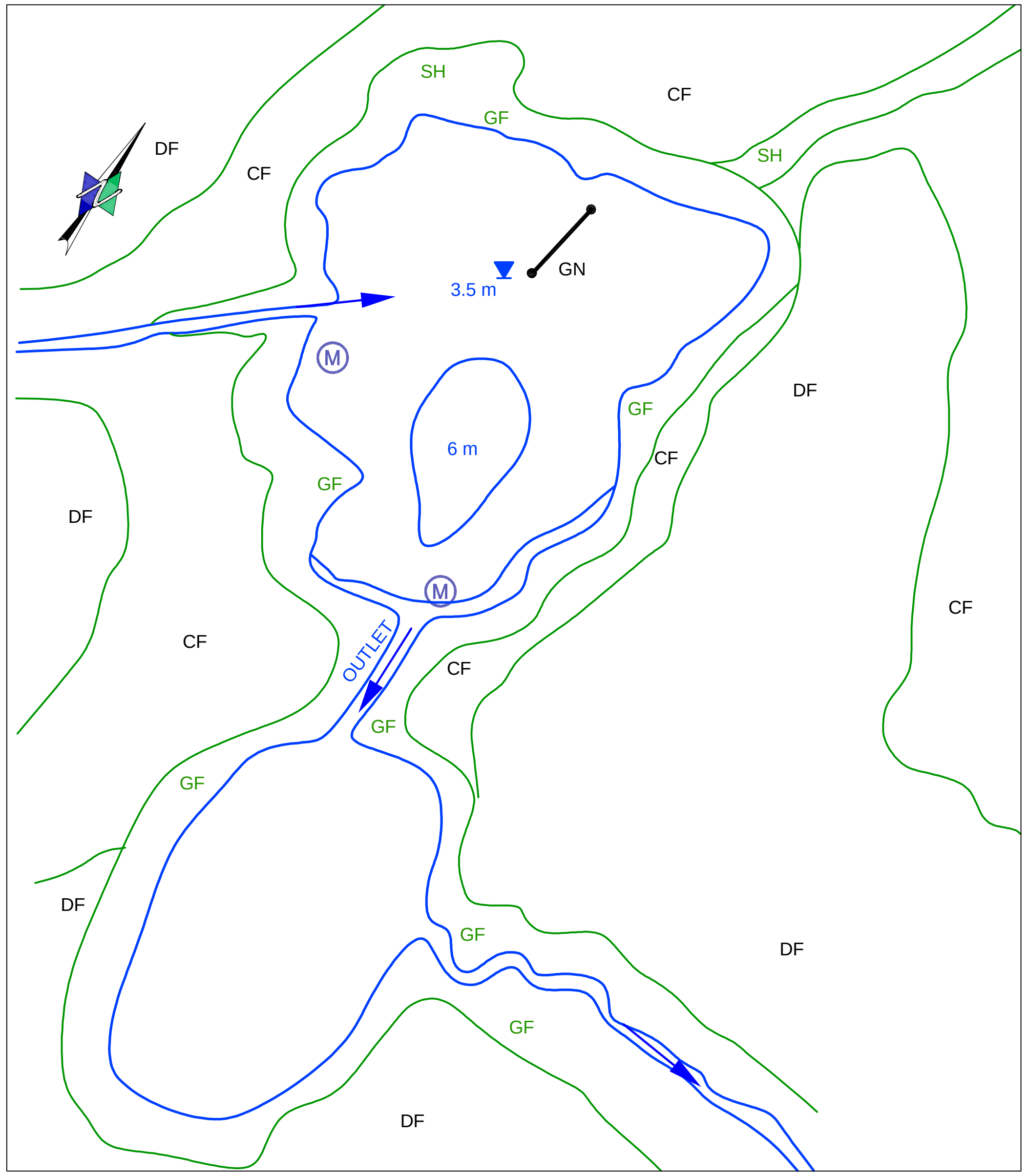


PHOTO 1. Aerial view of unnamed waterbody LL2.

PHOTO 2. South outlet of waterbody LL2.

Unnamed Waterbody LL2

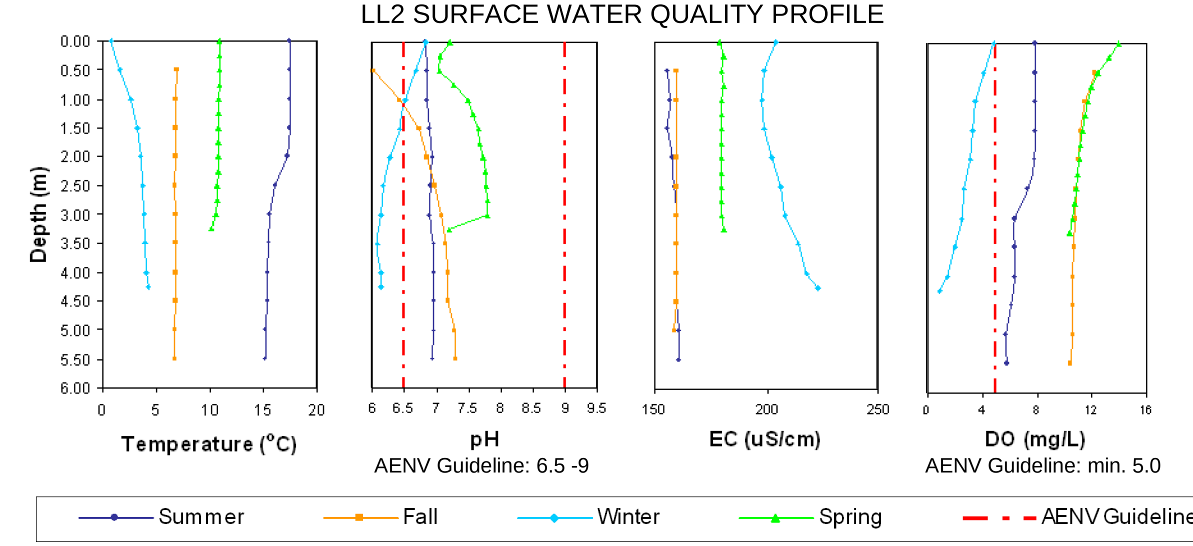
LL2 is part of the Christina River watershed, draining via another waterbody through a southeastern outlet of low flow (0.023 m/s), into Waddell Creek. LL2 had an approximate surface area of 0.3 km^2 and ranged in depth from 3.7 to 6.5 m. The euphotic zone extended to 3 m (secchi x = 0.99 m) but likely did not penetrate to the deepest section of the waterbody. Turbidity was low at 2.72 NTU. Riparian vegetation included black spruce stands and white spruce and aspen forest. The shoreline was comprised of sedge, grass, willow and cattails, and to a lesser extent, sand and cobble. A marshy wetland with emergent rushes, cattails and bulrushes was located on the northern shore. Substrate was silt with some sand and submerged vegetation was ubiquitous throughout. Although sufficient depth was present, inadequate DO precluded overwintering habitat for sport and forage fish except species able to tolerate low oxygen levels (ie pike and stickleback). Spawning, rearing and feeding habitat potential was high for sport and forage fish based in part on the abundance of fish captured.

LL2 FISHERIES COLLECTION DATA

Sampling Season	Angling: Fish Captured	Angling: Effort (h)	Minnow Trap: Fish Captured	Minnow Trap: Effort (h)	Gill Nets: Fish Captured	Gill Nets: Effort (h)
Winter	0	167.63	0	39	--	--
Spring	--	--	133 PRDC 84 BRST 1 FTMN	35.08	13 WHSC	17.8
Summer	--	--	171 SPSH 10 BRST 1 FTMN 1 WHSC	35.17	17 WHSC	35.75
Fall	--	--	6 SPSH	4.25	0	4.92
Total	**0**	**167.63**	**177 SPSH 133 PRDC 94 BRST 2 FTMN 1 WHSC**	**113.5**	**30 WHSC**	**58.47**

Note(s):
'--' = method not used during this survey
BRST = Brook Stickleback, FTMN = Fathead Minnow, PRDC = Pearl Dace, SPSH = Spottail Shiner, WHSC = White Sucker

LL2 SURFACE WATER QUALITY PROFILE



AENV, 1999
CCME, 2002

LL2 HABITAT POTENTIAL RANKING

Fish Habitat Potential	Large Bodied/Sport Fish	Forage Fish
Overwintering	low	moderate
Spawning	high	high
Rearing	high	high
Feeding	high	high

Title:

LEISMER STUDY AREA, LL2, WATERBODY DATA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: GI	Revision Date: JUNE 7, 07	
File: 4455-HABITAT-07-WB		
Drawn by: BSW	Checked: TJ	Fig. No.: 8.5-39

LEGEND

Ba BARE GROUND
Bd BEDROCK
Bo BOULDER
L.Bo LARGE BOULDER
Co COBBLE
S.Co SMALL COBBLE
L.Co LARGE COBBLE
Gr GRAVEL
S.Gr SMALL GRAVEL
L.Gr LARGE GRAVEL

ESCARPMENT

Sa SAND
Si SILT
Or ORGANIC MATERIAL
DP DEBRIS PILE
BL BEAVER LODGE
BD BEAVER DAM
EM EMERGENT MACROPHYTES
SM SUBMERGENT MACROPHYTES
FM FLOATING MACROPHYTES
IV INSTREAM VEGETATION
TV TERRESTIAL VEGETATION
DEADFALL
RW ROOTWAD
SH SHRUB

MF MIXEDWOOD FOREST
CF CONIFEROUS FOREST
DF DECIDUOUS FOREST
SE SEDGES
GF GRASS/FORBES
MO MOSS

MT MINNOW TRAP

UCB UNDERCUT BANK
OHC OVERHEAD COVER
OHV OVERHANGING VEGETATION
ISC INSTREAM COVER
INV INUNDATED VEGETATION

USB UNSTABLE BANK

BW BACKWATER
IP IMPOUNDMENT POND
SN SNYE
CH CHUTE
CA CASCADE

SHALLOW SLOPE
MODERATE SLOPE
MODERATELY STEEP SLOPE
STEEP SLOPE
FLOW DIRECTION

RA RAPIDS
RF RIFFLE
R1 CLASS 1 RUN
R2 CLASS 2 RUN
R3 CLASS 3 RUN
P1 CLASS 1 POOL
P2 CLASS 2 POOL
P3 CLASS 3 POOL
FL FLAT
FA FALLS

WATER DEPTH

T1 TRANSECT

LL3 AQUATIC HABITAT MAP

NOT TO SCALE

PHOTO 1. View of unnamed waterbody LL3 from east shore.

PHOTO 2. South outlet of unnamed waterbody LL3.

Unnamed Waterbody LL3

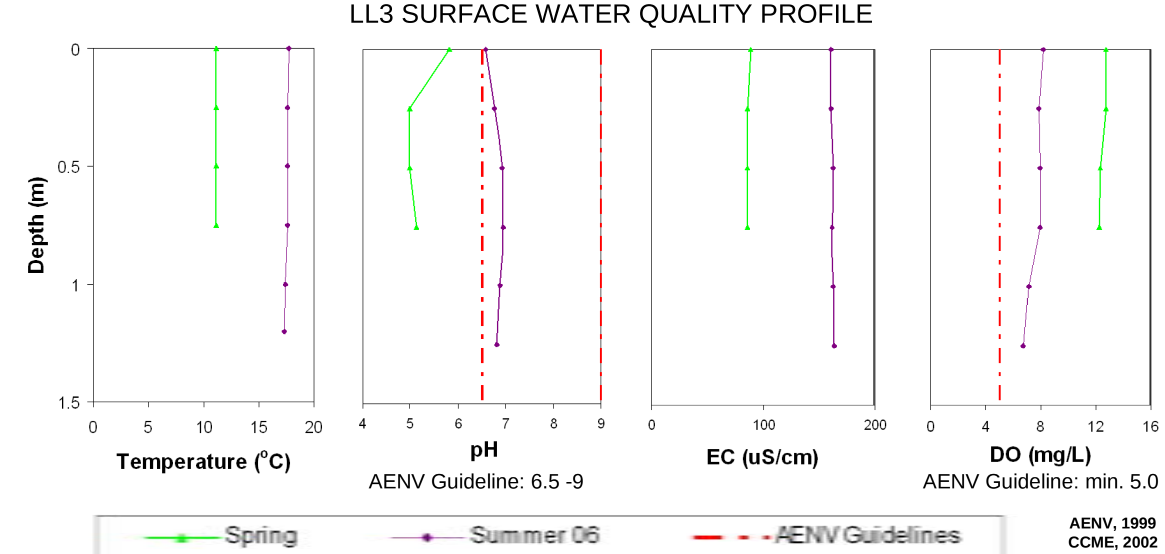
LL3 is part of the House River watershed and drains into House River through a southwest outlet. Surface area was approximately 1.5 km² and depth was greater than 1 m. The lower limit of the euphotic zone was 3.69 m (secchi = 1.23 m) and turbidity was low at 11.05 NTU. Riparian vegetation consisted of grass, sedge and shrubs, flanked by black spruce bog and a treed island was located in the eastern portion of the waterbody. Substrate was silt with sections of sand and cobble. Overwintering habitat potential was unknown. Spawning, rearing and feeding habitat potential were high for sport fish based on the capture of large juvenile northern pike in the spring. Although no forage fish were captured, potential for spawning, rearing and feeding habitat was high; the capture of northern pike implies the presence of feeder fish and the habitat observed can potentially support a forage fish population.

LL3 HABITAT POTENTIAL RANKING

Fish Habitat Potential	Large Bodied/Sport Fish	Forage Fish
Overwintering	–	–
Spawning	high	high
Rearing	high	high
Feeding	high	high

Note(s):
'–' = not sampled

LL3 SURFACE WATER QUALITY PROFILE



AENV, 1999
CCME, 2002

LL3 FISHERIES COLLECTION DATA

Sampling Season	Angling: Fish Captured	Angling: Effort (h)	Minnow Trap: Fish Captured	Minnow Trap: Effort (h)	Gill Nets: Fish Captured	Gill Nets: Effort (h)
Winter	N/A	N/A	N/A	N/A	N/A	N/A
Spring	--	--	0	35.6	8 NRPK	19.47
Summer	N/A	N/A	N/A	N/A	N/A	N/A
Fall	N/A	N/A	N/A	N/A	N/A	N/A
Total	**--**	**--**	**0**	**35.6**	**8 NRPK**	**19.47**

Note(s):
N/A = not sampled; '--' = method not used during this survey
NRPK = Northern Pike

Title:

LEISMER STUDY AREA, LL3, WATERBODY DATA

NORTH AMERICAN OIL SANDS CORPORATION

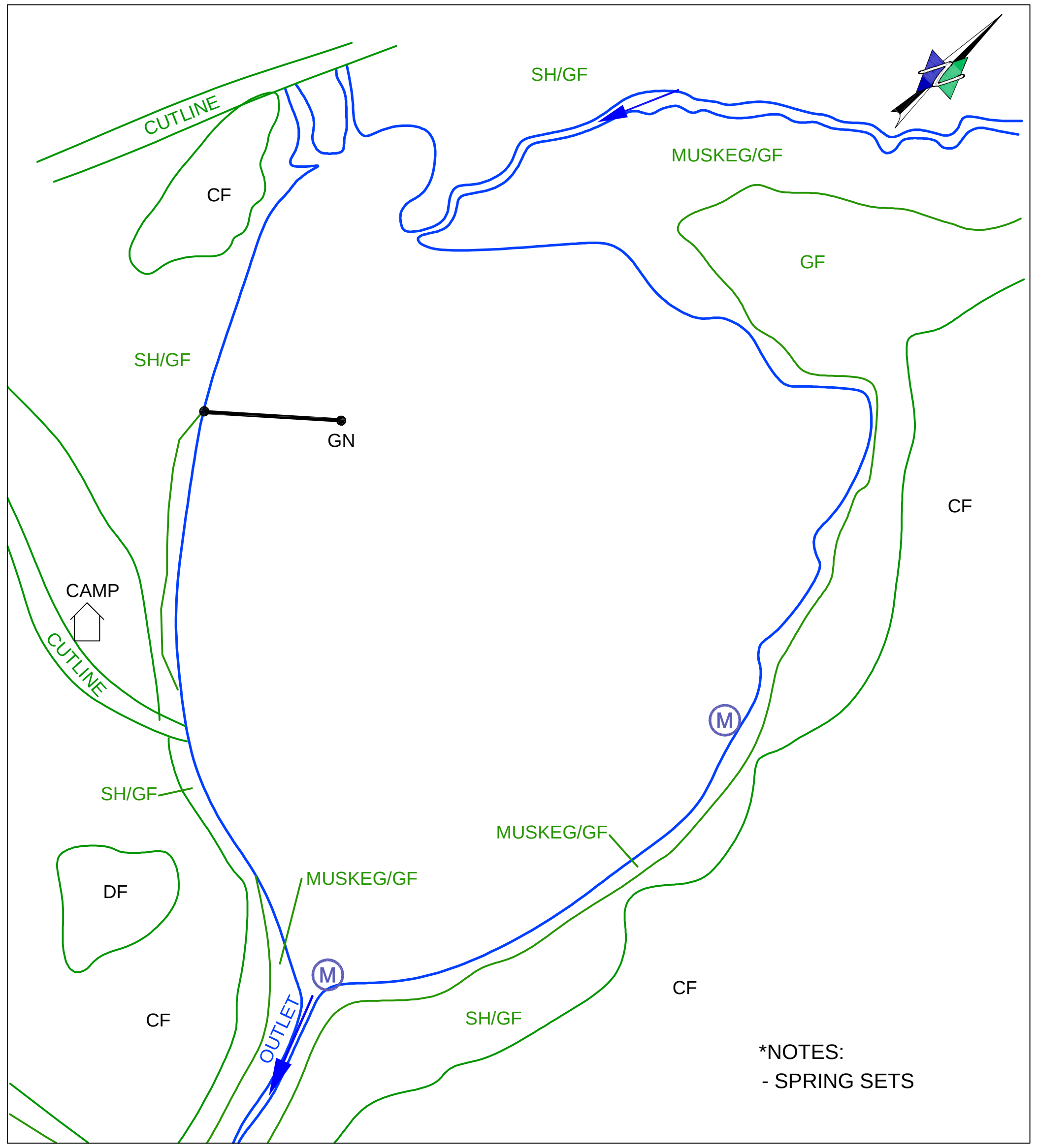
Approved: GI	Revision Date: JUNE 7, 07	
File: 4455-HABITAT-07-WB		
Drawn by: BSW	Checked: TJ	Fig. No.: 8.5-40

LEGEND

	Ba	BARE GROUND
	Bd	BEDROCK
	Bo	BOULDER
	L.Bo	LARGE BOULDER
	Co	COBBLE
	S.Co	SMALL COBBLE
	L.Co	LARGE COBBLE
	Gr	GRAVEL
	S.Gr	SMALL GRAVEL
	L.Gr	LARGE GRAVEL
		ESCARPMENT
	Sa	SAND
	Si	SILT
	Or	ORGANIC MATERIAL
	DP	DEBRIS PILE
	BL	BEAVER LODGE
	BD	BEAVER DAM
	EM	EMERGENT MACROPHYTES
	SM	SUBMERGENT MACROPHYTES
	FM	FLOATING MACROPHYTES
	IV	INSTREAM VEGETATION
	TV	TERRESTIAL VEGETATION
		DEADFALL
	RW	ROOTWAD
	SH	SHRUB
	MF	MIXEDWOOD FOREST
	CF	CONIFEROUS FOREST
	DF	DECIDUOUS FOREST
	SE	SEDGES
	GF	GRASS/FORBES
	MO	MOSS
	MT	MINNOW TRAP
	UCB	UNDERCUT BANK
	OHC	OVERHEAD COVER
	OHV	OVERHANGING VEGETATION
	ISC	INSTREAM COVER
	INV	INUNDATED VEGETATION
	USB	UNSTABLE BANK
	BW	BACKWATER
	IP	IMPOUNDMENT POND
	SN	SNYE
	CH	CHUTE
	CA	CASCADE
		SHALLOW SLOPE
		MODERATE SLOPE
		MODERATELY STEEP SLOPE
		STEEP SLOPE
		FLOW DIRECTION
	RA	RAPIDS
	RF	RIFFLE
	R1	CLASS 1 RUN
	R2	CLASS 2 RUN
	R3	CLASS 3 RUN
	P1	CLASS 1 POOL
	P2	CLASS 2 POOL
	P3	CLASS 3 POOL
	FL	FLAT
	FA	FALLS
		WATER DEPTH
	T1	TRANSECT

LL4 AQUATIC HABITAT MAP

NOT TO SCALE



LL4 FISHERIES COLLECTION DATA

Sampling Season	Angling		Minnow Trap		Gill Nets	
	Fish Captured	Effort (h)	Fish Captured	Effort (h)	Fish Captured	Effort (h)
Winter	0	133.55	2 BRST	38.68	--	--
Spring	--	--	185 BRST 13 FTMN	53.58	26 NRPK 13 WHSC 2 PRDC	23.47
Summer	--	--	27 BRST	13.78	28 WHSC 1 ARGR	7.58
Fall	--	--	13 BRST	59.52	6 WHSC 6 ARGR 2 NRPK 1 LNSC	37.03
Total	**0**	**133.55**	**227 BRST 13 FTMN**	**165.56**	**47 WHSC 28 NRPK 7 ARGR 2 PRDC 1 LNSC**	**68.08**

Note(s):
'--' = method not used during this survey
ARGR = Arctic Grayling, BRST = Brook Stickleback, FTMN = Fathead Minnow, LNSC = Longnose Sucker, NRPK = Northern Pike, PRDC = Pearl Dace, WHSC = White Sucker

PHOTO 1. Aerial view of unnamed waterbody LL4.

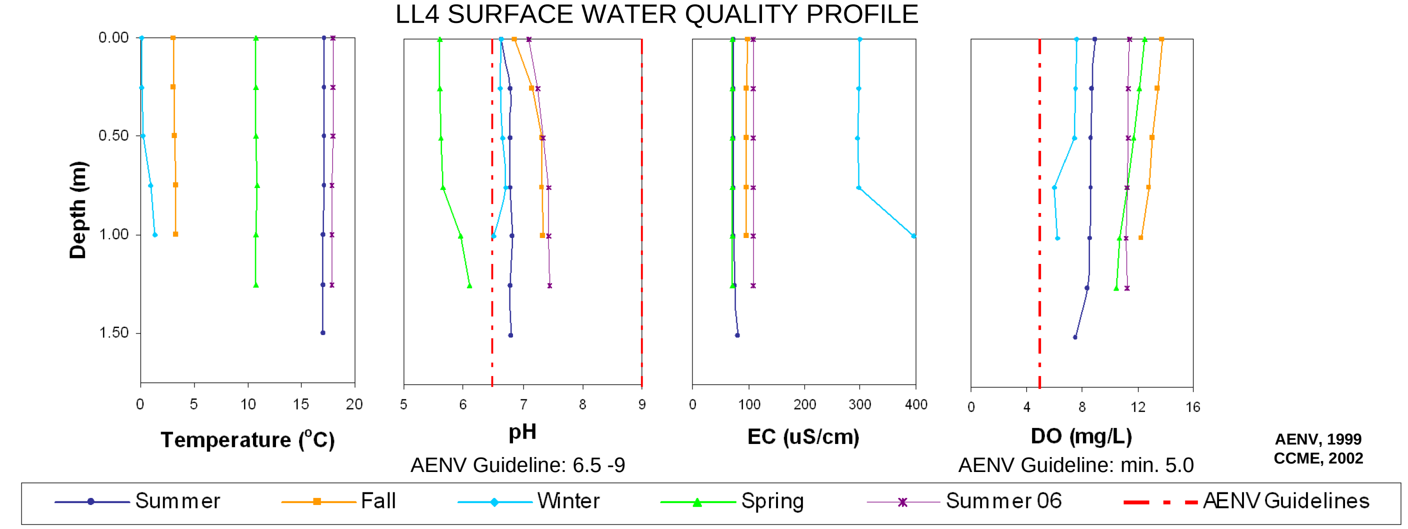
PHOTO 2. Southwest outlet of unnamed waterbody LL4.

Unnamed Waterbody LL4

LL4 is the headwaters of the Christina River and drains through a well-connected southeast outlet. Approximate surface area was 1.2 km² and overall depth was about 1.5 m. The euphotic zone reached the waterbody floor (secchi x = 0.67 m) and mean turbidity was low at 13.58 NTU. Surrounding vegetation included tamarack fen and black spruce/ tamarack forest interspersed with small aspen stands. Shoreline vegetation consisted of grass and shrubs, and substrate was comprised of silt with some sandy sections. Overwintering potential was low for sport fish and moderate for forage fish. Although winter oxygen levels were adequate, water depth constrained overwintering habitat to small forage fish such as the stickleback captured in winter 2006. Spawning, rearing and feeding habitat potential were high for both sport and forage fish based on the diversity and abundance of species captured. The capture of Arctic Grayling in summer and fall 2005 indicated use of this waterbody by this species which is rated as 'sensitive' by AENV.

PHOTO 3. Fathead minnow (*pimephales promelas*) from unnamed waterbody LL4.

LL4 SURFACE WATER QUALITY PROFILE



LL4 HABITAT POTENTIAL RANKING

Fish Habitat Potential	Large Bodied/Sport Fish	Forage Fish
Overwintering	low	moderate
Spawning	high	high
Rearing	high	high
Feeding	high	high

Title: **LEISMER STUDY AREA, LL4, WATERBODY DATA**	NORTH AMERICAN OIL SANDS CORPORATION	
Approved: GI	Revision Date: JUNE 7, 07	
File: 4455-HABITAT-07-WB		
Drawn by: BSW	Checked: TJ	Fig. No.: 8.5-41

LEGEND

Ba BARE GROUND
Bd BEDROCK
Bo BOULDER
L.Bo LARGE BOULDER
Co COBBLE
S.Co SMALL COBBLE
L.Co LARGE COBBLE
Gr GRAVEL
S.Gr SMALL GRAVEL
L.Gr LARGE GRAVEL

ESCARPMENT
Sa SAND
Si SILT
Or ORGANIC MATERIAL
DP DEBRIS PILE
BL BEAVER LODGE
BD BEAVER DAM
EM EMERGENT MACROPHYTES
SM SUBMERGENT MACROPHYTES
FM FLOATING MACROPHYTES
IV INSTREAM VEGETATION
TV TERRESTIAL VEGETATION
DEADFALL
RW ROOTWAD
SH SHRUB

MF MIXEDWOOD FOREST
CF CONIFEROUS FOREST
DF DECIDUOUS FOREST
SE SEDGES
GF GRASS/FORBES
MO MOSS

MT MINNOW TRAP

UCB UNDERCUT BANK
OHC OVERHEAD COVER
OHV OVERHANGING VEGETATION
ISC INSTREAM COVER
INV INUNDATED VEGETATION

USB UNSTABLE BANK

BW BACKWATER
IP IMPOUNDMENT POND
SN SNYE
CH CHUTE
CA CASCADE

SHALLOW SLOPE
MODERATE SLOPE
MODERATELY STEEP SLOPE
STEEP SLOPE
FLOW DIRECTION

RA RAPIDS
RF RIFFLE
R1 CLASS 1 RUN
R2 CLASS 2 RUN
R3 CLASS 3 RUN
P1 CLASS 1 POOL
P2 CLASS 2 POOL
P3 CLASS 3 POOL
FL FLAT
FA FALLS

WATER DEPTH
T1 TRANSECT

LL5 AQUATIC HABITAT MAP

NOT TO SCALE

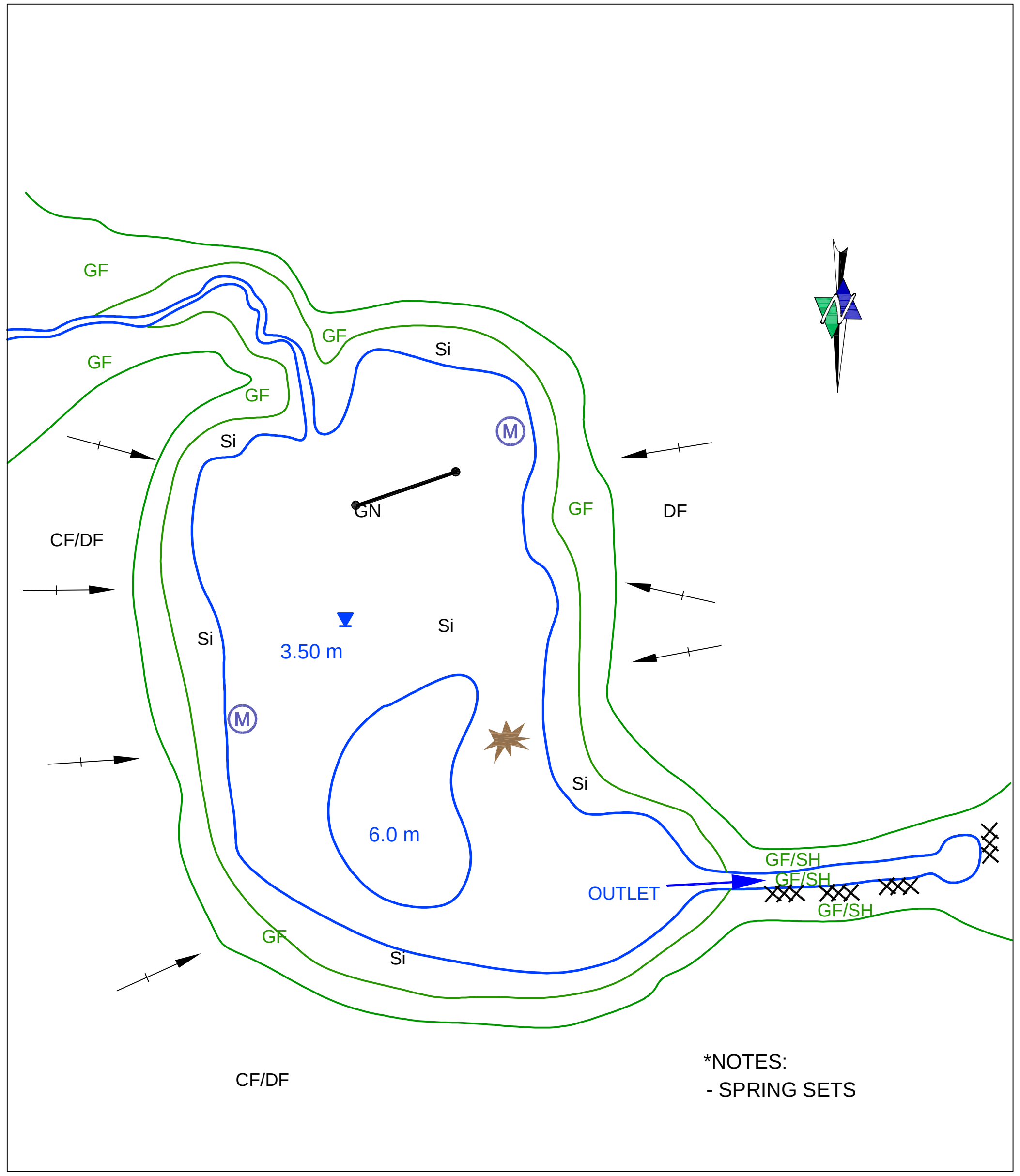


PHOTO 1. Aerial view of unnamed waterbody LL5.

PHOTO 2. Beaver dam on unnamed waterbody LL5.

Unnamed Waterbody LL5

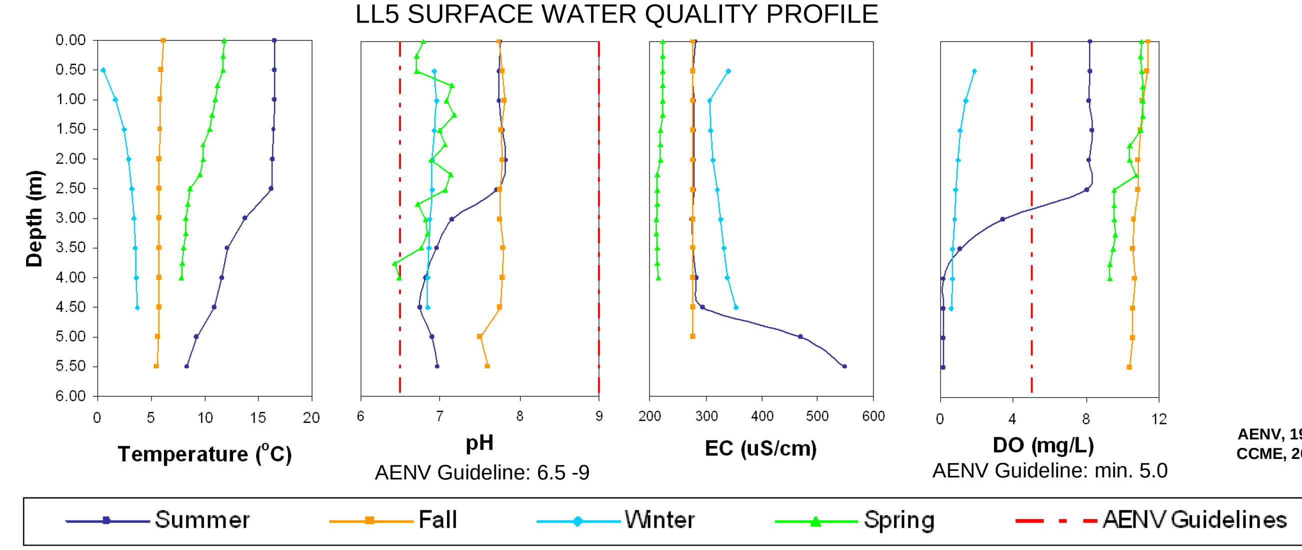
LL5 drains north into May River and is part of the Christina River watershed. The waterbody had an approximate surface area of 0.03 km² and was beaver impounded with a maximum depth of about 6 m. The euphotic zone was 5.88 m (secchi x = 1.96 m) and mean turbidity was low (4.4 NTU). Riparian vegetation consisted of aspen and spruce mixed forest and aquatic vegetation was prevalent including emergent cattails, rush and sedge, and submerged coontail, pond weed and lilies. Substrate was silty organics with trace sand on shore. Although depth was sufficient, overwintering habitat potential was limited to species tolerant of low oxygen conditions (ie stickleback). Spawning, rearing and feeding habitat potential was low for sport fish as access to the waterbody would be limited to flood events and to species capable of utilizing highly vegetated habitat (ie pike). Spawning, rearing and feeding potential habitat for forage fish was moderate based on the presence of stickleback during fish capture efforts. Wildlife observations included loons with young, a moose with calf, beaver and black bear and cubs in the vicinity.

LL5 HABITAT POTENTIAL RANKING

Fish Habitat Potential	Large Bodied/Sport Fish	Forage Fish
Overwintering	nil*	low
Spawning	low	moderate
Rearing	low	moderate
Feeding	low	moderate

Note(s):
nil* = no habitat observed

LL5 SURFACE WATER QUALITY PROFILE



LL5 FISHERIES COLLECTION DATA

Sampling Season	Angling		Minnow Trap		Gill Nets	
	Fish Captured	Effort (h)	Fish Captured	Effort (h)	Fish Captured	Effort (h)
Winter	0	46.34	0	23.58	--	--
Spring	--	--	0	38	0	18.98
Summer	--	--	0	0.75	--	--
Fall	--	--	23 BRST	2.5	0	1.05
Total	**0**	**46.34**	**23 BRST**	**64.83**	**0**	**20.03**

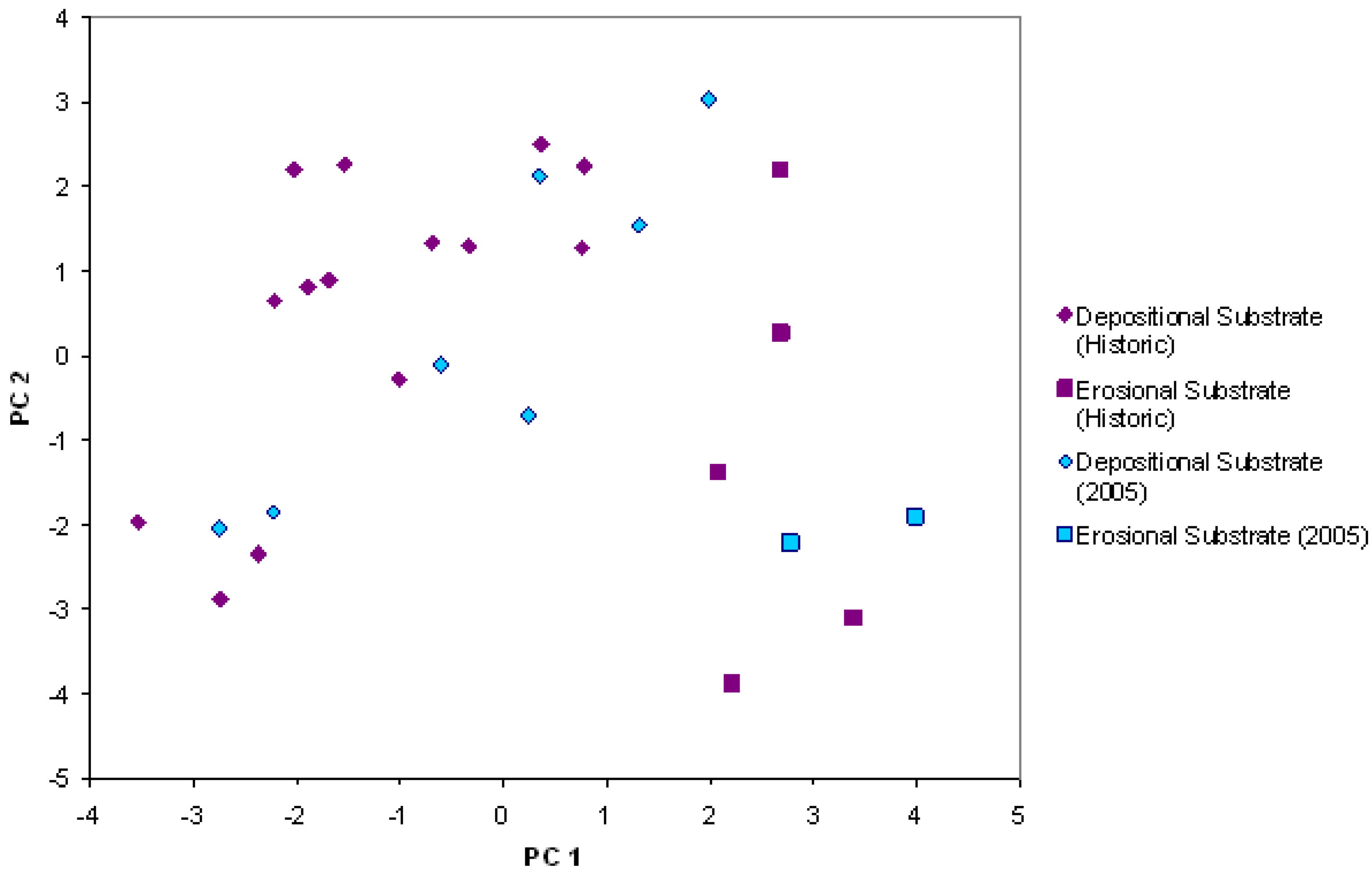
Note(s):
'--' = method not used during this survey
BRST = Brook Stickleback

Title:

LEISMER STUDY AREA, LL5, WATERBODY DATA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: GI	Revision Date: JUNE 7, 07	
File: 4455-HABITAT-07-WB		
Drawn by: BSW	Checked: TJ	Fig. No.: 8.5-42



Title:

Principal Component Analysis Showing Relationships among Benthic Invertebrate Communities from Depositional and Erosional Sites (includes data from historic samples)

NORTH AMERICAN OIL SANDS CORPORATION

Approved: DJ	Revision Date: June 6, 2007
File:	

Drawn by:	Checked:	Fig. No.:
JC	LZ	8.5-43

I:\4455-514_NAOSC\NAOSC_Maps\General Maps\March\Figure 8.25-29 Principal Component Analysis Showing Relationships among Benthic Invertebrate Communities from Depositional and Erosional Sites (includes data from historical project samples).mxd

APPENDIX 5A
Geologic and Hydrostratigraphic Mapping

5A1 GEOLOGIC AND HYDROSTRATIGRAPHIC MAPPING METHODOLOGY

Geologic mapping was completed in two parts: detailed geologic mapping was completed within the LSA and additional geologic mapping was completed throughout the RSA for the purposes of extrapolating the local hydrostratigraphic surfaces.

5A1.1 Detailed Mapping of the LSA

The detailed mapping objective was to delineate potential aquifers (porous sand) within the Mannville Group in the LSA using well log data. Detailed mapping of geologic units stratigraphically higher than the Mannville Group (i.e., the Colorado Group) was referenced from North American's Leismer Demonstration Project Application (North American, 2006).

A total of 1635 well logs (Table 5A-1; Figure 5A-1) were used in the final Mannville mapping. Selected wireline logs were omitted from the final mapping for the following reasons:

- Incomplete, illegible or unavailable geophysical logs;
- Multiple wells in one LSD location (picked one well per LSD);
- High well density in eastern part of the study (e.g., picked one well per Section in Rge 6, Twp 83); and
- Incorrect KB elevation.

The geology from the Wabiskaw Member to the Devonian surface including the Basal McMurray Aquifer was reviewed and mapped across Township 75. The purpose of the additional mapping in Township 75 was to determine the extent of the connection of Basal McMurray Aquifer identified in the LSA to the thick and regionally extensive Basal McMurray Aquifer located south of the LSA.

5A1.1.1 Isopach Maps

Aquifer isopach maps were created for the Lower Grand Rapids, Clearwater A, Clearwater B and Basal McMurray aquifers. The selected type log illustrates the position of the Lower Grand Rapids, Clearwater B and Basal McMurray aquifers within the Mannville Group (Figure 5A-2). The Clearwater A is located stratigraphically higher than the Clearwater B but lower than the top of the Clearwater Formation, where present in the north and southeast portions of the study area. The evaluation criteria used for the four aquifers are listed in Table 5A-2.

The Basal McMurray Aquifer was identified from geophysical logs using a minimum of 30% porosity and an approximate gamma response of less than 60 API. The spontaneous potential and resistivity responses were also used in identifying the aquifer. An upper resistivity limit of 10 ohm's was used to determine the oil/water interface. The zones of Basal McMurray Aquifer that met the evaluation criteria were added to create a net Basal McMurray Aquifer isopach.

The Clearwater B and Clearwater A aquifer structure tops and bottoms were identified from geophysical logs using a minimum of 30% porosity and an approximate gamma response of less than 60 API. The spontaneous potential and resistivity responses were also used in identifying the aquifers. The structure top of the Clearwater A and B aquifers were picked at the gas/water interface where gas is present. Gas was identified using neutron and density porosity cross-over.

The Lower Grand Rapids Aquifer structure top and bottom were identified from geophysical logs using a minimum of 30% porosity and an approximate gamma response of less than 60 API. The spontaneous potential and resistivity responses were also used in identifying the aquifer. The structure top of the Lower Grand Rapids Aquifer was picked at the oil/water interface where oil is present, particularly at and adjacent to the Thornbury Lease.

Aquifer thicknesses for the Lower Grand Rapids, Clearwater A, and Clearwater B were calculated by subtracting the net porous sand top and bottom at each well location. The thickness values for all four aquifers were contoured in Golden Software's Surfer 8 by kriging (linear variogram) using a 500 m grid spacing. The linear default variogram fit used in the kriging routine provided good fit to the well log data. Those wells where the aquifer was absent in the Clearwater or the McMurray formations were assigned a value of -5 to control the contouring of data beyond where the aquifer was present.

The initial isopach maps were reviewed for anomalies in the surface (e.g., zero thickness surrounded by 30 m thicknesses). In most cases, the gamma response had been high and noted during log review. Those wells where gamma response was high compared with adjacent well logs were flagged and removed from the isopach map surface. The surface was contoured again to create the final four porous sand isopach maps.

5A1.1.2 Structure Maps

Additional geology information was collected during well log review which allowed geology structure mapping within the LSA. Geologic structure tops LSA were based on the type log (1AA/3-15-78-10 W4M) provided on Figure 5A-2.

The structure maps were created for the top of the Grand Rapids Formation, Clearwater Formation, Wabiskaw Member, McMurray Formation and sub-Cretaceous Unconformity. The surfaces were contoured by kriging using a linear variogram and a 500 m grid spacing. The structure surfaces were checked when first mapped to identify any anomalies. Those well logs with incorrect KB elevations were removed from the structure mapping and the final structure maps were created.

5A1.2 Mapping of the RSA

One hundred and sixty-seven borehole logs were reviewed to complete the geologic mapping for the RSA (Table 5A-3). The geologic picks fore each borehole were selected after reviewing the available wireline data for that borehole. The borehole wireline data typically included:

- Gamma ray
- Spontaneous potential
- Resistivity
- Neutron porosity
- Density porosity

Data quality was maintained by:

- Comparing the geology pick to nearby wells and geologic trends;

- Comparing geologic picks to the type log; and
- Reviewing structure and isopach maps for anomalous data.

With respect to the RSA mapping, hydrostratigraphic surfaces that were not picked during the review of the wireline logs were based on various publications. A summary of the LSA and RSA hydrostratigraphic surface data sources are presented in Table 5A-4.

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Northing (m) NAD 27	Easting (m) NAD 27	KB (m asl)	TD (m)	Top Grand Rapids (m bKB)	Top Grand Rapids (m asl)	Grand Rapids Watersand Thickness (m)	Grand Rapids Watersand Top (m bKB)	Grand Rapids Watersand Top (m asl)	Grand Rapids Watersand Base (m bKB)	Grand Rapids Watersand Base (m asl)	Top Clearwater (m bKB)	Top Clearwater (m asl)	Upper Clearwater Watersand Thickness (m)	Middle Clearwater Watersand Thickness (m)	Upper Clearwater Watersand Thickness (Surfer) (m)	Middle Clearwater Watersand Thickness (Surfer) (m)	Upper Clearwater Watersand Top (m bKB)	Upper Clearwater Watersand Top (m asl)
100/03-01-075-06 W4/00	03-01-075-06 W4	6146079	512822	653.6	505.0															
102/07-02-075-06 W4/00	07-02-075-06 W4	6146478	511589	659.4	502.0															
100/11-04-075-06 W4/00	11-04-075-06 W4	6146872	507913	657.8	484.5															
100/11-05-075-06 W4/00	11-05-075-06 W4	6146870	506277	632.6	469.0															
100/06-08-075-06 W4/00	06-08-075-06 W4	6148076	506276	648.6	481.0															
100/07-09-075-06 W4/00	07-09-075-06 W4	6148079	508315	651.7	498.0															
100/06-10-075-06 W4/00	06-10-075-06 W4	6148082	509546	647.4	478.5															
100/10-12-075-06 W4/00	10-12-075-06 W4	6148494	513219	641.5	526.0															
100/07-13-075-06 W4/00	07-13-075-06 W4	6149720	513215	639.4	510.0															
100/10-16-075-06 W4/00	10-16-075-06 W4	6150110	508311	623.8	501.0															
100/06-18-075-06 W4/00	06-18-075-06 W4	6149703	504639	642.5	483.0															
1AA/10-19-075-06 W4/00	10-19-075-06 W4	6151714	505040	644.6	503.0															
100/07-20-075-06 W4/00	07-20-075-06 W4	6151314	506674	612.5	458.0															
100/06-21-075-06 W4/00	06-21-075-06 W4	6151316	507905	635.1	469.0															
100/12-23-075-06 W4/00	12-23-075-06 W4	6151724	510769	624.5	468.0															
100/12-26-075-06 W4/00	12-26-075-06 W4	6153353	510765	599.6	428.0															
100/03-27-075-06 W4/00	03-27-075-06 W4	6152546	509536	619.0	442.0															
1AB/11-29-075-06 W4/00	11-29-075-06 W4	6153344	506268	602.2	445.0															
100/05-30-075-06 W4/00	05-30-075-06 W4	6152940	504232	630.1	490.0															
1AA/02-31-075-06 W4/00	02-31-075-06 W4	6154147	505037	612.2	467.0															
100/03-32-075-06 W4/00	03-32-075-06 W4	6154149	506267	605.7	443.0															
100/09-32-075-06 W4/00	09-32-075-06 W4	6154954	507072	601.0	442.0															
1AA/14-32-075-06 W4/00	14-32-075-06 W4	6155355	506265	602.2	447.0															
1AA/13-33-075-06 W4/00	13-33-075-06 W4	6155357	507495	605.5	448.0															
100/16-34-075-06 W4/00	16-34-075-06 W4	6155363	510336	611.3	455.0															
100/16-35-075-06 W4/00	16-35-075-06 W4	6155367	511969	609.6	442.0															
100/06-36-075-06 W4/00	06-36-075-06 W4	6154565	512798	612.6	440.0															
100/10-01-075-07 W4/00	10-01-075-07 W4	6146868	503406	634.0	478.2															
100/10-04-075-07 W4/00	10-04-075-07 W4	6146867	498499	665.1	548.6															
100/10-06-075-07 W4/00	10-06-075-07 W4	6146869	495228	694.3	609.6															
100/10-10-075-07 W4/00	10-10-075-07 W4	6148475	500135	660.0	495.0															
100/10-11-075-07 W4/00	10-11-075-07 W4	6148476	501770	648.0	480.1															
100/06-16-075-07 W4/00	06-16-075-07 W4	6149702	498097	671.9	512.0															
100/10-19-075-07 W4/00	10-19-075-07 W4	6151715	495233	681.3	521.0															
1AA/06-22-075-07 W4/00	06-22-075-07 W4	6151311	499731	668.4	505.0															
100/06-23-075-07 W4/00	06-23-075-07 W4	6151311	501365	681.2	506.0															
1AA/15-24-075-07 W4/00	15-24-075-07 W4	6152116	503402	664.9	514.0															
100/01-27-075-07 W4/00	01-27-075-07 W4	6152537	500538	677.5	514.0															
100/06-29-075-07 W4/00	06-29-075-07 W4	6152941	496465	671.8	492.6															
100/10-34-075-07 W4/00	10-34-075-07 W4	6154950	500135	627.9	518.2															
100/11-36-075-07 W4/00	11-36-075-07 W4	6154951	502997	623.0	454.2															
100/06-04-075-08 W4/00	06-04-075-08 W4	6146481	488278	713.8	558.0															
100/08-06-075-08 W4/00	08-06-075-08 W4	6146489	485814	699.4	549.0															
100/12-07-075-08 W4/00	12-07-075-08 W4	6148504	484609	673.9	507.5															
100/11-08-075-08 W4/00	11-08-075-08 W4	6148497	486648	669.3	512.0															
100/12-08-075-08 W4/00	12-08-075-08 W4	6148498	486244	668.3	513.0															
100/12-09-075-08 W4/00	12-09-075-08 W4	6148493	487879	684.0	530.0															
100/11-10-075-08 W4/00	11-10-075-08 W4	6148488	489918	681.5	518.0															
100/09-11-075-08 W4/00	09-11-075-08 W4	6148483	492361	685.7	529.0															
100/12-14-075-08 W4/00	12-14-075-08 W4	6150114	491153	671.9	504.0															
100/12-15-075-08 W4/00	12-15-075-08 W4	6150118	489518	652.5	500.0															
100/09-17-075-08 W4/00	09-17-075-08 W4	6150123	487460	662.5	498.0															
100/11-18-075-08 W4/00	11-18-075-08 W4	6150131	485018	665.0	506.0															
100/14-18-075-08 W4/00	14-18-075-08 W4	6150533	485020	666.4	500.0															
100/06-23-075-08 W4/00	06-23-075-08 W4	6151320	491559	673.9	609.0															
100/11-30-075-08 W4/00	11-30-075-08 W4	6153368	485029	681.2	511.0															

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Upper Clearwater Watersand Base (m bKB)	Upper Clearwater Watersand Base (m asl)	Middle Clearwater Watersand Top (m bKB)	Middle Clearwater Watersand Top (m asl)	Middle Clearwater Watersand Base (m bKB)	Middle Clearwater Watersand Base (m asl)	Top Wabiskaw (m bKB)	Top Wabiskaw (m asl)	Top McMurray (m bKB)	Top McMurray (m asl)	Paleo Surface (m bKB)	Paleo Surface (m asl)	Watersand Thickness (m)	Watersand Thickness (Surfer) (m)	Watersand Surface Elevation (m asl)	Log Analysis Notes:
100/03-01-075-06 W4/00	03-01-075-06 W4							399.0	254.6	419.0	234.6	488.0	165.6	0.0	-5.0	165.6	
102/07-02-075-06 W4/00	07-02-075-06 W4							408.0	251.4	427.0	232.4	491.0	168.4	0.0	-5.0	168.4	
100/11-04-075-06 W4/00	11-04-075-06 W4							403.0	254.8	418.0	239.8	480.0	177.8	0.0	-5.0	177.8	
100/11-05-075-06 W4/00	11-05-075-06 W4							376.0	256.6	392.0	240.6	452.0	180.6	0.0	-5.0	180.6	
100/06-08-075-06 W4/00	06-08-075-06 W4							397.0	251.6	411.0	237.6	472.0	176.6	0.0	-5.0	176.6	
100/07-09-075-06 W4/00	07-09-075-06 W4							398.0	253.7	412.0	239.7	485.0	166.7	6.0	6.0	172.7	
100/06-10-075-06 W4/00	06-10-075-06 W4							398.0	249.4	412.0	235.4	465.0	182.4	0.0	-5.0	182.4	
100/10-12-075-06 W4/00	10-12-075-06 W4							399.0	242.5	416.0	225.5	513.0	128.5	28.0	28.0	156.5	
100/07-13-075-06 W4/00	07-13-075-06 W4							390.0	249.4	407.0	232.4	495.0	144.4	29.0	29.0	173.4	
100/10-16-075-06 W4/00	10-16-075-06 W4							379.0	244.8	395.0	228.8	493.0	130.8	19.0	19.0	149.8	
100/06-18-075-06 W4/00	06-18-075-06 W4							393.0	249.5	405.0	237.5	470.0	172.5	2.0	2.0	174.5	
1AA/10-19-075-06 W4/00	10-19-075-06 W4							390.0	254.6	405.0	239.6	487.0	157.6	8.0	8.0	165.6	
100/07-20-075-06 W4/00	07-20-075-06 W4							361.0	251.5	377.0	235.5	448.0	164.5	10.0	10.0	174.5	
100/06-21-075-06 W4/00	06-21-075-06 W4							377.0	258.1	390.0	245.1	449.0	186.1	0.0	-5.0	186.1	
100/12-23-075-06 W4/00	12-23-075-06 W4							364.0	260.5	382.0	242.5	452.0	172.5	2.0	2.0	174.5	
100/12-26-075-06 W4/00	12-26-075-06 W4							339.0	260.6	357.0	242.6	411.0	188.6	3.0	3.0	191.6	
100/03-27-075-06 W4/00	03-27-075-06 W4							364.0	255.0	382.0	237.0	433.0	186.0	0.0	-5.0	186.0	
1AB/11-29-075-06 W4/00	11-29-075-06 W4							349.0	253.2	361.0	241.2	429.0	173.2	10.0	10.0	183.2	
100/05-30-075-06 W4/00	05-30-075-06 W4							380.0	250.1	395.0	235.1	475.0	155.1	1.0	1.0	156.1	
1AA/02-31-075-06 W4/00	02-31-075-06 W4							360.0	252.2	372.0	240.2	452.0	160.2	10.0	10.0	170.2	
100/03-32-075-06 W4/00	03-32-075-06 W4							351.0	254.7	363.0	242.7	433.0	172.7	6.0	6.0	178.7	
100/09-32-075-06 W4/00	09-32-075-06 W4							346.0	255.0	356.0	245.0	430.0	171.0	10.0	10.0	181.0	
1AA/14-32-075-06 W4/00	14-32-075-06 W4							350.0	252.2	362.0	240.2	432.0	170.2	8.0	8.0	178.2	
1AA/13-33-075-06 W4/00	13-33-075-06 W4							349.0	256.5	358.0	247.5	434.0	171.5	5.0	5.0	176.5	
100/16-34-075-06 W4/00	16-34-075-06 W4							360.0	251.3	377.0	234.3	442.0	169.3	0.0	-5.0	169.3	
100/16-35-075-06 W4/00	16-35-075-06 W4							343.0	266.6	361.0	248.6	417.0	192.6	0.0	-5.0	192.6	
100/06-36-075-06 W4/00	06-36-075-06 W4							347.0	265.6	362.0	250.6	422.0	190.6	2.0	2.0	192.6	
100/10-01-075-07 W4/00	10-01-075-07 W4							382.0	252.0	397.0	237.0	464.0	170.0	0.0	-5.0	170.0	
100/10-04-075-07 W4/00	10-04-075-07 W4							414.0	251.1	430.0	235.1	486.0	179.1	0.0	-5.0	179.1	
100/10-06-075-07 W4/00	10-06-075-07 W4							446.0	248.3	464.0	230.3	518.0	176.3	0.0	-5.0	176.3	
100/10-10-075-07 W4/00	10-10-075-07 W4							407.0	253.0	423.0	237.0	482.0	178.0	5.0	5.0	183.0	
100/10-11-075-07 W4/00	10-11-075-07 W4							398.0	250.0	415.0	233.0	467.0	181.0	1.0	1.0	182.0	
100/06-16-075-07 W4/00	06-16-075-07 W4							423.0	248.9	440.0	231.9	498.0	173.9	3.0	3.0	176.9	
100/10-19-075-07 W4/00	10-19-075-07 W4							422.0	259.3	444.0	237.3	493.0	188.3	3.0	3.0	191.3	
1AA/06-22-075-07 W4/00	06-22-075-07 W4							410.0	258.4	434.0	234.4	493.0	175.4	0.0	-5.0	175.4	
100/06-23-075-07 W4/00	06-23-075-07 W4							425.0	256.2	441.0	240.2	499.0	182.2	0.0	-5.0	182.2	
1AA/15-24-075-07 W4/00	15-24-075-07 W4							410.0	254.9	429.0	235.9	502.0	162.9	5.0	5.0	167.9	
100/01-27-075-07 W4/00	01-27-075-07 W4							420.0	257.5	440.0	237.5	503.0	174.5	0.0	-5.0	174.5	
100/06-29-075-07 W4/00	06-29-075-07 W4							414.0	257.8	430.0	241.8	484.0	187.8	0.0	-5.0	187.8	
100/10-34-075-07 W4/00	10-34-075-07 W4							378.0	249.9	396.0	231.9	438.0	189.9	0.0	-5.0	189.9	
100/11-36-075-07 W4/00	11-36-075-07 W4							367.0	256.0	385.0	238.0	439.0	184.0	0.0	-5.0	184.0	
100/06-04-075-08 W4/00	06-04-075-08 W4							469.0	244.8	482.0	231.8	545.0	168.8	0.0	-5.0	168.8	
100/08-06-075-08 W4/00	08-06-075-08 W4							461.0	238.4	473.0	226.4	520.0	179.4	0.0	-5.0	179.4	
100/12-07-075-08 W4/00	12-07-075-08 W4							428.0	245.9	459.0	214.9	491.0	182.9	4.0	4.0	186.9	
100/11-08-075-08 W4/00	11-08-075-08 W4							427.0	242.3	442.0	227.3	492.0	177.3	0.0	-5.0	177.3	
100/12-08-075-08 W4/00	12-08-075-08 W4							425.0	243.3	438.0	230.3	489.0	179.3	0.0	-5.0	179.3	
100/12-09-075-08 W4/00	12-09-075-08 W4							443.0	241.0	457.0	227.0	509.0	175.0	2.0	2.0	177.0	
100/11-10-075-08 W4/00	11-10-075-08 W4							433.0	248.5	453.0	228.5	503.0	178.5	1.0	1.0	179.5	
100/09-11-075-08 W4/00	09-11-075-08 W4							449.0	236.7	466.0	219.7	515.0	170.7	2.0	2.0	172.7	
100/12-14-075-08 W4/00	12-14-075-08 W4							424.0	247.9	446.0	225.9	491.0	180.9	0.0	-5.0	180.9	
100/12-15-075-08 W4/00	12-15-075-08 W4							409.0	243.5	428.0	224.5	477.0	175.5	1.0	1.0	176.5	
100/09-17-075-08 W4/00	09-17-075-08 W4							416.0	246.5	435.0	227.5	482.0	180.5	3.0	3.0	183.5	
100/11-18-075-08 W4/00	11-18-075-08 W4							418.0	247.0	457.0	208.0	483.0	182.0	0.0	-5.0	182.0	
100/14-18-075-08 W4/00	14-18-075-08 W4							421.0	245.4	460.0	206.4	487.0	179.4	0.0	-5.0	179.4	
100/06-23-075-08 W4/00	06-23-075-08 W4							422.0	251.9	436.0	237.9	489.0	184.9				
100/11-30-075-08 W4/00	11-30-075-08 W4							434.0	247.2	445.0	236.2	495.0	186.2	0.0	-5.0	186.2	

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Northing (m) NAD 27	Easting (m) NAD 27	KB (m asl)	TD (m)	Top Grand Rapids (m bKB)	Top Grand Rapids (m asl)	Grand Rapids Watersand Thickness (m)	Grand Rapids Watersand Top (m bKB)	Grand Rapids Watersand Top (m asl)	Grand Rapids Watersand Base (m bKB)	Grand Rapids Watersand Base (m asl)	Top Clearwater (m bKB)	Top Clearwater (m asl)	Upper Clearwater Watersand Thickness (m)	Middle Clearwater Watersand Thickness (m)	Upper Clearwater Thickness (Surfer) (m)	Middle Clearwater Thickness (Surfer) (m)	Upper Clearwater Watersand Top (m bKB)	Upper Clearwater Watersand Top (m asl)
100/02-32-075-08 W4/00	02-32-075-08 W4	6154166	487068	662.9	500.0															
100/03-34-075-08 W4/00	03-34-075-08 W4	6154159	489931	637.4	474.0															
100/07-35-075-08 W4/00	07-35-075-08 W4	6154557	491968	640.8	470.0															
100/10-01-075-09 W4/00	10-01-075-09 W4	6146898	483772	680.2	529.0															
100/10-02-075-09 W4/00	10-02-075-09 W4	6146904	482137	675.5	506.0															
100/10-03-075-09 W4/00	10-03-075-09 W4	6146911	480501	683.6	511.0															
100/06-04-075-09 W4/00	06-04-075-09 W4	6146519	478459	662.2	500.0															
100/09-07-075-09 W4/00	09-07-075-09 W4	6148542	476006	657.8	479.8															
100/09-08-075-09 W4/00	09-08-075-09 W4	6148534	477642	656.4	488.0															
100/12-10-075-09 W4/00	12-10-075-09 W4	6148524	479701	663.3	502.0															
100/01-11-075-09 W4/00	01-11-075-09 W4	6147707	482544	671.6	510.0															
100/11-12-075-09 W4/00	11-12-075-09 W4	6148508	483374	668.6	508.0															
100/13-12-075-09 W4/00	13-12-075-09 W4	6148912	482972	675.1	510.0															
100/01-13-075-09 W4/00	01-13-075-09 W4	6149330	484185	666.7	507.0															
100/06-13-075-09 W4/00	06-13-075-09 W4	6149735	483379	668.4	505.0															
100/12-13-075-09 W4/00	12-13-075-09 W4	6150139	482977	662.5	516.0															
100/11-15-075-09 W4/00	11-15-075-09 W4	6150151	480112	661.9	494.0															
100/12-16-075-09 W4/00	12-16-075-09 W4	6150160	478074	666.2	496.0															
100/12-17-075-09 W4/00	12-17-075-09 W4	6150169	476439	673.6	513.0															
100/12-19-075-09 W4/00	12-19-075-09 W4	6151786	474814	681.9	530.0															
100/11-24-075-09 W4/00	11-24-075-09 W4	6151746	483387	677.3	524.9															
100/05-30-075-09 W4/00	05-30-075-09 W4	6153013	474821	692.3	494.0															
100/10-34-075-09 W4/00	10-34-075-09 W4	6154995	480537	677.2	515.0															
100/06-03-075-10 W4/00	06-03-075-10 W4	6146559	470274	687.3	676.7															
100/05-23-075-10 W4/00	05-23-075-10 W4	6151397	471537	686.3	497.0															
100/05-25-075-10 W4/00	05-25-075-10 W4	6153016	473181	682.4	486.0															
100/07-26-075-10 W4/00	07-26-075-10 W4	6153021	472355	678.4	500.0															
100/08-27-075-10 W4/00	08-27-075-10 W4	6153029	471124	670.8	479.0															
100/08-28-075-10 W4/00	08-28-075-10 W4	6153040	469491	663.9	477.0															
100/10-31-075-10 W4/00	10-31-075-10 W4	6155078	465837	661.0	508.0															
100/11-32-075-10 W4/00	11-32-075-10 W4	6155068	467066	664.0	510.0															
100/16-34-075-10 W4/00	16-34-075-10 W4	6155442	471140	664.7	476.0															
100/16-07-075-11 W4/00	16-07-075-11 W4	6149093	456391	659.9	520.0															
100/15-08-075-11 W4/00	15-08-075-11 W4	6149081	457622	649.6	502.0															
100/07-10-075-11 W4/00	07-10-075-11 W4	6148246	460884	652.5	505.0															
102/11-12-075-11 W4/00	11-12-075-11 W4	6148624	463754	680.7	527.0															
100/07-17-075-11 W4/00	07-17-075-11 W4	6149905	457630	666.2	521.0															
100/04-19-075-11 W4/00	04-19-075-11 W4	6151136	455200	673.3	537.0															
100/08-19-075-11 W4/00	08-19-075-11 W4	6151526	456415	677.9	547.0															
100/04-20-075-11 W4/00	04-20-075-11 W4	6151120	456834	676.0	535.0															
100/11-21-075-11 W4/00	11-21-075-11 W4	6151904	458880	660.5	524.3															
100/05-24-075-11 W4/00	05-24-075-11 W4	6151462	463374	648.6	494.0															
100/14-25-075-11 W4/00	14-25-075-11 W4	6153892	463798	659.7	507.0															
100/09-30-075-11 W4/00	09-30-075-11 W4	6153557	456435	669.1	528.0															
100/02-34-075-11 W4/00	02-34-075-11 W4	6154319	460938	656.5	1254.6															
100/12-04-075-11 W4	12-04-075-11 W4	6147062	458430	661.2	526.0															
100/09-06-075-11 W4	09-06-075-11 W4	6147082	456371	663.6	533.0															
100/06-01-075-12 W4/00	06-01-075-12 W4	6146706	453923	649.7	527.0															
100/15-02-075-12 W4/00	15-02-075-12 W4	6147523	452700	680.2	542.0															
100/10-03-075-12 W4/00	10-03-075-12 W4	6147139	451060	681.7	545.0															
100/09-04-075-12 W4/00	09-04-075-12 W4	6147153	449828	680.1	532.0															
100/11-05-075-12 W4/00	11-05-075-12 W4	6147181	447385	681.2	562.0															
100/12-06-075-12 W4/00	12-06-075-12 W4	6147206	445345	680.7	543.0															
100/07-08-075-12 W4/00	07-08-075-12 W4	6148383	447803	680.3	550.0															
100/15-11-075-12 W4/00	15-11-075-12 W4	6149132	452717	678.5	538.0															
100/16-12-075-12 W4/00	16-12-075-12 W4	6149110	454756	669.4	542.0															

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Upper Clearwater Watersand Base (m bKB)	Upper Clearwater Watersand Base (m asl)	Middle Clearwater Watersand Top (m bKB)	Middle Clearwater Watersand Top (m asl)	Middle Clearwater Watersand Base (m bKB)	Middle Clearwater Watersand Base (m asl)	Top Wabiskaw (m bKB)	Top Wabiskaw (m asl)	Top McMurray (m bKB)	Top McMurray (m asl)	Paleo Surface (m bKB)	Paleo Surface (m asl)	Watersand Thickness (m)	Watersand Thickness (Surfer) (m)	Watersand Surface Elevation (m asl)	Log Analysis Notes:
100/02-32-075-08 W4/00	02-32-075-08 W4							419.0	243.9	441.0	221.9	487.0	175.9	0.0	-5.0	175.9	
100/03-34-075-08 W4/00	03-34-075-08 W4							390.0	247.4	401.0	236.4	455.0	182.4	1.0	1.0	183.4	
100/07-35-075-08 W4/00	07-35-075-08 W4							395.0	245.8	406.0	234.8	461.0	179.8	0.0	-5.0	179.8	
100/10-01-075-09 W4/00	10-01-075-09 W4							435.0	245.2	452.0	228.2	502.0	178.2	3.0	3.0	181.2	
100/10-02-075-09 W4/00	10-02-075-09 W4							428.0	247.5	461.0	214.5	490.0	185.5	3.0	3.0	188.5	
100/10-03-075-09 W4/00	10-03-075-09 W4							442.0	241.6	457.0	226.6	502.0	181.6	7.0	7.0	188.6	
100/06-04-075-09 W4/00	06-04-075-09 W4							427.0	235.2	441.1	221.1	489.0	173.2	0.0	-5.0	173.2	
100/09-07-075-09 W4/00	09-07-075-09 W4							425.0	232.8	434.0	223.8	476.0	181.8	0.0	-5.0	181.8	
100/09-08-075-09 W4/00	09-08-075-09 W4							424.0	232.4	436.0	220.4	483.0	173.4	4.0	4.0	177.4	
100/12-10-075-09 W4/00	12-10-075-09 W4							421.0	242.3	434.0	229.3	488.0	175.3	0.0	-5.0	175.3	
100/01-11-075-09 W4/00	01-11-075-09 W4							425.0	246.6	465.0	206.6	491.0	180.6	14.0	14.0	194.6	
100/11-12-075-09 W4/00	11-12-075-09 W4							426.0	242.6	460.0	208.6	493.0	175.6	10.0	10.0	185.6	
100/13-12-075-09 W4/00	13-12-075-09 W4							433.0	242.1	466.0	209.1	495.0	180.1	7.0	7.0	187.1	
100/01-13-075-09 W4/00	01-13-075-09 W4							420.0	246.7	463.0	203.7	486.0	180.7	3.0	3.0	183.7	
100/06-13-075-09 W4/00	06-13-075-09 W4							430.0	238.4	456.0	212.4	490.0	178.4	0.0	-5.0	178.4	
100/12-13-075-09 W4/00	12-13-075-09 W4							422.0	240.5	441.0	221.5	484.0	178.5	0.0	-5.0	178.5	
100/11-15-075-09 W4/00	11-15-075-09 W4							429.0	232.9	441.0	220.9	488.0	173.9	0.0	-5.0	173.9	
100/12-16-075-09 W4/00	12-16-075-09 W4							437.0	229.2	449.0	217.2	489.0	177.2	0.0	-5.0	177.2	
100/12-17-075-09 W4/00	12-17-075-09 W4							442.0	231.6	453.0	220.6	493.0	180.6	0.0	-5.0	180.6	
100/12-19-075-09 W4/00	12-19-075-09 W4							448.0	233.9	461.0	220.9	482.0	199.9	0.0	-5.0	199.9	
100/11-24-075-09 W4/00	11-24-075-09 W4							439.0	238.3	451.0	226.3	503.0	174.3	0.0	-5.0	174.3	
100/05-30-075-09 W4/00	05-30-075-09 W4							460.0	232.3	475.0	217.3	491.0	201.3	0.0	-5.0	201.3	
100/10-34-075-09 W4/00	10-34-075-09 W4							438.0	239.2	455.0	222.2	497.0	180.2	0.0	-5.0	180.2	
100/06-03-075-10 W4/00	06-03-075-10 W4							457.0	230.3	475.0	212.3	496.0	191.3	0.0	-5.0	191.3	
100/05-23-075-10 W4/00	05-23-075-10 W4							457.0	229.3	472.0	214.3	489.0	197.3	0.0	-5.0	197.3	
100/05-25-075-10 W4/00	05-25-075-10 W4							450.0	232.4	465.0	217.4	481.0	201.4	0.0	-5.0	201.4	
100/07-26-075-10 W4/00	07-26-075-10 W4							444.0	234.4	460.0	218.4	475.0	203.4	0.0	-5.0	203.4	
100/08-27-075-10 W4/00	08-27-075-10 W4							439.0	231.8	456.0	214.8	471.0	199.8	0.0	-5.0	199.8	
100/08-28-075-10 W4/00	08-28-075-10 W4							433.0	230.9	450.0	213.9	463.0	200.9	0.0	-5.0	200.9	
100/10-31-075-10 W4/00	10-31-075-10 W4							432.0	229.0	448.0	213.0	501.0	160.0	12.0	12.0	172.0	
100/11-32-075-10 W4/00	11-32-075-10 W4							431.0	233.0	447.0	217.0	504.0	160.0	8.0	8.0	168.0	
100/16-34-075-10 W4/00	16-34-075-10 W4							429.0	235.7	444.0	220.7	463.0	201.7	0.0	-5.0	201.7	
100/16-07-075-11 W4/00	16-07-075-11 W4							446.0	213.9	463.0	196.9	514.0	145.9	4.0	4.0	149.9	
100/15-08-075-11 W4/00	15-08-075-11 W4							434.0	215.6	451.0	198.6	499.0	150.6	0.0	-5.0	150.6	
100/07-10-075-11 W4/00	07-10-075-11 W4							432.0	220.5	448.0	204.5	495.0	157.5	10.0	10.0	167.5	
102/11-12-075-11 W4/00	11-12-075-11 W4							460.0	220.7	476.0	204.7	520.0	160.7	1.0	1.0	161.7	
100/07-17-075-11 W4/00	07-17-075-11 W4							449.0	217.2	465.0	201.2	515.0	151.2	4.0	4.0	155.2	
100/04-19-075-11 W4/00	04-19-075-11 W4							462.0	211.3	478.0	195.3	532.0	141.3	9.0	9.0	150.3	
100/08-19-075-11 W4/00	08-19-075-11 W4							464.0	213.9	481.0	196.9	532.0	145.9	4.0	4.0	149.9	
100/04-20-075-11 W4/00	04-20-075-11 W4							461.0	215.0	477.0	199.0	530.0	146.0	6.0	6.0	152.0	
100/11-21-075-11 W4/00	11-21-075-11 W4							443.0	217.5	459.0	201.5	506.0	154.5	0.0	-5.0	154.5	
100/05-24-075-11 W4/00	05-24-075-11 W4							424.0	224.6	440.0	208.6	483.0	165.6	6.0	6.0	171.6	
100/14-25-075-11 W4/00	14-25-075-11 W4							436.0	223.7	452.0	207.7	495.0	164.7	0.0	-5.0	164.7	
100/09-30-075-11 W4/00	09-30-075-11 W4							451.0	218.1	468.0	201.1	523.0	146.1	17.0	17.0	163.1	
100/02-34-075-11 W4/00	02-34-075-11 W4							447.0	209.5	460.0	196.5	499.0	157.5	0.0	-5.0	157.5	
100/12-04-075-11 W4	12-04-075-11 W4							443.0	218.2	460.0	201.2	511.0	150.2	0.0	-5.0	150.2	
100/09-06-075-11 W4	09-06-075-11 W4							447.0	216.6	463.0	200.6	517.0	146.6	5.0	5.0	151.6	
100/06-01-075-12 W4/00	06-01-075-12 W4							434.0	215.7	451.0	198.7	507.0	142.7	9.0	9.0	151.7	
100/15-02-075-12 W4/00	15-02-075-12 W4							465.0	215.2	478.0	202.2	536.0	144.2	11.0	11.0	155.2	gamma runs high
100/10-03-075-12 W4/00	10-03-075-12 W4							470.0	211.7	482.0	199.7	535.0	146.7	0.0	-5.0	146.7	gamma runs high
100/09-04-075-12 W4/00	09-04-075-12 W4							468.0	212.1	480.0	200.1	521.0	159.1	0.0	-5.0	159.1	
100/11-05-075-12 W4/00	11-05-075-12 W4							470.0	211.2	483.0	198.2	529.0	152.2	4.0	4.0	156.2	
100/12-06-075-12 W4/00	12-06-075-12 W4							470.0	210.7	480.0	200.7	524.0	156.7	0.0	-5.0	156.7	gamma runs high
100/07-08-075-12 W4/00	07-08-075-12 W4							469.0	211.3	481.0	199.3	533.0	147.3	8.0	8.0	155.3	
100/15-11-075-12 W4/00	15-11-075-12 W4							462.0	216.5	473.0	205.5	534.0	144.5	16.0	16.0	160.5	
100/16-12-075-12 W4/00	16-12-075-12 W4							456.0	213.4	467.0	202.4	526.0	143.4	4.0	4.0	147.4	

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Northing (m) NAD 27	Easting (m) NAD 27	KB (m asl)	TD (m)	Top Grand Rapids (m bKB)	Top Grand Rapids (m asl)	Grand Rapids Watersand Thickness (m)	Grand Rapids Watersand Top (m bKB)	Grand Rapids Watersand Top (m asl)	Grand Rapids Watersand Base (m bKB)	Grand Rapids Watersand Base (m asl)	Top Clearwater (m bKB)	Top Clearwater (m asl)	Upper Clearwater Watersand Thickness (m)	Middle Clearwater Watersand Thickness (m)	Upper Clearwater Watersand Thickness (Surfer) (m)	Middle Clearwater Watersand Thickness (Surfer) (m)	Upper Clearwater Watersand Top (m bKB)	Upper Clearwater Watersand Top (m asl)
100/06-13-075-12 W4/00	06-13-075-12 W4	6149943	453957	676.1	533.0															
100/15-14-075-12 W4/00	15-14-075-12 W4	6150760	452735	680.5	554.0															
100/11-15-075-12 W4/00	11-15-075-12 W4	6150381	450692	677.6	528.5															
100/11-18-075-12 W4/00	11-18-075-12 W4	6150438	445789	688.7	543.8															
100/10-19-075-12 W4/00	10-19-075-12 W4	6152042	446212	694.2	570.0															
100/15-20-075-12 W4/00	15-20-075-12 W4	6152424	447851	683.4	542.0															
102/08-21-075-12 W4/00	08-21-075-12 W4	6151596	449879	675.1	600.0															
100/10-23-075-12 W4/00	10-23-075-12 W4	6151967	452748	679.2	536.1															
100/06-24-075-12 W4/00	06-24-075-12 W4	6151552	453974	677.5	547.0															
100/06-25-075-12 W4/00	06-25-075-12 W4	6153180	453991	673.3	560.8															
100/10-28-075-12 W4/00	10-28-075-12 W4	6153632	449499	680.1	551.0															
100/10-29-075-12 W4/00	10-29-075-12 W4	6153651	447866	687.5	543.0															
100/07-31-075-12 W4/00	07-31-075-12 W4	6154877	446247	697.8	555.0															
100/07-32-075-12 W4/00	07-32-075-12 W4	6154857	447880	697.9	565.0															
100/07-33-075-12 W4/00	07-33-075-12 W4	6154838	449513	689.8	558.0															
100/06-34-075-12 W4/00	06-34-075-12 W4	6154824	450742	674.2	563.9															
102/06-01-075-13 W4/00	06-01-075-13 W4	6146820	444109	692.9	562.0															
100/15-06-075-13 W4/00	15-06-075-13 W4	6147730	436346	745.4	626.0															
100/14-12-075-13 W4/00	14-12-075-13 W4	6149233	444140	687.3	551.0															
102/01-15-075-13 W4/00	01-15-075-13 W4	6149687	441683	708.5	578.0															
100/05-19-075-13 W4/00	05-19-075-13 W4	6151783	435597	749.8	621.0															
100/07-24-075-13 W4/00	07-24-075-13 W4	6151661	444574	709.9	561.4															
100/06-28-075-13 W4/00	06-28-075-13 W4	6153360	439291	726.2	589.0															
100/06-30-075-13 W4/00	06-30-075-13 W4	6153406	436024	739.0	603.0															
100/07-31-075-13 W4/00	07-31-075-13 W4	6155009	436451	743.6	604.5															
100/06-34-075-13 W4/00	06-34-075-13 W4	6154946	440946	694.3	572.0															
100/07-03-075-14 W4/00	07-03-075-14 W4	6146999	431424	777.8	652.0															
100/11-11-075-14 W4/00	11-11-075-14 W4	6148991	432687	767.8	636.1															
100/05-12-075-14 W4/00	05-12-075-14 W4	6148570	433912	759.7	619.0															
100/10-19-075-14 W4/00	10-19-075-14 W4	6152326	426605	783.2	619.0															
100/06-27-075-14 W4/00	06-27-075-14 W4	6153480	431122	756.2	612.0															
100/11-29-075-14 W4/00	11-29-075-14 W4	6153935	427862	745.9	587.0															
100/06-30-075-14 W4/00	06-30-075-14 W4	6153560	426222	754.4	605.9															
100/06-31-075-14 W4/00	06-31-075-14 W4	6155168	426249	733.3	562.1															
100/06-32-075-14 W4/00	06-32-075-14 W4	6155141	427882	742.2	571.5															
100/11-33-075-14 W4/00	11-33-075-14 W4	6155517	429521	726.0	567.2															
100/12-34-075-14 W4/00	12-34-075-14 W4	6155497	430751	723.2	595.0															
1AA/10-01-076-06 W4/00	10-01-076-06 W4	6156597	513195	591.7	431.0	188.0	403.7	16.0	243.0	348.7	259.0	332.7	262.0	329.7	5.0	10.0	5.0	10.0	273.0	318.7
1AA/04-02-076-06 W4/00	04-02-076-06 W4	6155786	510759	603.6	450.0	197.0	406.6	14.0	259.0	344.6	273.0	330.6	273.0	330.6	0.0	17.0	-5.0	17.0		
1AA/02-03-076-06 W4/00	02-03-076-06 W4	6155784	509932	603.6	455.0	200.0	403.6						278.0	325.6						
1AA/06-04-076-06 W4/00	06-04-076-06 W4	6156182	507896	601.6	434.0	197.0	404.6	13.0	262.0	339.6	275.0	326.6	275.0	326.6	5.0	16.0	5.0	16.0	282.0	319.6
1AA/01-05-076-06 W4/00	01-05-076-06 W4	6155779	507071	599.0	440.0	195.0	404.0	21.0	250.0	349.0	271.0	328.0	271.0	328.0	5.0	15.0	5.0	15.0	280.0	319.0
1AA/12-07-076-06 W4/00	12-07-076-06 W4	6158188	504227	592.9	410.0			20.0	237.0	355.9	257.0	335.9	257.0	335.9	0.0	22.0	-5.0	22.0		
100/16-08-076-06 W4/00	16-08-076-06 W4	6158594	507066	577.6	487.0								244.0	333.6						
1AA/16-09-076-06 W4/00	16-09-076-06 W4	6158597	508697	572.0	422.5								232.0	340.0						

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Upper Clearwater Watersand Base (m bKB)	Upper Clearwater Watersand Base (m asl)	Middle Clearwater Watersand Top (m bKB)	Middle Clearwater Watersand Top (m asl)	Middle Clearwater Watersand Base (m bKB)	Middle Clearwater Watersand Base (m asl)	Top Wabiskaw (m bKB)	Top Wabiskaw (m asl)	Top McMurray (m bKB)	Top McMurray (m asl)	Paleo Surface (m bKB)	Paleo Surface (m asl)	Watersand Thickness (m)	Watersand Thickness (Surfer) (m)	Watersand Surface Elevation (m asl)	Log Analysis Notes:
100/06-13-075-12 W4/00	06-13-075-12 W4							462.0	214.1	478.0	198.1	530.0	146.1	9.0	9.0	155.1	
100/15-14-075-12 W4/00	15-14-075-12 W4							467.0	213.5	483.0	197.5	532.0	148.5	13.0	13.0	161.5	
100/11-15-075-12 W4/00	11-15-075-12 W4							465.0	212.6	481.0	196.6	528.0	149.6	10.0	10.0	159.6	
100/11-18-075-12 W4/00	11-18-075-12 W4							479.0	209.7	496.0	192.7	532.0	156.7	0.0	-5.0	156.7	
100/10-19-075-12 W4/00	10-19-075-12 W4							483.0	211.2	500.0	194.2	540.0	154.2	0.0	-5.0	154.2	
100/15-20-075-12 W4/00	15-20-075-12 W4							468.0	215.4	485.0	198.4	530.0	153.4	5.0	5.0	158.4	
102/08-21-075-12 W4/00	08-21-075-12 W4							465.0	210.1	481.0	194.1	525.0	150.1	10.0	10.0	160.1	
100/10-23-075-12 W4/00	10-23-075-12 W4							469.0	210.2	484.0	195.2	531.0	148.2	4.0	4.0	152.2	
100/06-24-075-12 W4/00	06-24-075-12 W4							466.0	211.5	480.0	197.5	532.0	145.5	12.0	12.0	157.5	
100/06-25-075-12 W4/00	06-25-075-12 W4							458.0	215.3	474.0	199.3	527.0	146.3	10.0	10.0	156.3	
100/10-28-075-12 W4/00	10-28-075-12 W4							467.0	213.1	484.0	196.1	528.0	152.1	12.0	12.0	164.1	
100/10-29-075-12 W4/00	10-29-075-12 W4							473.0	214.5	489.0	198.5	539.0	148.5	6.0	6.0	154.5	
100/07-31-075-12 W4/00	07-31-075-12 W4							485.0	212.8	503.0	194.8	545.0	152.8	17.0	17.0	169.8	
100/07-32-075-12 W4/00	07-32-075-12 W4							483.0	214.9	498.0	199.9	545.0	152.9	2.0	2.0	154.9	
100/07-33-075-12 W4/00	07-33-075-12 W4							478.0	211.8	484.0	205.8	541.0	148.8	10.0	10.0	158.8	
100/06-34-075-12 W4/00	06-34-075-12 W4							461.0	213.2	477.0	197.2	546.0	128.2	0.0	-5.0	128.2	
102/06-01-075-13 W4/00	06-01-075-13 W4							472.0	220.9	482.0	210.9	527.0	165.9	13.0	13.0	178.9	
100/15-06-075-13 W4/00	15-06-075-13 W4							546.0	199.4	560.0	185.4	610.0	135.4	12.0	12.0	147.4	
100/14-12-075-13 W4/00	14-12-075-13 W4							477.0	210.3	492.0	195.3	530.0	157.3	0.0	-5.0	157.3	gamma runs high
102/01-15-075-13 W4/00	01-15-075-13 W4							499.0	209.5	515.0	193.5	555.0	153.5	0.0	-5.0	153.5	
100/05-19-075-13 W4/00	05-19-075-13 W4							544.0	205.8	560.0	189.8	613.0	136.8	25.0	25.0	161.8	
100/07-24-075-13 W4/00	07-24-075-13 W4							492.0	217.9	508.0	201.9	545.0	164.9	8.0	8.0	172.9	
100/06-28-075-13 W4/00	06-28-075-13 W4							520.0	206.2	531.0	195.2	581.0	145.2	1.0	1.0	146.2	
100/06-30-075-13 W4/00	06-30-075-13 W4							529.0	210.0	542.0	197.0	596.0	143.0	19.0	19.0	162.0	
100/07-31-075-13 W4/00	07-31-075-13 W4							533.0	210.6	546.0	197.6	595.0	148.6	3.0	3.0	151.6	
100/06-34-075-13 W4/00	06-34-075-13 W4							486.0	208.3	499.0	195.3	543.0	151.3	2.0	2.0	153.3	
100/07-03-075-14 W4/00	07-03-075-14 W4							579.0	198.8	596.0	181.8	630.0	147.8	0.0	-5.0	147.8	
100/11-11-075-14 W4/00	11-11-075-14 W4							567.0	200.8	586.0	181.8	631.0	136.8	8.0	8.0	144.8	
100/05-12-075-14 W4/00	05-12-075-14 W4							559.0	200.7	575.0	184.7	615.0	144.7	12.0	12.0	156.7	gamma runs high
100/10-19-075-14 W4/00	10-19-075-14 W4							581.0	202.2	594.0	189.2	615.0	168.2	0.0	-5.0	168.2	
100/06-27-075-14 W4/00	06-27-075-14 W4							554.0	202.2	568.0	188.2	611.0	145.2				
100/11-29-075-14 W4/00	11-29-075-14 W4							540.0	205.9	553.0	192.9	574.0	171.9	0.0	-5.0	171.9	
100/06-30-075-14 W4/00	06-30-075-14 W4							549.0	205.4	561.0	193.4	583.0	171.4	0.0	-5.0	171.4	
100/06-31-075-14 W4/00	06-31-075-14 W4							527.0	206.3	540.0	193.3	562.0	171.3	0.0	-5.0	171.3	
100/06-32-075-14 W4/00	06-32-075-14 W4							534.0	208.2	547.0	195.2	567.0	175.2	0.0	-5.0	175.2	
100/11-33-075-14 W4/00	11-33-075-14 W4							518.0	208.0	531.0	195.0	553.0	173.0	0.0	-5.0	173.0	
100/12-34-075-14 W4/00	12-34-075-14 W4							519.0	204.2	531.0	192.2	579.0	144.2	0.0	-5.0	144.2	gamma runs high
1AA/10-01-076-06 W4/00	10-01-076-06 W4	278.0	313.7	302.0	289.7	312.0	279.7	336.0	255.7	353.0	238.7	415.0	176.7	6.0	6.0	182.7	
1AA/04-02-076-06 W4/00	04-02-076-06 W4			307.0	296.6	324.0	279.6	345.0	258.6	365.0	238.6	432.0	171.6	11.0	11.0	182.6	res runs low
1AA/02-03-076-06 W4/00	02-03-076-06 W4							348.0	255.6	365.0	238.6	436.0	167.6	19.0	19.0	186.6	gamma high
1AA/06-04-076-06 W4/00	06-04-076-06 W4	287.0	314.6	306.0	295.6	322.0	279.6	345.0	256.6	365.0	236.6	424.0	177.6	5.0	5.0	182.6	
1AA/01-05-076-06 W4/00	01-05-076-06 W4	285.0	314.0	303.0	296.0	318.0	281.0	342.0	257.0	363.0	236.0	426.0	173.0	4.0	4.0	177.0	
1AA/12-07-076-06 W4/00	12-07-076-06 W4			290.0	302.9	312.0	280.9	334.0	258.9	359.0	233.9	398.0	194.9	0.0	-5.0	194.9	
100/16-08-076-06 W4/00	16-08-076-06 W4							321.0	256.6	341.0	236.6	429.0	148.6	27.0	27.0	175.6	gamma high
1AA/16-09-076-06 W4/00	16-09-076-06 W4							313.0	259.0	335.0	237.0	400.0	172.0	8.0	8.0	180.0	gamma high

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Northing (m) NAD 27	Easting (m) NAD 27	KB (m asl)	TD (m)	Top Grand Rapids (m bKB)	Top Grand Rapids (m asl)	Grand Rapids Watersand Thickness (m)	Grand Rapids Watersand Top (m bKB)	Grand Rapids Watersand Top (m asl)	Grand Rapids Watersand Base (m bKB)	Grand Rapids Watersand Base (m asl)	Top Clearwater (m bKB)	Top Clearwater (m asl)	Upper Clearwater Watersand Thickness (m)	Middle Clearwater Watersand Thickness (m)	Upper Clearwater Watersand Thickness (Surfer) (m)	Middle Clearwater Watersand Thickness (Surfer) (m)	Upper Clearwater Watersand Top (m bKB)	Upper Clearwater Watersand Top (m asl)
100/06-10-076-06 W4/00	06-10-076-06 W4	6157794	509525	585.0	431.0	179.0	406.0	12.0	240.0	345.0	252.0	333.0	252.0	333.0	5.0	19.0	5.0	19.0	262.0	323.0
1AA/16-11-076-06 W4/00	16-11-076-06 W4	6158605	511960	578.6	434.0	173.0	405.6	15.0	227.0	351.6	242.0	336.6	242.0	336.6	7.0	10.0	7.0	10.0	253.0	325.6
1AA/01-12-076-06 W4/00	01-12-076-06 W4	6157403	513595	590.7	432.0	190.0	400.7	14.0	241.0	349.7	255.0	335.7	262.0	328.7	6.0	11.0	6.0	11.0	274.0	316.7
1AA/03-13-076-06 W4/00	03-13-076-06 W4	6159029	512785	576.3	423.0			14.0	225.0	351.3	239.0	337.3	240.0	336.3	8.0	11.0	8.0	11.0	251.0	325.3
1AA/05-14-076-06 W4/00	05-14-076-06 W4	6159426	510750	572.1	412.0	161.0	411.1	14.0	217.0	355.1	231.0	341.1	232.0	340.1	5.0	18.0	5.0	18.0	241.0	331.1
1AA/13-15-076-06 W4/00	13-15-076-06 W4	6160227	509117	570.4	436.0	165.0	405.4						230.0	340.4						
103/06-16-076-06 W4/00	06-16-076-06 W4	6159420	507890	568.2	506.0			15.0	208.0	360.2	223.0	345.2	223.0	345.2	0.0	20.0	-5.0	20.0		
100/10-17-076-06 W4/00	10-17-076-06 W4	6159820	506661	566.8	423.0			19.0	212.0	354.8	231.0	335.8	232.0	334.8	0.0	21.0	-5.0	21.0		
100/16-20-076-06 W4/00	16-20-076-06 W4	6161831	507061	563.9	384.0	149.0	414.9	7.0	210.0	353.9	217.0	346.9	219.0	344.9	0.0	24.0	-5.0	24.0		
100/11-21-076-06 W4/00	11-21-076-06 W4	6161431	507887	564.4	400.0	154.0	410.4	19.0	207.0	357.4	226.0	338.4	226.0	338.4	0.0	29.0	-5.0	29.0		
1AA/04-22-076-06 W4/00	04-22-076-06 W4	6160629	509116	570.1	425.0			4.0	228.0	342.1	232.0	338.1	232.0	338.1	0.0	31.0	-5.0	31.0		
1AA/02-23-076-06 W4/00	02-23-076-06 W4	6160634	511552	572.7	415.0								244.0	328.7						
100/06-24-076-06 W4/00	06-24-076-06 W4	6161040	512779	570.5	416.0	170.0	400.5	4.0	224.0	346.5	228.0	342.5	245.0	325.5	4.0	7.0	4.0	7.0	252.0	318.5
1AA/12-26-076-06 W4/00	12-26-076-06 W4	6163066	510741	564.4	395.0	154.0	410.4	3.0	227.0	337.4	230.0	334.4	231.0	333.4	0.0	5.0	-5.0	5.0		
1AA/11-28-076-06 W4/00	11-28-076-06 W4	6163060	507884	557.8	363.5	147.0	410.8	2.0	209.0	348.8	211.0	346.8	213.0	344.8	0.0	22.0	-5.0	22.0		
100/08-29-076-06 W4/00	08-29-076-06 W4	6162656	507060	559.9	375.0	141.0	418.9	16.0	194.0	365.9	210.0	349.9	210.0	349.9	6.0	23.0	6.0	23.0	227.0	332.9
100/12-32-076-06 W4/00	12-32-076-06 W4	6164665	505850	565.0	374.0	146.0	419.0	15.0	200.0	365.0	215.0	350.0	215.0	350.0	0.0	21.0	-5.0	21.0		
1AA/08-02-076-07 W4/00	08-02-076-07 W4	6156178	502171	587.2	406.0	187.0	400.2	16.0	238.0	349.2	254.0	333.2	254.0	333.2	0.0	34.0	-5.0	34.0		
100/06-05-076-07 W4/00	06-05-076-07 W4	6156179	496468	663.4	488.0	259.0	404.4	22.0	307.0	356.4	329.0	334.4	329.0	334.4	0.0	38.0	-5.0	38.0		
1AA/05-10-076-07 W4/00	05-10-076-07 W4	6157786	499330	607.2	425.5	198.0	409.2	21.0	250.0	357.2	271.0	336.2	271.0	336.2	0.0	36.0	-5.0	36.0		
1AA/06-11-076-07 W4/00	06-11-076-07 W4	6157786	501364	608.0	425.0	198.0	410.0	21.0	250.0	358.0	271.0	337.0	271.0	337.0	0.0	37.0	-5.0	37.0		
1AA/06-12-076-07 W4/00	06-12-076-07 W4	6157787	502996	602.1	418.5	195.0	407.1	16.0	245.0	357.1	261.0	341.1	263.0	339.1	0.0	29.0	-5.0	29.0		
1AA/07-13-076-07 W4/00	07-13-076-07 W4	6159416	503398	587.8	406.0	181.0	406.8	22.0	228.0	359.8	250.0	337.8	250.0	337.8	0.0	33.0	-5.0	33.0		
1AA/06-14-076-07 W4/00	06-14-076-07 W4	6159415	501364	610.8	415.0	190.0	420.8	21.0	240.0	370.8	261.0	349.8	261.0	349.8	0.0	23.0	-5.0	23.0		
1AA/10-14-076-07 W4/00	10-14-076-07 W4	6159817	501766	594.8	430.0	186.0	408.8	14.0	230.0	364.8	244.0	350.8	250.0	344.8	0.0	26.0	-5.0	26.0		
1AA/14-14-076-07 W4/00	14-14-076-07 W4	6160219	501364	606.5	410.3	189.0	417.5	17.0	238.0	368.5	255.0	351.5	255.0	351.5	0.0	27.0	-5.0	27.0		
1AA/16-14-076-07 W4/00	16-14-076-07 W4	6160220	502169	593.4	395.0	175.0	418.4	15.0	230.0	363.4	245.0	348.4	248.0	345.4	0.0	30.0	-5.0	30.0		
1AA/11-15-076-07 W4/00	11-15-076-07 W4	6159817	499733	607.4	423.0	194.0	413.4	20.0	246.0	361.4	266.0	341.4	266.0	341.4	0.0	33.0	-5.0	33.0		
1AA/06-16-076-07 W4/00	06-16-076-07 W4	6159415	498102	610.8	430.0	198.0	412.8	29.0	243.0	367.8	272.0	338.8	272.0	338.8	0.0	36.0	-5.0	36.0		
100/07-17-076-07 W4/00	07-17-076-07 W4	6159416	496874	620.0	443.0	218.0	402.0						278.0	342.0						
1AA/10-22-076-07 W4/00	10-22-076-07 W4	6161426	500136	592.0	400.0	178.0	414.0	25.0	223.0	369.0	248.0	344.0	248.0	344.0	5.0	29.0	5.0	29.0	263.0	329.0
1AA/09-23-076-07 W4/00	09-23-076-07 W4	6161426	502168	588.8	401.0	175.0	413.8	23.0	224.0	364.8	247.0	341.8	247.0	341.8	0.0	25.0	-5.0	25.0		
100/10-23-076-07 W4/00	10-23-076-07 W4	6161426	501766	590.6	402.0	177.0	413.6	24.0	226.0	364.6	250.0	340.6	250.0	340.6	0.0	25.0	-5.0	25.0		
100/07-24-076-07 W4/00	07-24-076-07 W4	6161025	503396	575.8	378.0	157.0	418.8	22.0	209.0	366.8	231.0	344.8	231.0	344.8	0.0	31.0	-5.0	31.0		
102/07-34-076-07 W4/00	07-34-076-07 W4	6164261	500135	566.9	376.0	147.0	419.9	22.0	190.0	376.9	212.0	354.9	216.0	350.9	0.0	23.0	-5.0	23.0		
100/08-36-076-07 W4/00	08-36-076-07 W4	6164263	503796	566.8	376.0	146.0	420.8	22.0	195.0	371.8	217.0	349.8	217.0	349.8	0.0	23.0	-5.0	23.0		
100/03-06-076-08 W4/00	03-06-076-08 W4	6155799	485038	645.4	475.0	247.0	398.4	48.0	283.0	362.4	331.0	314.4	331.0	314.4	0.0	39.0	-5.0	39.0		
100/10-08-076-08 W4/00	10-08-076-08 W4	6158206	487081	633.8	462.0	230.0	403.8	33.0	275.0	358.8	308.0	325.8	310.0	323.8	0.0	38.0	-5.0	38.0		
100/10-11-076-08 W4/00	10-11-076-08 W4	6158194	491975	640.4	466.3	236.0	404.4	27.0	278.0	362.4	305.0	335.4	312.0	328.4	0.0	37.0	-5.0	37.0		
100/11-21-076-08 W4/00	11-21-076-08 W4	6161440	488318	646.8	588.3	241.0	405.8	28.0	287.0	359.8	315.0	331.8	315.0	331.8	0.0	34.0	-5.0	34.0		
100/10-23-076-08 W4/00	10-23-076-08 W4	6161431	491981	615.7	545.6	209.0	406.7	18.0	257.0	358.7	275.0	340.7	275.0	340.7	14.0	33.0	14.0	33.0	294.0	321.7
100/04-30-076-08 W4/00	04-30-076-08 W4	6162275	484658	665.5	497.1	261.0	404.5	30.0	302.0	363.5	332.0	333.5	332.0	333.5	0.0	37.0	-5.0	37.0		
100/10-32-076-08 W4/00	10-32-076-08 W4	6164681	487100	618.1	429.8	208.0	410.1	23.0	251.0	367.1	274.0	344.1	281.0	337.1	0.0	37.0	-5.0	37.0		
100/16-02-076-09 W4/00	16-02-076-09 W4	6157015	482581	682.2	506.0	284.0	398.2	41.0	325.0	357.2	366.0	316.2	366.0	316.2	0.0	38.0	-5.0	38.0		
100/07-06-076-09 W4/00	07-06-076-09 W4	6156243	475646	706.6	514.0	306.0	400.6	36.0	348.0	358.6	384.0	322.6	384.0	322.6	0.0	39.0	-5.0	39.0		
100/07-07-076-09 W4/00	07-07-076-09 W4	6157852	475655	699.8	503.1	301.0	398.8	39.0	339.0	360.8	378.0	321.8	382.0	317.8	0.0	37.0	-5.0	37.0		
100/05-08-076-09 W4/00	05-08-076-09 W4	6157848	476481	718.5	528.0	321.0	397.5	34.0	362.0	356.5	396.0	322.5	401.0	317.5	0.0	38.0	-5.0	38.0		
100/06-11-076-09 W4/00	06-11-076-09 W4	6157822	481778	694.0	514.0	299.0	395.0	37.0	340.0	354.0	377.0	317.0	377.0	317.0	0.0	37.0	-5.0	37.0		
100/06-12-076-09 W4/00	06-12-076-09 W4	6157816	483410	674.7	497.0	275.0	399.7	43.0	315.0	359.7	358.0	316.7	358.0	316.7	0.0	37.0	-5.0	37.0		
100/05-13-076-09 W4/00	05-13-076-09 W4	6159446	483013	682.1	496.0	282.0	400.1	32.0	328.0	354.1	360.0	322.1	360.0	322.1	0.0	38.0	-5.0	38.0		
100/07-16-076-09 W4/00	07-16-076-09 W4	6159464	478926	701.8	520.0	300.0	401.8	38.0	337.0	364.8	375.0	326.8	379.0	322.8	0.0	39.0	-5.0	39.0		
100/03-19-076-09 W4/00	03-19-076-09 W4	6160690	475268	664.6	466.5	262.0	402.6	38.0	301.0	363.6	339.0	325.6	339.0	325.6	0.0	37.0	-5.0	37.0		
100/07-20-076-09 W4/00	07-20-076-09 W4	6161081	477303	681.5	498.0	276.0	405.5	42.0	321.0	360.5	363.0	318.5	363.0	318.5	0.0	37.0	-5.0	37.0		
100/07-21-076-09 W4/00	07-21-076-09 W4	6161073	478934	686.8	508.0	276.0	410.8	34.0	321.0	365.8	355.0	331.8	358.0	328.8	0.0	34.0	-5.0	34.0		
100/05-23-076-09 W4/00	05-23-076-09 W4	6161062	481389	677.6	491.0	277.0	400.6	41.0	314.0	363.6	355.0	322.6	355.0	322.6	0.0	31.0	-5.0	31.0		
100/06-24-076-09 W4/00	06-24-076-09 W4	6161053	483422	678.4	494.5	272.0	406.4	39.0	314.0	364.4	353.0	325.4	353.0	325.4	0.0	34.0	-5.0	34.0		

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Upper Clearwater Watersand Base (m bKB)	Upper Clearwater Watersand Base (m asl)	Middle Clearwater Watersand Top (m bKB)	Middle Clearwater Watersand Top (m asl)	Middle Clearwater Watersand Base (m bKB)	Middle Clearwater Watersand Base (m asl)	Top Wabiskaw (m bKB)	Top Wabiskaw (m asl)	Top McMurray (m bKB)	Top McMurray (m asl)	Paleo Surface (m bKB)	Paleo Surface (m asl)	Watersand Thickness (m)	Watersand Thickness (Surfer) (m)	Watersand Surface Elevation (m asl)	Log Analysis Notes:
100/06-10-076-06 W4/00	06-10-076-06 W4	267.0	318.0	290.0	295.0	309.0	276.0	329.0	256.0	350.0	235.0	414.0	171.0	11.0	11.0	182.0	
1AA/16-11-076-06 W4/00	16-11-076-06 W4	260.0	318.6	284.0	294.6	294.0	284.6	318.0	260.6	337.0	241.6	408.0	170.6	0.0	-5.0	170.6	
1AA/01-12-076-06 W4/00	01-12-076-06 W4	280.0	310.7	304.0	286.7	315.0	275.7	339.0	251.7	365.0	225.7	416.0	174.7	7.0	7.0	181.7	
1AA/03-13-076-06 W4/00	03-13-076-06 W4	259.0	317.3	282.0	294.3	293.0	283.3	317.0	259.3	334.0	242.3	405.0	171.3	0.0	-5.0	171.3	
1AA/05-14-076-06 W4/00	05-14-076-06 W4	246.0	326.1	270.0	302.1	288.0	284.1	309.0	263.1	332.0	240.1	397.0	175.1	9.0	9.0	184.1	
1AA/13-15-076-06 W4/00	13-15-076-06 W4							312.0	258.4	342.0	228.4	415.0	155.4	21.0	21.0	176.4	gamma high
103/06-16-076-06 W4/00	06-16-076-06 W4			273.0	295.2	293.0	275.2	305.0	263.2	322.0	246.2	385.0	183.2	0.0	-5.0	183.2	
100/10-17-076-06 W4/00	10-17-076-06 W4			282.0	284.8	303.0	263.8	315.0	251.8	335.0	231.8	404.0	162.8	1.0	1.0	163.8	
100/16-20-076-06 W4/00	16-20-076-06 W4			261.0	302.9	285.0	278.9	299.0	264.9	318.0	245.9	370.0	193.9	0.0	-5.0	193.9	
100/11-21-076-06 W4/00	11-21-076-06 W4			262.0	302.4	291.0	273.4	311.0	253.4	330.0	234.4	387.0	177.4	0.0	-5.0	177.4	
1AA/04-22-076-06 W4/00	04-22-076-06 W4			271.0	299.1	302.0	268.1	315.0	255.1	329.0	241.1	405.0	165.1	11.0	11.0	176.1	
1AA/02-23-076-06 W4/00	02-23-076-06 W4							316.0	256.7	337.0	235.7	396.0	176.7	0.0	-5.0	176.7	gamma high
100/06-24-076-06 W4/00	06-24-076-06 W4	256.0	314.5	282.0	288.5	289.0	281.5	313.0	257.5	331.0	239.5	400.0	170.5	0.0	-5.0	170.5	
1AA/12-26-076-06 W4/00	12-26-076-06 W4			275.0	289.4	280.0	284.4	304.0	260.4	328.0	236.4	389.0	175.4	0.0	-5.0	175.4	
1AA/11-28-076-06 W4/00	11-28-076-06 W4			255.0	302.8	277.0	280.8	295.0	262.8	311.0	246.8	360.0	197.8	0.0	-5.0	197.8	
100/08-29-076-06 W4/00	08-29-076-06 W4	233.0	326.9	257.0	302.9	280.0	279.9	293.0	266.9	314.0	245.9	362.0	197.9	0.0	-5.0	197.9	
100/12-32-076-06 W4/00	12-32-076-06 W4			262.0	303.0	283.0	282.0	296.0	269.0	318.0	247.0	363.0	202.0	0.0	-5.0	202.0	
1AA/08-02-076-07 W4/00	08-02-076-07 W4			290.0	297.2	324.0	263.2	336.0	251.2	353.0	234.2	393.0	194.2	0.0	-5.0	194.2	
100/06-05-076-07 W4/00	06-05-076-07 W4			361.0	302.4	399.0	264.4	411.0	252.4	429.0	234.4	472.0	191.4	0.0	-5.0	191.4	
1AA/05-10-076-07 W4/00	05-10-076-07 W4			305.0	302.2	341.0	266.2	354.0	253.2	379.0	228.2	415.0	192.2	0.0	-5.0	192.2	
1AA/06-11-076-07 W4/00	06-11-076-07 W4			305.0	303.0	342.0	266.0	350.0	258.0	378.0	230.0	415.0	193.0	0.0	-5.0	193.0	
1AA/06-12-076-07 W4/00	06-12-076-07 W4			300.0	302.1	329.0	273.1	342.0	260.1	352.0	250.1	407.0	195.1	2.0	2.0	197.1	
1AA/07-13-076-07 W4/00	07-13-076-07 W4			285.0	302.8	318.0	269.8	332.0	255.8	346.0	241.8	392.0	195.8	2.0	2.0	197.8	
1AA/06-14-076-07 W4/00	06-14-076-07 W4			303.0	307.8	326.0	284.8	340.0	270.8	374.0	236.8	410.0	200.8	0.0	-5.0	200.8	
1AA/10-14-076-07 W4/00	10-14-076-07 W4			291.0	303.8	317.0	277.8	329.0	265.8	355.0	239.8	397.0	197.8	0.0	-5.0	197.8	
1AA/14-14-076-07 W4/00	14-14-076-07 W4			298.0	308.5	325.0	281.5	338.0	268.5	365.0	241.5	407.0	199.5	7.0	7.0	206.5	
1AA/16-14-076-07 W4/00	16-14-076-07 W4			285.0	308.4	315.0	278.4	330.0	263.4	353.0	240.4	389.0	204.4	3.0	3.0	207.4	
1AA/11-15-076-07 W4/00	11-15-076-07 W4			305.0	302.4	338.0	269.4	350.0	257.4	379.0	228.4	410.0	197.4	0.0	-5.0	197.4	
1AA/06-16-076-07 W4/00	06-16-076-07 W4			308.0	302.8	344.0	266.8	357.0	253.8	375.0	235.8	418.0	192.8	5.0	5.0	197.8	
100/07-17-076-07 W4/00	07-17-076-07 W4							366.0	254.0	377.0	243.0	428.0	192.0	0.0	-5.0	192.0	gamma ran high
1AA/10-22-076-07 W4/00	10-22-076-07 W4	268.0	324.0	289.0	303.0	318.0	274.0	330.0	262.0	356.0	236.0	396.0	196.0	2.0	2.0	198.0	
1AA/09-23-076-07 W4/00	09-23-076-07 W4			286.0	302.8	311.0	277.8	324.0	264.8	351.0	237.8	391.0	197.8	0.0	-5.0	197.8	
100/10-23-076-07 W4/00	10-23-076-07 W4			288.0	302.6	313.0	277.6	326.0	264.6	356.0	234.6	392.0	198.6	4.0	4.0	202.6	
100/07-24-076-07 W4/00	07-24-076-07 W4			267.0	308.8	298.0	277.8	312.0	263.8	325.0	250.8	369.0	206.8	0.0	-5.0	206.8	
102/07-34-076-07 W4/00	07-34-076-07 W4			265.0	301.9	288.0	278.9	299.0	267.9	319.0	247.9	364.0	202.9	0.0	-5.0	202.9	
100/08-36-076-07 W4/00	08-36-076-07 W4			263.0	303.8	286.0	280.8	299.0	267.8	316.0	250.8	364.0	202.8	0.0	-5.0	202.8	
100/03-06-076-08 W4/00	03-06-076-08 W4			358.0	287.4	397.0	248.4	409.0	236.4	425.0	220.4	467.0	178.4	0.0	-5.0	178.4	
100/10-08-076-08 W4/00	10-08-076-08 W4			339.0	294.8	377.0	256.8	389.0	244.8	404.0	229.8	449.0	184.8				
100/10-11-076-08 W4/00	10-11-076-08 W4			341.0	299.4	378.0	262.4	391.0	249.4	407.0	233.4	456.0	184.4	4.0	4.0	188.4	
100/11-21-076-08 W4/00	11-21-076-08 W4			350.0	296.8	384.0	262.8	395.0	251.8	406.0	240.8	461.0	185.8	4.0	4.0	189.8	
100/10-23-076-08 W4/00	10-23-076-08 W4	308.0	307.7	319.0	296.7	352.0	263.7	365.0	250.7	376.0	239.7	430.0	185.7	0.0	-5.0	185.7	
100/04-30-076-08 W4/00	04-30-076-08 W4			368.0	297.5	405.0	260.5	416.0	249.5	427.0	238.5	476.0	189.5	0.0	-5.0	189.5	
100/10-32-076-08 W4/00	10-32-076-08 W4			314.0	304.1	351.0	267.1	362.0	256.1	372.0	246.1	421.0	197.1	0.0	-5.0	197.1	
100/16-02-076-09 W4/00	16-02-076-09 W4			393.0	289.2	431.0	251.2	442.0	240.2	457.0	225.2	497.0	185.2	0.0	-5.0	185.2	
100/07-06-076-09 W4/00	07-06-076-09 W4			412.0	294.6	451.0	255.6	463.0	243.6	478.0	228.6	498.0	208.6	0.0	-5.0	208.6	
100/07-07-076-09 W4/00	07-07-076-09 W4			411.0	288.8	448.0	251.8	460.0	239.8	474.0	225.8	497.0	202.8	0.0	-5.0	202.8	
100/05-08-076-09 W4/00	05-08-076-09 W4			430.0	288.5	468.0	250.5	479.0	239.5	494.0	224.5	522.0	196.5	0.0	-5.0	196.5	
100/06-11-076-09 W4/00	06-11-076-09 W4			406.0	288.0	443.0	251.0	455.0	239.0	472.0	222.0	506.0	188.0	0.0	-5.0	188.0	
100/06-12-076-09 W4/00	06-12-076-09 W4			384.0	290.7	421.0	253.7	433.0	241.7	452.0	222.7	490.0	184.7	0.0	-5.0	184.7	
100/05-13-076-09 W4/00	05-13-076-09 W4			389.0	293.1	427.0	255.1	437.0	245.1	460.0	222.1	492.0	190.1	0.0	-5.0	190.1	
100/07-16-076-09 W4/00	07-16-076-09 W4			409.0	292.8	448.0	253.8	460.0	241.8	472.0	229.8	510.0	191.8	0.0	-5.0	191.8	
100/03-19-076-09 W4/00	03-19-076-09 W4			371.0	293.6	408.0	256.6	419.0	245.6	431.0	233.6	462.0	202.6	0.0	-5.0	202.6	
100/07-20-076-09 W4/00	07-20-076-09 W4			388.0	293.5	425.0	256.5	438.0	243.5	450.0	231.5	492.0	189.5	0.0	-5.0	189.5	
100/07-21-076-09 W4/00	07-21-076-09 W4			391.0	295.8	425.0	261.8	436.0	250.8	447.0	239.8	493.0	193.8	0.0	-5.0	193.8	
100/05-23-076-09 W4/00	05-23-076-09 W4			385.0	292.6	416.0	261.6	431.0	246.6	442.0	235.6	487.0	190.6	0.0	-5.0	190.6	
100/06-24-076-09 W4/00	06-24-076-09 W4			383.0	295.4	417.0	261.4	428.0	250.4	439.0	239.4	487.0	191.4	0.0	-5.0	191.4	

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Northing (m) NAD 27	Easting (m) NAD 27	KB (m asl)	TD (m)	Top Grand Rapids (m bKB)	Top Grand Rapids (m asl)	Grand Rapids Watersand Thickness (m)	Grand Rapids Watersand Top (m bKB)	Grand Rapids Watersand Top (m asl)	Grand Rapids Watersand Base (m bKB)	Grand Rapids Watersand Base (m asl)	Top Clearwater (m bKB)	Top Clearwater (m asl)	Upper Clearwater Watersand Thickness (m)	Middle Clearwater Watersand Thickness (m)	Upper Clearwater Watersand Thickness (Surfer) (m)	Middle Clearwater Watersand Thickness (Surfer) (m)	Upper Clearwater Watersand Top (m bKB)	Upper Clearwater Watersand Top (m asl)
100/10-26-076-09 W4/00	10-26-076-09 W4	6163089	482203	654.4	473.7	249.0	405.4	38.0	282.0	372.4	320.0	334.4	327.0	327.4	0.0	33.0	-5.0	33.0		
100/06-28-076-09 W4/00	06-28-076-09 W4	6162703	478539	658.9	471.0	253.0	405.9						338.0	320.9						
100/11-29-076-09 W4/00	11-29-076-09 W4	6163114	476911	654.9	468.2	248.0	406.9	36.0	288.0	366.9	324.0	330.9	332.0	322.9	0.0	34.0	-5.0	34.0		
100/08-35-076-09 W4/00	08-35-076-09 W4	6164294	482610	638.3	448.0	230.0	408.3	37.0	268.0	370.3	305.0	333.3	311.0	327.3	0.0	35.0	-5.0	35.0		
100/10-01-076-10 W4/00	10-01-076-10 W4	6156655	474013	683.5	500.0	286.0	397.5	33.0	331.0	352.5	364.0	319.5	366.0	317.5	0.0	37.0	-5.0	37.0		
100/09-05-076-10 W4/00	09-05-076-10 W4	6156695	467888	668.1	510.0	279.0	389.1	31.0	320.0	348.1	351.0	317.1	353.0	315.1	0.0	38.0	-5.0	38.0		
100/10-06-076-10 W4/00	10-06-076-10 W4	6156711	465853	660.9	500.0	273.0	387.9	31.0	314.0	346.9	345.0	315.9	347.0	313.9	0.0	37.0	-5.0	37.0		
100/06-07-076-10 W4/00	06-07-076-10 W4	6157920	465460	664.2	498.0	273.0	391.2	27.0	315.0	349.2	342.0	322.2	344.0	320.2	0.0	37.0	-5.0	37.0		
100/08-10-076-10 W4/00	08-10-076-10 W4	6157879	471160	672.4	485.0	271.0	401.4	39.0	311.0	361.4	350.0	322.4	353.0	319.4	0.0	39.0	-5.0	39.0		
100/12-11-076-10 W4/00	12-11-076-10 W4	6158279	471586	672.0	564.0	273.0	399.0	39.0	313.0	359.0	352.0	320.0	352.0	320.0	0.0	37.0	-5.0	37.0		
100/12-13-076-10 W4/00	12-13-076-10 W4	6159897	473227	666.0	465.0	257.0	409.0	35.0	306.0	360.0	341.0	325.0	341.0	325.0	0.0	37.0	-5.0	37.0		
100/06-17-076-10 W4/00	06-17-076-10 W4	6159537	467104	671.6	517.0	277.0	394.6	30.0	323.0	348.6	353.0	318.6	353.0	318.6	0.0	39.0	-5.0	39.0		
100/06-21-076-10 W4/00	06-21-076-10 W4	6161133	468746	681.3	499.0	284.0	397.3	30.0	327.0	354.3	357.0	324.3	357.0	324.3	0.0	34.0	-5.0	34.0		
100/10-24-076-10 W4/00	10-24-076-10 W4	6161501	474042	659.8	467.0	255.0	404.8	34.0	298.0	361.8	332.0	327.8	332.0	327.8	0.0	33.0	-5.0	33.0		
1AA/09-27-076-10 W4/00	09-27-076-10 W4	6163148	471195	679.1	482.0	275.0	404.1	32.0	317.0	362.1	349.0	330.1	349.0	330.1	0.0	35.0	-5.0	35.0		
100/03-28-076-10 W4/00	03-28-076-10 W4	6162360	468755	684.3	501.0	286.0	398.3	27.0	330.0	354.3	357.0	327.3	359.0	325.3	0.0	32.0	-5.0	32.0		
100/14-28-076-10 W4/00	14-28-076-10 W4	6163566	468763	684.0	502.0	284.0	400.0	29.0	331.0	353.0	360.0	324.0	360.0	324.0	0.0	33.0	-5.0	33.0		
100/11-29-076-10 W4/00	11-29-076-10 W4	6163176	467131	684.6	516.0	288.0	396.6	34.0	330.0	354.6	364.0	320.6	364.0	320.6	0.0	32.0	-5.0	32.0		
100/14-33-076-10 W4/00	14-33-076-10 W4	6165175	468775	686.6	505.0	285.0	401.6	31.0	325.0	361.6	356.0	330.6	360.0	326.6	0.0	32.0	-5.0	32.0		
100/07-34-076-10 W4/00	07-34-076-10 W4	6164357	470801	682.0	484.9	277.0	405.0	34.0	316.0	366.0	350.0	332.0	352.0	330.0	0.0	32.0	-5.0	32.0		
100/10-35-076-10 W4/00	10-35-076-10 W4	6164748	472432	663.1	460.0	257.0	406.1	42.0	297.0	366.1	339.0	324.1	339.0	324.1	0.0	33.0	-5.0	33.0		
100/08-36-076-10 W4/00	08-36-076-10 W4	6164334	474461	642.1	453.0	235.0	407.1	39.0	278.0	364.1	317.0	325.1	317.0	325.1	0.0	31.0	-5.0	31.0		
100/03-04-076-11 W4/00	03-04-076-11 W4	6155965	458918	660.3	507.0	271.0	389.3	45.0	304.0	356.3	349.0	311.3	349.0	311.3	0.0	37.0	-5.0	37.0		
100/10-05-076-11 W4/00	10-05-076-11 W4	6156781	457696	660.0	514.5	290.0	370.0	29.0	329.0	331.0	358.0	302.0	358.0	302.0	0.0	37.0	-5.0	37.0		
100/06-14-076-11 W4/00	06-14-076-11 W4	6159575	462214	665.1	502.0	272.0	393.1	30.0	317.0	348.1	347.0	318.1	347.0	318.1	0.0	38.0	-5.0	38.0		
100/07-17-076-11 W4/00	07-17-076-11 W4	6159616	457723	671.5	531.9	295.0	376.5	29.0	323.0	348.5	352.0	319.5	361.0	310.5	0.0	37.0	-5.0	37.0		
100/10-27-076-11 W4/00	10-27-076-11 W4	6163225	461018	668.4	531.3	273.0	395.4	31.0	317.0	351.4	348.0	320.4	353.0	315.4	0.0	30.0	-5.0	30.0		
100/07-36-076-11 W4/00	07-36-076-11 W4	6164404	464287	676.7	506.0	276.0	400.7	29.0	320.0	356.7	349.0	327.7	355.0	321.7	0.0	34.0	-5.0	34.0		
100/10-03-076-12 W4/00	10-03-076-12 W4	6156851	451168	674.7	550.0	295.0	379.7	32.0	337.0	337.7	369.0	305.7	376.0	298.7	0.0	38.0	-5.0	38.0		
100/11-04-076-12 W4/00	11-04-076-12 W4	6156874	449133	696.7	553.0	322.0	374.7	26.0	369.0	327.7	395.0	301.7	403.0	293.7	0.0	34.0	-5.0	34.0		
100/09-05-076-12 W4/00	09-05-076-12 W4	6156884	448307	701.1	567.0	323.0	378.1	32.0	364.0	337.1	396.0	305.1	405.0	296.1	0.0	35.0	-5.0	35.0		
100/10-06-076-12 W4/00	10-06-076-12 W4	6156908	446272	710.3	586.2	331.0	379.3	31.0	375.0	335.3	406.0	304.3	415.0	295.3	0.0	36.0	-5.0	36.0		
100/06-07-076-12 W4/00	06-07-076-12 W4	6158119	445884	720.1	601.0	344.0	376.1	31.0	386.0	334.1	417.0	303.1	425.0	295.1	0.0	34.0	-5.0	34.0		
100/07-08-076-12 W4/00	07-08-076-12 W4	6158095	447918	713.2	585.2	338.0	375.2	32.0	380.0	333.2	412.0	301.2	419.0	294.2	0.0	34.0	-5.0	34.0		
100/15-11-076-12 W4/00	15-11-076-12 W4	6158844	452822	668.3	533.0	287.0	381.3	31.0	328.0	340.3	359.0	309.3	369.0	299.3	0.0	34.0	-5.0	34.0		
100/06-12-076-12 W4/00	06-12-076-12 W4	6158026	454042	665.6	526.0	285.0	380.6	25.0	331.0	334.6	356.0	309.6	364.0	301.6	0.0	33.0	-5.0	33.0		
100/06-13-076-12 W4/00	06-13-076-12 W4	6159655	454059	667.6	525.0	277.0	390.6	30.0	324.0	343.6	354.0	313.6	363.0	304.6	0.0	31.0	-5.0	31.0		
100/06-14-076-12 W4/00	06-14-076-12 W4	6159672	452428	675.1	539.0	290.0	385.1	31.0	332.0	343.1	363.0	312.1	373.0	302.1	0.0	34.0	-5.0	34.0		
100/09-15-076-12 W4/00	09-15-076-12 W4	6160084	451607	688.3	554.0	305.0	383.3	34.0	347.0	341.3	381.0	307.3	387.0	301.3	0.0	34.0	-5.0	34.0		
100/10-17-076-12 W4/00	10-17-076-12 W4	6160126	447943	715.3	580.0	335.0	380.3	25.0	380.0	335.3	405.0	310.3	418.0	297.3	0.0	31.0	-5.0	31.0		
100/07-20-076-12 W4/00	07-20-076-12 W4	6161332	447957	712.5	560.0	333.0	379.5						420.0	292.5						
100/07-22-076-12 W4/00	07-22-076-12 W4	6161295	451218	693.5	545.0	315.0	378.5	22.0	358.0	335.5	380.0	313.5	392.0	301.5	0.0	34.0	-5.0	34.0		
100/14-23-076-12 W4/00	14-23-076-12 W4	6162085	452454	678.0	538.0	293.0	385.0						375.0	303.0						
100/07-26-076-12 W4/00	07-26-076-12 W4	6162906	452866	673.0	528.8	287.0	386.0						368.0	305.0						
100/11-30-076-12 W4/00	11-30-076-12 W4	6163388	445949	704.6	554.0															
100/06-31-076-12 W4/00	06-31-076-12 W4	6164594	445964	702.3	547.7	315.0	387.3	23.0	355.0	347.3	378.0	324.3	394.0	308.3	0.0	31.0	-5.0	31.0		
100/10-32-076-12 W4/00	10-32-076-12 W4	6164972	448000	690.4	544.4	303.0	387.4	20.0	348.0	342.4	368.0	322.4	384.0	306.4	0.0	34.0	-5.0	34.0		
100/06-33-076-12 W4/00	06-33-076-12 W4	6164555	449222	692.1	541.0	301.0	391.1	32.0	346.0	346.1	378.0	314.1	383.0	309.1	0.0	34.0	-5.0	34.0		
100/06-34-076-12 W4/00	06-34-076-12 W4	6164537	450852	675.2	545.0	286.0	389.2	28.0	332.0	343.2	360.0	315.2	371.0	304.2	0.0	31.0	-5.0	31.0		
100/10-36-076-12 W4/00	10-36-076-12 W4	6164899	454516	662.4	507.0	268.0	394.4						348.0	314.4						
100/10-02-076-13 W4/00	10-02-076-13 W4	6156949	443009	748.8	597.0	375.0	373.8	24.0	419.0	329.8	443.0	305.8	455.0	293.8	0.0	32.0	-5.0	32.0		
100/15-03-076-13 W4/00	15-03-076-13 W4	6157372	441382	717.6	585.0	343.0	374.6						425.0	292.6						
100/16-04-076-13 W4/00	16-04-076-13 W4	6157389	440153	713.1	588.0	337.0	376.1						421.0	292.1						
100/02-07-076-13 W4/00	02-07-076-13 W4	6157843	436492	712.6	572.0	338.0	374.6	28.0	384.0	328.6	412.0	300.6	423.0	289.6	0.0	30.0	-5.0	30.0		
100/11-09-076-13 W4/00	11-09-076-13 W4	6158607	439364	706.4	569.0	332.0	374.4	25.0	375.0	331.4	400.0	306.4	413.0	293.4	0.0	30.0	-5.0	30.0		
100/11-12-076-13 W4/00	11-12-076-13 W4	6158542	444258	731.9	593.0	356.0	375.9	23.0	400.0	331.9	423.0	308.9	434.0	297.9	0.0	31.0	-5.0	31.0		

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Upper Clearwater Watersand Base (m bKB)	Upper Clearwater Watersand Base (m asl)	Middle Clearwater Watersand Top (m bKB)	Middle Clearwater Watersand Top (m asl)	Middle Clearwater Watersand Base (m bKB)	Middle Clearwater Watersand Base (m asl)	Top Wabiskaw (m bKB)	Top Wabiskaw (m asl)	Top McMurray (m bKB)	Top McMurray (m asl)	Paleo Surface (m bKB)	Paleo Surface (m asl)	Watersand Thickness (m)	Watersand Thickness (Surfer) (m)	Watersand Surface Elevation (m asl)	Log Analysis Notes:
100/10-26-076-09 W4/00	10-26-076-09 W4			352.0	302.4	385.0	269.4	401.0	253.4	413.0	241.4	459.0	195.4	0.0	-5.0	195.4	
100/06-28-076-09 W4/00	06-28-076-09 W4							412.0	246.9	424.0	234.9	465.0	193.9	0.0	-5.0	193.9	gamma ran high
100/11-29-076-09 W4/00	11-29-076-09 W4			357.0	297.9	391.0	263.9	403.0	251.9	415.0	239.9	462.0	192.9	0.0	-5.0	192.9	
100/08-35-076-09 W4/00	08-35-076-09 W4			336.0	302.3	371.0	267.3	384.0	254.3	396.0	242.3	444.0	194.3	0.0	-5.0	194.3	
100/10-01-076-10 W4/00	10-01-076-10 W4			395.0	288.5	432.0	251.5	444.0	239.5	459.0	224.5	475.0	208.5	0.0	-5.0	208.5	
100/09-05-076-10 W4/00	09-05-076-10 W4			387.0	281.1	425.0	243.1	436.0	232.1	447.0	221.1	501.0	167.1	7.0	7.0	174.1	
100/10-06-076-10 W4/00	10-06-076-10 W4			381.0	279.9	418.0	242.9	430.0	230.9	441.0	219.9	493.0	167.9	4.0	4.0	171.9	
100/06-07-076-10 W4/00	06-07-076-10 W4			378.0	286.2	415.0	249.2	427.0	237.2	437.0	227.2	491.0	173.2	3.0	3.0	176.2	
100/08-10-076-10 W4/00	08-10-076-10 W4			381.0	291.4	420.0	252.4	431.0	241.4	441.0	231.4	469.0	203.4	0.0	-5.0	203.4	
100/12-11-076-10 W4/00	12-11-076-10 W4			382.0	290.0	419.0	253.0	429.0	243.0	440.0	232.0	474.0	198.0	4.0	4.0	202.0	
100/12-13-076-10 W4/00	12-13-076-10 W4			372.0	294.0	409.0	257.0	422.0	244.0	430.0	236.0	454.0	212.0	0.0	-5.0	212.0	
100/06-17-076-10 W4/00	06-17-076-10 W4			385.0	286.6	424.0	247.6	435.0	236.6	449.0	222.6	500.0	171.6	1.0	1.0	172.6	
100/06-21-076-10 W4/00	06-21-076-10 W4			392.0	289.3	426.0	255.3	438.0	243.3	449.0	232.3	495.0	186.3	0.0	-5.0	186.3	
100/10-24-076-10 W4/00	10-24-076-10 W4			364.0	295.8	397.0	262.8	410.0	249.8	422.0	237.8	449.0	210.8	0.0	-5.0	210.8	
1AA/09-27-076-10 W4/00	09-27-076-10 W4			380.0	299.1	415.0	264.1	427.0	252.1	439.0	240.1	473.0	206.1	0.0	-5.0	206.1	
100/03-28-076-10 W4/00	03-28-076-10 W4			392.0	292.3	424.0	260.3	436.0	248.3	448.0	236.3	494.0	190.3	0.0	-5.0	190.3	
100/14-28-076-10 W4/00	14-28-076-10 W4			392.0	292.0	425.0	259.0	440.0	244.0	453.0	231.0	494.0	190.0	0.0	-5.0	190.0	
100/11-29-076-10 W4/00	11-29-076-10 W4			397.0	287.6	429.0	255.6	445.0	239.6	456.0	228.6	509.0	175.6	7.0	7.0	182.6	
100/14-33-076-10 W4/00	14-33-076-10 W4			393.0	293.6	425.0	261.6	442.0	244.6	453.0	233.6	499.0	187.6	1.0	1.0	188.6	
100/07-34-076-10 W4/00	07-34-076-10 W4			383.0	299.0	415.0	267.0	431.0	251.0	444.0	238.0	478.0	204.0	0.0	-5.0	204.0	
100/10-35-076-10 W4/00	10-35-076-10 W4			363.0	300.1	396.0	267.1	412.0	251.1	425.0	238.1	452.0	211.1	0.0	-5.0	211.1	
100/08-36-076-10 W4/00	08-36-076-10 W4			343.0	299.1	374.0	268.1	390.0	252.1	403.0	239.1	433.0	209.1	0.0	-5.0	209.1	
100/03-04-076-11 W4/00	03-04-076-11 W4			383.0	277.3	420.0	240.3	433.0	227.3	447.0	213.3	497.0	163.3	14.0	14.0	177.3	
100/10-05-076-11 W4/00	10-05-076-11 W4			393.0	267.0	430.0	230.0	443.0	217.0	454.0	206.0	508.0	152.0	14.0	14.0	166.0	
100/06-14-076-11 W4/00	06-14-076-11 W4			382.0	283.1	420.0	245.1	431.0	234.1	444.0	221.1	497.0	168.1	6.0	6.0	174.1	
100/07-17-076-11 W4/00	07-17-076-11 W4			393.0	278.5	430.0	241.5	444.0	227.5	457.0	214.5	509.0	162.5	8.0	8.0	170.5	
100/10-27-076-11 W4/00	10-27-076-11 W4			386.0	282.4	416.0	252.4	433.0	235.4	442.0	226.4	500.0	168.4	0.0	-5.0	168.4	
100/07-36-076-11 W4/00	07-36-076-11 W4			387.0	289.7	421.0	255.7	435.0	241.7	448.0	228.7	498.0	178.7	5.0	5.0	183.7	
100/10-03-076-12 W4/00	10-03-076-12 W4			409.0	265.7	447.0	227.7	458.0	216.7	475.0	199.7	528.0	146.7	1.0	1.0	147.7	
100/11-04-076-12 W4/00	11-04-076-12 W4			435.0	261.7	469.0	227.7	483.0	213.7	500.0	196.7	548.0	148.7	0.0	-5.0	148.7	
100/09-05-076-12 W4/00	09-05-076-12 W4			435.0	266.1	470.0	231.1	483.0	218.1	499.0	202.1	552.0	149.1	0.0	-5.0	149.1	
100/10-06-076-12 W4/00	10-06-076-12 W4			446.0	264.3	482.0	228.3	493.0	217.3	506.0	204.3	561.0	149.3	23.0	23.0	172.3	
100/06-07-076-12 W4/00	06-07-076-12 W4			455.0	265.1	489.0	231.1	502.0	218.1	519.0	201.1	568.0	152.1	19.0	19.0	171.1	
100/07-08-076-12 W4/00	07-08-076-12 W4			452.0	261.2	486.0	227.2	500.0	213.2	516.0	197.2	563.0	150.2	0.0	-5.0	150.2	
100/15-11-076-12 W4/00	15-11-076-12 W4			398.0	270.3	432.0	236.3	448.0	220.3	465.0	203.3	515.0	153.3	1.0	1.0	154.3	
100/06-12-076-12 W4/00	06-12-076-12 W4			397.0	268.6	430.0	235.6	446.0	219.6	462.0	203.6	514.0	151.6	3.0	3.0	154.6	
100/06-13-076-12 W4/00	06-13-076-12 W4			396.0	271.6	427.0	240.6	444.0	223.6	457.0	210.6	520.0	147.6	0.0	-5.0	147.6	
100/06-14-076-12 W4/00	06-14-076-12 W4			405.0	270.1	439.0	236.1	453.0	222.1	466.0	209.1	522.0	153.1	1.0	1.0	154.1	
100/09-15-076-12 W4/00	09-15-076-12 W4			420.0	268.3	454.0	234.3	469.0	219.3	484.0	204.3	539.0	149.3	5.0	5.0	154.3	
100/10-17-076-12 W4/00	10-17-076-12 W4			450.0	265.3	481.0	234.3	495.0	220.3	514.0	201.3	561.0	154.3	0.0	-5.0	154.3	
100/07-20-076-12 W4/00	07-20-076-12 W4							492.0	220.5	503.0	209.5	555.0	157.5	0.0	-5.0	157.5	gamma runs high
100/07-22-076-12 W4/00	07-22-076-12 W4			425.0	268.5	459.0	234.5	471.0	222.5	486.0	207.5	534.0	159.5	0.0	-5.0	159.5	gamma runs high
100/14-23-076-12 W4/00	14-23-076-12 W4							453.0	225.0	466.0	212.0	530.0	148.0	1.0	1.0	149.0	gamma runs high
100/07-26-076-12 W4/00	07-26-076-12 W4							448.0	225.0	462.0	211.0	519.0	154.0	6.0	6.0	160.0	gamma runs high
100/11-30-076-12 W4/00	11-30-076-12 W4							478.0	226.6	490.0	214.6	544.0	160.6	7.0	7.0	167.6	no log through CLWT and GDRD
100/06-31-076-12 W4/00	06-31-076-12 W4			426.0	276.3	457.0	245.3	472.0	230.3	485.0	217.3	542.0	160.3	6.0	6.0	166.3	
100/10-32-076-12 W4/00	10-32-076-12 W4			414.0	276.4	448.0	242.4	461.0	229.4	474.0	216.4	528.0	162.4	6.0	6.0	168.4	
100/06-33-076-12 W4/00	06-33-076-12 W4			413.0	279.1	447.0	245.1	460.0	232.1	474.0	218.1	530.0	162.1	20.0	20.0	182.1	
100/06-34-076-12 W4/00	06-34-076-12 W4			398.0	277.2	429.0	246.2	447.0	228.2	460.0	215.2	530.0	145.2	3.0	3.0	148.2	
100/10-36-076-12 W4/00	10-36-076-12 W4							426.0	236.4	439.0	223.4	502.0	160.4	2.0	2.0	162.4	gamma runs high
100/10-02-076-13 W4/00	10-02-076-13 W4			487.0	261.8	519.0	229.8	534.0	214.8	550.0	198.8	596.0	152.8	14.0	14.0	166.8	
100/15-03-076-13 W4/00	15-03-076-13 W4							505.0	212.6	517.0	200.6	563.0	154.6	7.0	7.0	161.6	gamma runs high
100/16-04-076-13 W4/00	16-04-076-13 W4							501.0	212.1	514.0	199.1	563.0	150.1	6.0	6.0	156.1	gamma runs high
100/02-07-076-13 W4/00	02-07-076-13 W4			455.0	257.6	485.0	227.6	503.0	209.6	519.0	193.6	563.0	149.6	12.0	12.0	161.6	
100/11-09-076-13 W4/00	11-09-076-13 W4			447.0	259.4	477.0	229.4	493.0	213.4	506.0	200.4	554.0	152.4	1.0	1.0	153.4	
100/11-12-076-13 W4/00	11-12-076-13 W4			469.0	262.9	500.0	231.9	514.0	217.9	530.0	201.9	577.0	154.9	13.0	13.0	167.9	

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Northing (m) NAD 27	Easting (m) NAD 27	KB (m asl)	TD (m)	Top Grand Rapids (m bKB)	Top Grand Rapids (m asl)	Grand Rapids Watersand Thickness (m)	Grand Rapids Watersand Top (m bKB)	Grand Rapids Watersand Top (m asl)	Grand Rapids Watersand Base (m bKB)	Grand Rapids Watersand Base (m asl)	Top Clearwater (m bKB)	Top Clearwater (m asl)	Upper Clearwater Watersand Thickness (m)	Middle Clearwater Watersand Thickness (m)	Upper Clearwater Watersand Thickness (Surfer) (m)	Middle Clearwater Watersand Thickness (Surfer) (m)	Upper Clearwater Watersand Top (m bKB)	Upper Clearwater Watersand Top (m asl)
100/10-14-076-13 W4/00	10-14-076-13 W4	6160186	443051	720.0	579.0	342.0	378.0	29.0	384.0	336.0	413.0	307.0	425.0	295.0	0.0	31.0	-5.0	31.0		
100/06-18-076-13 W4/00	06-18-076-13 W4	6159880	436119	683.9	547.0	310.0	373.9						392.0	291.9						
100/08-20-076-13 W4/00	08-20-076-13 W4	6161453	438578	702.7	567.0	321.0	381.7	35.0	361.0	341.7	396.0	306.7	405.0	297.7	0.0	30.0	-5.0	30.0		
100/05-24-076-13 W4/00	05-24-076-13 W4	6161382	443892	719.2	565.0	341.0	378.2	39.0	382.0	337.2	421.0	298.2	424.0	295.2	0.0	27.0	-5.0	27.0		
100/11-27-076-13 W4/00	11-27-076-13 W4	6163450	441061	702.9	559.4	319.0	383.9	38.0	359.0	343.9	397.0	305.9	403.0	299.9	0.0	30.0	-5.0	30.0		
100/12-32-076-13 W4/00	12-32-076-13 W4	6165110	437422	686.0	546.0	303.0	383.0	38.0	338.0	348.0	376.0	310.0	384.0	302.0	0.0	29.0	-5.0	29.0		
100/10-33-076-13 W4/00	10-33-076-13 W4	6165076	439856	708.9	555.0	323.0	385.9	34.0	361.0	347.9	395.0	313.9	405.0	303.9	0.0	33.0	-5.0	33.0		
100/12-34-076-13 W4/00	12-34-076-13 W4	6165064	440680	678.2	533.0	291.0	387.2	39.0	332.0	346.2	371.0	307.2	375.0	303.2	0.0	33.0	-5.0	33.0		
100/16-02-076-14 W4/100	16-02-076-14 W4	6157482	433624	700.2	557.0	325.0	375.2	36.0	365.0	335.2	401.0	299.2	407.0	293.2	0.0	28.0	-5.0	28.0		
100/06-05-076-14 W4/00	06-05-076-14 W4	6156768	427909	730.9	581.3	356.0	374.9						437.0	293.9						
100/11-09-076-14 W4/00	11-09-076-14 W4	6158752	429573	712.9	545.3	337.0	375.9						418.0	294.9						
100/11-10-076-14 W4/00	11-10-076-14 W4	6158726	431205	698.3	540.0	322.0	376.3	33.0	359.0	339.3	392.0	306.3	407.0	291.3	0.0	27.0	-5.0	27.0		
100/08-14-076-14 W4/00	08-14-076-14 W4	6159915	433660	691.2	551.0	315.0	376.2	41.0	353.0	338.2	394.0	297.2	399.0	292.2	0.0	28.0	-5.0	28.0		
100/12-15-076-14 W4/00	12-15-076-14 W4	6160361	430828	709.3	562.0	332.0	377.3	36.0	373.0	336.3	409.0	300.3	415.0	294.3	0.0	28.0	-5.0	28.0		
100/11-17-076-14 W4/00	11-17-076-14 W4	6160407	427969	711.2	554.5	333.0	378.2	40.0	371.0	340.2	411.0	300.2	417.0	294.2	4.0	27.0	4.0	27.0	440.0	271.2
100/12-19-076-14 W4/00	12-19-076-14 W4	6162050	425963	688.8	534.0	311.0	377.8	40.0	348.0	340.8	388.0	300.8	397.0	291.8	4.0	26.0	4.0	26.0	418.0	270.8
100/06-20-076-14 W4/00	06-20-076-14 W4	6161614	427989	698.2	564.0	321.0	377.2	37.0	359.0	339.2	396.0	302.2	406.0	292.2	0.0	27.0	-5.0	27.0		
100/14-23-076-14 W4/00	14-23-076-14 W4	6162340	432892	694.5	559.0	313.0	381.5	38.0	352.0	342.5	390.0	304.5	395.0	299.5	0.0	28.0	-5.0	28.0		
100/05-26-076-14 W4/00	05-26-076-14 W4	6163171	432502	676.8	540.0	294.0	382.8	34.0	332.0	344.8	366.0	310.8	376.0	300.8	0.0	28.0	-5.0	28.0		
100/02-27-076-14 W4/00	02-27-076-14 W4	6162782	431671	680.0	525.0	296.0	384.0	37.0	335.0	345.0	372.0	308.0	378.0	302.0	0.0	28.0	-5.0	28.0		
100/13-28-076-14 W4/100	13-28-076-14 W4	6164027	429256	681.4	543.0	299.0	382.4	38.0	340.0	341.4	378.0	303.4	386.0	295.4	0.0	30.0	-5.0	30.0		
100/10-30-076-14 W4/00	10-30-076-14 W4	6163665	426795	685.8	549.2	304.0	381.8	34.0	343.0	342.8	377.0	308.8	388.0	297.8	0.0	29.0	-5.0	29.0		
100/10-34-076-14 W4/00	10-34-076-14 W4	6165195	431709	674.5	522.0	290.0	384.5	39.0	327.0	347.5	366.0	308.5	376.0	298.5	0.0	28.0	-5.0	28.0		
100/05-35-076-14 W4/00	05-35-076-14 W4	6164780	432527	670.0	521.0	283.0	387.0	39.0	320.0	350.0	359.0	311.0	366.0	304.0	0.0	29.0	-5.0	29.0		
100/01-01-077-06 W4/00	01-01-077-06 W4	6165505	513570	567.0	411.0	169.0	398.0	6.0	235.0	332.0	241.0	326.0	245.0	322.0	20.0	0.0	20.0	-5.0	261.0	306.0
100/09-01-077-06 W4/00	09-01-077-06 W4	6166309	513568	566.4	426.0	162.0	404.4	11.0	226.0	340.4	237.0	329.4	237.0	329.4	21.0	0.0	21.0	-5.0	252.0	314.4
100/06-03-077-06 W4/00	06-03-077-06 W4	6165897	509507	561.8	376.0	148.0	413.8						225.0	336.8	9.0	22.0	9.0	22.0	243.0	318.8
100/11-07-077-06 W4/00	11-07-077-06 W4	6167899	504619	565.1	372.5	146.0	419.1	15.0	198.0	367.1	213.0	352.1	213.0	352.1	13.0	24.0	13.0	24.0	232.0	333.1
100/05-08-077-06 W4/00	05-08-077-06 W4	6167499	505846	566.1	357.0	143.0	423.1	15.0	198.0	368.1	213.0	353.1	215.0	351.1	0.0	6.0	-5.0	6.0		
100/07-13-077-06 W4/00	07-13-077-06 W4	6169143	513157	566.5	395.0	159.0	407.5		224.0	342.5	228.0	338.5	235.0	331.5						
100/11-14-077-06 W4/00	11-14-077-06 W4	6169540	511127	569.1	410.0	160.0	409.1	14.0	215.0	354.1	229.0	340.1	229.0	340.1	0.0	0.0		-5.0		
100/06-16-077-06 W4/00	06-16-077-06 W4	6169131	507873	569.4	367.0	151.0	418.4	17.0	204.0	365.4	221.0	348.4	221.0	348.4	14.0	0.0	14.0	-5.0	240.0	329.4
100/10-18-077-06 W4/00	10-18-077-06 W4	6169529	505019	569.8	379.0	147.0	422.8	14.0	202.0	367.8	216.0	353.8	219.0	350.8	20.0	8.0	20.0	8.0	234.0	335.8
100/10-22-077-06 W4/00	10-22-077-06 W4	6171146	509898	568.4	405.0	152.0	416.4	17.0	210.0	358.4	227.0	341.4	227.0	341.4	14.0	0.0	14.0	-5.0	247.0	321.4
100/07-25-077-06 W4/00	07-25-077-06 W4	6172381	513147	568.8	422.0	156.0	412.8	14.0	215.0	353.8	229.0	339.8	229.0	339.8	12.0	0.0	12.0	-5.0	249.0	319.8
100/11-27-077-06 W4/00	11-27-077-06 W4	6172774	509492	581.1	418.0	164.0	417.1	13.0	224.0	357.1	237.0	344.1	241.0	340.1	8.0	0.0	8.0	-5.0	259.0	322.1
100/06-29-077-06 W4/00	06-29-077-06 W4	6172366	506241	576.4	391.0	155.0	421.4	17.0	210.0	366.4	227.0	349.4	230.0	346.4	14.0	6.0	14.0	6.0	247.0	329.4
1AA/10-30-077-06 W4/00	10-30-077-06 W4	6172766	505016	581.8	392.0	158.0	423.8						235.0	346.8						
100/10-31-077-06 W4/00	10-31-077-06 W4	6174375	505014	588.6	403.0	163.0	425.6	20.0	218.0	370.6	238.0	350.6	238.0	350.6	12.0	0.0	12.0	-5.0	254.0	334.6
100/06-32-077-06 W4/00	06-32-077-06 W4	6173974	506239	601.7	419.0	178.0	423.7	18.0	234.0	367.7	252.0	349.7	252.0	349.7	8.0	0.0	8.0	-5.0	271.0	330.7
100/09-36-077-06 W4/00	09-36-077-06 W4	6174393	513542	577.0	431.0	164.0	413.0	19.0	220.0	357.0	239.0	338.0	239.0	338.0	12.0	0.0	12.0	-5.0	259.0	318.0
100/11-03-077-07 W4/00	11-03-077-07 W4	6166296	499730	563.6	387.0	145.0	418.6	21.0	190.0	373.6	211.0	352.6	215.0	348.6	0.0	24.0	-5.0	24.0		
100/10-04-077-07 W4/00	10-04-077-07 W4	6166297	498503	569.7	385.0	150.0	419.7	23.0	195.0	374.7	218.0	351.7	220.0	349.7	0.0	21.0	-5.0	21.0		
100/12-05-077-07 W4/00	12-05-077-07 W4	6166298	496071	563.2	367.0	140.0	423.2	28.0	187.0	376.2	215.0	348.2	215.0	348.2	0.0	29.0	-5.0	29.0		
100/03-07-077-07 W4/00	03-07-077-07 W4	6167104	494845	572.1	787.7	151.0	421.1	18.0	207.0	365.1	225.0	347.1	225.0	347.1	12.0	27.0	12.0	27.0	241.0	331.1
1AA/06-07-077-07 W4/00	06-07-077-07 W4	6167506	494846	565.0	369.0	143.0	422.0						218.0	347.0						
100/11-07-077-07 W4/00	11-07-077-07 W4	6167908	494846	566.0	392.3	147.0	419.0	19.0	198.0	368.0	217.0	349.0	217.0	349.0	1.0	22.0	1.0	22.0	242.0	324.0
100/11-08-077-07 W4/00	11-08-077-07 W4	6167907	496474	563.6	386.0	144.0	419.6	25.0	191.0	372.6	216.0	347.6	220.0	343.6	0.0	30.0	-5.0	30.0		
100/11-09-077-07 W4/00	11-09-077-07 W4	6167906	498102	566.0	391.1	145.0	421.0	22.0	193.0	373.0	215.0	351.0	219.0	347.0	0.0	23.0	-5.0	23.0		
100/11-10-077-07 W4/00	11-10-077-07 W4	6167905	499730	567.1	376.0	144.0	423.1	19.0	192.0	375.1	211.0	356.1	216.0	351.1	0.0	20.0	-5.0	20.0		
100/06-13-077-07 W4/00	06-13-077-07 W4	6169133	502985	566.4	366.0	144.0	422.4						217.0	349.4						
100/11-15-077-07 W4/00	11-15-077-07 W4	6169534	499730	571.2	378.0	150.0	421.2	21.0	199.0	372.2	220.0	351.2	223.0	348.2	11.0	22.0	11.0	22.0	239.0	332.2
1AA/02-16-077-07 W4/00	02-16-077-07 W4	6168730	498504	565.0	381.0	142.0	423.0						216.0	349.0						
100/11-19-077-07 W4/00	11-19-077-07 W4	6171146	494850	555.7	381.6	133.0	422.7	26.0	180.0	375.7	206.0	349.7	208.0	347.7	8.0	21.0	8.0	21.0	224.0	331.7

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Upper Clearwater Watersand Base (m bKB)	Upper Clearwater Watersand Base (m asl)	Middle Clearwater Watersand Top (m bKB)	Middle Clearwater Watersand Top (m asl)	Middle Clearwater Watersand Base (m bKB)	Middle Clearwater Watersand Base (m asl)	Top Wabiskaw (m bKB)	Top Wabiskaw (m asl)	Top McMurray (m bKB)	Top McMurray (m asl)	Paleo Surface (m bKB)	Paleo Surface (m asl)	Watersand Thickness (m)	Watersand Thickness (Surfer) (m)	Watersand Surface Elevation (m asl)	Log Analysis Notes:
100/10-14-076-13 W4/00	10-14-076-13 W4			456.0	264.0	487.0	233.0	501.0	219.0	518.0	202.0	563.0	157.0	12.0	12.0	169.0	
100/06-18-076-13 W4/00	06-18-076-13 W4							472.0	211.9	484.0	199.9	535.0	148.9	1.0	1.0	149.9	gamma runs high
100/08-20-076-13 W4/00	08-20-076-13 W4			437.0	265.7	467.0	235.7	484.0	218.7	495.0	207.7	553.0	149.7	13.0	13.0	162.7	
100/05-24-076-13 W4/00	05-24-076-13 W4			457.0	262.2	484.0	235.2	496.0	223.2	507.0	212.2	557.0	162.2	18.0	18.0	180.2	
100/11-27-076-13 W4/00	11-27-076-13 W4			435.0	267.9	465.0	237.9	484.0	218.9	493.0	209.9	545.0	157.9	15.0	15.0	172.9	
100/12-32-076-13 W4/00	12-32-076-13 W4			417.0	269.0	446.0	240.0	465.0	221.0	477.0	209.0	533.0	153.0	5.0	5.0	158.0	
100/10-33-076-13 W4/00	10-33-076-13 W4			437.0	271.9	470.0	238.9	486.0	222.9	500.0	208.9	550.0	158.9	0.0	-5.0	158.9	
100/12-34-076-13 W4/00	12-34-076-13 W4			407.0	271.2	440.0	238.2	457.0	221.2	474.0	204.2	517.0	161.2	0.0	-5.0	161.2	
100/16-02-076-14 W4/100	16-02-076-14 W4			442.0	258.2	470.0	230.2	488.0	212.2	501.0	199.2	551.0	149.2	6.0	6.0	155.2	
100/06-05-076-14 W4/00	06-05-076-14 W4							522.0	208.9	534.0	196.9						gamma runs high
100/11-09-076-14 W4/00	11-09-076-14 W4							501.0	211.9	512.0	200.9	543.0	169.9	0.0	-5.0	169.9	gamma runs high
100/11-10-076-14 W4/00	11-10-076-14 W4			442.0	256.3	469.0	229.3	487.0	211.3	498.0	200.3	534.0	164.3	0.0	-5.0	164.3	
100/08-14-076-14 W4/00	08-14-076-14 W4			434.0	257.2	462.0	229.2	480.0	211.2	492.0	199.2	544.0	147.2	10.0	10.0	157.2	
100/12-15-076-14 W4/00	12-15-076-14 W4			453.0	256.3	481.0	228.3	501.0	208.3	510.0	199.3	559.0	150.3	0.0	-5.0	150.3	
100/11-17-076-14 W4/00	11-17-076-14 W4	444.0	267.2	455.0	256.2	482.0	229.2	500.0	211.2	512.0	199.2	550.0	161.2				
100/12-19-076-14 W4/00	12-19-076-14 W4	422.0	266.8	435.0	253.8	461.0	227.8	479.0	209.8	492.0	196.8	529.0	159.8	0.0	-5.0	159.8	
100/06-20-076-14 W4/00	06-20-076-14 W4			444.0	254.2	471.0	227.2	488.0	210.2	499.0	199.2	530.0	168.2	0.0	-5.0	168.2	
100/14-23-076-14 W4/00	14-23-076-14 W4			434.0	260.5	462.0	232.5	479.0	215.5	489.0	205.5	540.0	154.5	4.0	4.0	158.5	
100/05-26-076-14 W4/00	05-26-076-14 W4			414.0	262.8	442.0	234.8	459.0	217.8	470.0	206.8	523.0	153.8	0.0	-5.0	153.8	
100/02-27-076-14 W4/00	02-27-076-14 W4			419.0	261.0	447.0	233.0	464.0	216.0	475.0	205.0	525.0	155.0	1.0	1.0	156.0	
100/13-28-076-14 W4/100	13-28-076-14 W4			424.0	257.4	454.0	227.4	471.0	210.4	481.0	200.4	529.0	152.4	3.0	3.0	155.4	
100/10-30-076-14 W4/00	10-30-076-14 W4			428.0	257.8	457.0	228.8	475.0	210.8	485.0	200.8	525.0	160.8	5.0	5.0	165.8	
100/10-34-076-14 W4/00	10-34-076-14 W4			411.0	263.5	439.0	235.5	457.0	217.5	466.0	208.5	520.0	154.5	2.0	2.0	156.5	
100/05-35-076-14 W4/00	05-35-076-14 W4			402.0	268.0	431.0	239.0	449.0	221.0	458.0	212.0	512.0	158.0	1.0	1.0	159.0	
100/01-01-077-06 W4/00	01-01-077-06 W4	281.0	286.0					327.0	240.0	346.0	221.0	401.0	166.0	0.0	-5.0	166.0	
100/09-01-077-06 W4/00	09-01-077-06 W4	273.0	293.4					313.0	253.4	331.0	235.4	391.0	175.4	5.0	5.0	180.4	
100/06-03-077-06 W4/00	06-03-077-06 W4	252.0	309.8	260.0	301.8	282.0	279.8	296.0	265.8	309.0	252.8	369.0	192.8	0.0	-5.0	192.8	
100/11-07-077-06 W4/00	11-07-077-06 W4	245.0	320.1	262.0	303.1	286.0	279.1	300.0	265.1	313.0	252.1	361.0	204.1	5.0	5.0	209.1	
100/05-08-077-06 W4/00	05-08-077-06 W4			263.0	303.1	269.0	297.1	292.0	274.1	304.0	262.1	348.0	218.1	0.0	-5.0	218.1	
100/07-13-077-06 W4/00	07-13-077-06 W4							307.0	259.5	322.0	244.5	385.0	181.5	0.0	-5.0	181.5	gamma runs high
100/11-14-077-06 W4/00	11-14-077-06 W4							307.0	262.1	321.0	248.1	413.0	156.1	13.0	13.0	169.1	high gamma through clearwater, adjacent log picks ~20 m zone, replace log with 03-14 at a later date
100/06-16-077-06 W4/00	06-16-077-06 W4	254.0	315.4					305.0	264.4	316.0	253.4	360.0	209.4	0.0	-5.0	209.4	
100/10-18-077-06 W4/00	10-18-077-06 W4	254.0	315.8	275.0	294.8	283.0	286.8	298.0	271.8	314.0	255.8	362.0	207.8	0.0	-5.0	207.8	
100/10-22-077-06 W4/00	10-22-077-06 W4	261.0	307.4					303.0	265.4	318.0	250.4	385.0	183.4	0.0	-5.0	183.4	
100/07-25-077-06 W4/00	07-25-077-06 W4	261.0	307.8					307.0	261.8	321.0	247.8	413.0	155.8	12.0	12.0	167.8	
100/11-27-077-06 W4/00	11-27-077-06 W4	267.0	314.1					316.0	265.1	330.0	251.1	396.0	185.1	0.0	-5.0	185.1	
100/06-29-077-06 W4/00	06-29-077-06 W4	261.0	315.4	285.0	291.4	291.0	285.4	305.0	271.4	320.0	256.4	368.0	208.4	0.0	-5.0	208.4	
1AA/10-30-077-06 W4/00	10-30-077-06 W4							314.0	267.8	328.0	253.8	371.0	210.8	0.0	-5.0	210.8	gamma runs high
100/10-31-077-06 W4/00	10-31-077-06 W4	266.0	322.6					312.0	276.6	324.0	264.6	379.0	209.6	0.0	-5.0	209.6	
100/06-32-077-06 W4/00	06-32-077-06 W4	279.0	322.7					328.0	273.7	342.0	259.7	397.0	204.7	0.0	-5.0	204.7	
100/09-36-077-06 W4/00	09-36-077-06 W4	271.0	306.0					313.0	264.0	328.0	249.0	396.0	181.0	6.0	6.0	187.0	
100/11-03-077-07 W4/00	11-03-077-07 W4			262.0	301.6	286.0	277.6	299.0	264.6	313.0	250.6	361.0	202.6	4.0	4.0	206.6	
100/10-04-077-07 W4/00	10-04-077-07 W4			267.0	302.7	288.0	281.7	301.0	268.7	314.0	255.7	367.0	202.7	0.0	-5.0	202.7	
100/12-05-077-07 W4/00	12-05-077-07 W4			257.0	306.2	286.0	277.2	301.0	262.2	314.0	249.2	361.0	202.2	3.0	3.0	205.2	
100/03-07-077-07 W4/00	03-07-077-07 W4	253.0	319.1	269.0	303.1	296.0	276.1	310.0	262.1	319.0	253.1	370.0	202.1				
1AA/06-07-077-07 W4/00	06-07-077-07 W4							300.0	265.0	309.0	256.0	359.0	206.0	0.0	-5.0	206.0	gamma runs high
100/11-07-077-07 W4/00	11-07-077-07 W4	243.0	323.0	265.0	301.0	287.0	279.0	301.0	265.0	313.0	253.0	364.0	202.0	0.0	-5.0	202.0	
100/11-08-077-07 W4/00	11-08-077-07 W4			261.0	302.6	291.0	272.6	306.0	257.6	322.0	241.6	364.0	199.6	0.0	-5.0	199.6	
100/11-09-077-07 W4/00	11-09-077-07 W4			264.0	302.0	287.0	279.0	301.0	265.0	313.0	253.0	361.0	205.0	0.0	-5.0	205.0	
100/11-10-077-07 W4/00	11-10-077-07 W4			264.0	303.1	284.0	283.1	297.0	270.1	311.0	256.1	364.0	203.1	0.0	-5.0	203.1	
100/06-13-077-07 W4/00	06-13-077-07 W4							293.0	273.4	308.0	258.4	359.0	207.4	0.0	-5.0	207.4	gamma runs high
100/11-15-077-07 W4/00	11-15-077-07 W4	250.0	321.2	269.0	302.2	291.0	280.2	306.0	265.2	317.0	254.2	368.0	203.2	0.0	-5.0	203.2	
1AA/02-16-077-07 W4/00	02-16-077-07 W4							298.0	267.0	310.0	255.0	360.0	205.0	0.0	-5.0	205.0	gamma runs high
100/11-19-077-07 W4/00	11-19-077-07 W4	232.0	323.7	253.0	302.7	274.0	281.7	291.0	264.7	305.0	250.7	352.0	203.7	0.0	-5.0	203.7	

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Northing (m) NAD 27	Easting (m) NAD 27	KB (m asl)	TD (m)	Top Grand Rapids (m bKB)	Top Grand Rapids (m asl)	Grand Rapids Watersand Thickness (m)	Grand Rapids Watersand Top (m bKB)	Grand Rapids Watersand Top (m asl)	Grand Rapids Watersand Base (m bKB)	Grand Rapids Watersand Base (m asl)	Top Clearwater (m bKB)	Top Clearwater (m asl)	Upper Clearwater Watersand Thickness (m)	Middle Clearwater Watersand Thickness (m)	Upper Clearwater Watersand Thickness (Surfer) (m)	Middle Clearwater Watersand Thickness (Surfer) (m)	Upper Clearwater Watersand Top (m bKB)	Upper Clearwater Watersand Top (m asl)
100/06-20-077-07 W4/00	06-20-077-07 W4	6170742	496476	560.6	380.0	137.0	423.6	26.0	184.0	376.6	210.0	350.6	210.0	350.6	9.0	21.0	9.0	21.0	226.0	334.6
100/11-21-077-07 W4/00	11-21-077-07 W4	6171143	498103	559.6	389.0	136.0	423.6	23.0	187.0	372.6	210.0	349.6	212.0	347.6	0.0	17.0	-5.0	17.0		
1AA/11-23-077-07 W4/00	11-23-077-07 W4	6171143	501357	568.6	388.0	147.0	421.6	19.0	199.0	369.6	218.0	350.6	220.0	348.6	15.0	0.0	15.0	-5.0	236.0	332.6
100/06-24-077-07 W4/00	06-24-077-07 W4	6170741	502984	567.2	380.0	146.0	421.2	24.0	196.0	371.2	220.0	347.2	221.0	346.2	19.0	11.0	19.0	11.0	236.0	331.2
100/10-25-077-07 W4/00	10-25-077-07 W4	6172773	503384	580.6	397.0	160.0	420.6	19.0	213.0	367.6	232.0	348.6	234.0	346.6	14.0	0.0	14.0	-5.0	251.0	329.6
100/05-28-077-07 W4/00	05-28-077-07 W4	6172370	497702	558.4	354.0	139.0	419.4	21.0	186.0	372.4	207.0	351.4	207.0	351.4	12.0	0.0	12.0	-5.0	223.0	335.4
100/10-29-077-07 W4/00	10-29-077-07 W4	6172773	496879	555.0	374.9	135.0	420.0	24.0	182.0	373.0	206.0	349.0	207.0	348.0	6.0	0.0	6.0	-5.0	224.0	331.0
1AA/14-30-077-07 W4/00	14-30-077-07 W4	6173177	494852	553.0	380.0								205.0	348.0						
1AA/15-32-077-07 W4/00	15-32-077-07 W4	6174783	496881	555.6	360.0	135.0	420.6						205.0	350.6						
100/16-32-077-07 W4/00	16-32-077-07 W4	6174783	497282	556.5	360.0	134.0	422.5	31.0	177.0	379.5	208.0	348.5	208.0	348.5	11.0	0.0	11.0	-5.0	223.0	333.5
1AA/06-34-077-07 W4/00	06-34-077-07 W4	6173978	499730	562.7	380.0	136.0	426.7						210.0	352.7						
1AA/11-36-077-07 W4/00	11-36-077-07 W4	6174381	502981	571.9	388.0	150.0	421.9	22.0	203.0	368.9	225.0	346.9	225.0	346.9	8.0	0.0	8.0	-5.0	248.0	323.9
100/11-01-077-08 W4/00	11-01-077-08W4	6166302	493216	570.0	391.7	147.2	422.8	23.0	197.0	373.0	220.0	350.0	221.3	348.7	0.0	21.0	-5.0	21.0		
100/11-02-077-08 W4/00	11-02-077-08W4	6166305	491587	578.6	400.0	161.8	416.8	22.0	208.0	370.6	230.0	348.6	234.4	344.2	0.0	26.0	-5.0	26.0		
100/10-03-077-08 W4/00	10-03-077-08W4	6166307	490361	586.4	422.5	171.0	415.4	25.0	215.0	371.4	240.0	346.4	243.5	342.9	0.0	30.0	-5.0	30.0		
100/02-08-077-08 W4/00	02-08-077-08W4	6167120	487107	584.0	782.0	168.0	416.0	35.0	209.0	375.0	244.0	340.0	244.0	340.0	0.0	29.0	-5.0	29.0		
1AA/10-11-077-08 W4/00	10-11-077-08W4	6167913	491993	570.4	391.0	154.0	416.4	21.0	201.0	369.4	222.0	348.4	226.0	344.4	0.0	24.0	-5.0	24.0		
100/03-12-077-08 W4/00	03-12-077-08W4	6167106	493217	567.8	374.0	151.3	416.5	26.0	200.0	367.8	226.0	341.8	226.0	341.8	0.0	34.0	-5.0	34.0		
100/08-17-077-08 W4/00	08-17-077-08W4	6169150	487514	567.5	335.3	150.0	417.5	18.0	190.0	377.5	208.0	359.5	224.5	343.0	0.0	26.0	-5.0	26.0		
100/12-21-077-08 W4/00	12-21-077-08W4	6171160	487942	567.3	366.0	147.4	419.9	31.8	191.0	376.3	222.8	344.5	222.8	344.5	0.0	22.0	-5.0	22.0		
1AA/06-23-077-08 W4/00	06-23-077-08W4	6170749	491596	551.1	370.0	134.0	417.1						210.0	341.1						
1AA/14-24-077-08 W4/00	14-24-077-08W4	6171550	493224	555.9	373.0	132.0	423.9						208.0	347.9						
1AA/07-26-077-08 W4/00	07-26-077-08W4	6172377	492001	555.3	361.1	133.8	421.5	31.3	175.0	380.3	206.3	349.0	206.3	349.0	0.0	18.0	-5.0	18.0		
100/09-34-077-08 W4/00	09-34-077-08W4	6174390	490780	562.1	362.0	135.0	427.1						214.0	348.1						
100/11-06-077-09 W4	11-06-077-09W4	6166344	475285	631.0	431.0	221.0	410.0	29.0	263.0	368.0	292.0	339.0	303.0	328.0	0.0	29.0	-5.0	29.0		
100/07-09-077-09 W4	07-09-077-09W4	6167540	478956	621.9	425.0	212.0	409.9	29.0	255.0	366.9	284.0	337.9	293.0	328.9	0.0	30.0	-5.0	30.0		
100/16-10-077-09 W4	16-10-077-09W4	6168340	480995	611.9	373.0	199.0	412.9	28.0	245.0	366.9	273.0	338.9	281.0	330.9	0.0	28.0	-5.0	28.0		
100/06-11-077-09 W4	06-11-077-09W4	6167527	481805	636.1	442.0	224.0	412.1	28.0	265.0	371.1	293.0	343.1	306.0	330.1	0.0	24.5	-5.0	24.5		
100/08-13-077-09 W4	08-13-077-09W4	6169137	484254	580.9	384.5	165.0	415.9	31.0	207.0	373.9	238.0	342.9	246.0	334.9	0.0	22.5	-5.0	22.5		
100/09-14-077-09 W4	09-14-077-09W4	6169549	482628	591.2	358.5	174.0	417.2	30.0	222.0	369.2	252.0	339.2	258.0	333.2	0.0	29.0	-5.0	29.0		
100/07-15-077-09 W4	07-15-077-09W4	6169152	480591	576.0	379.0	169.0	407.0	28.0	214.0	362.0	242.0	334.0	249.0	327.0	0.0	26.0	-5.0	26.0		
100/06-16-077-09 W4	06-16-077-09W4	6169162	478557	597.2	357.0	183.0	414.2	28.0	230.0	367.2	258.0	339.2	265.0	332.2	0.0	28.0	-5.0	28.0		
100/12-17-077-09 W4	12-17-077-09W4	6169577	476524	609.3	408.0	194.0	415.3						275.0	334.3						
100/11-18-077-09 W4	11-18-077-09W4	6169584	475303	619.7	380.1	206.0	413.7						288.0	331.7						
100/07-20-077-09 W4	07-20-077-09W4	6170788	477344	586.9	348.1	172.0	414.9	29.0	216.0	370.9	245.0	341.9	252.0	334.9	0.0	20.0	-5.0	20.0		
100/15-21-077-09 W4	15-21-077-09W4	6171589	478975	581.4	364.0	162.0	419.4	30.0	210.0	371.4	240.0	341.4	247.0	334.4	0.0	24.0	-5.0	24.0		
100/10-22-077-09 W4	10-22-077-09W4	6171177	480600	585.8	393.2	167.0	418.8	28.0	216.0	369.8	244.0	341.8	250.0	335.8	0.0	0.0	-5.0	-5.0		
100/12-22-077-09W4	12-22-077-09W4	6171181	479787	587.4	427.0	170.0	417.4	32.0	214.0	373.4	246.0	341.4	253.0	334.4	0.0	24.0	-5.0	24.0		
102/15-23-077-09W4	15-23-077-09W4	6171575	482229	591.9	387.0	174.0	417.9						255.0	336.9						
100/16-23-077-09W4	16-23-077-09W4	6171573	482636	587.8	322.5	171.0	416.8	26.5	218.0	369.8	244.5	343.3	251.0	336.8	0.0	22.0	-5.0	22.0		
100/06-24-077-09W4	06-24-077-09W4	6170760	483446	573.3	332.5	156.0	417.3	29.0	202.0	371.3	231.0	342.3	237.0	336.3	0.0	0.0	-5.0	-5.0		
100/10-25-077-09W4	10-25-077-09W4	6172784	483860	576.7	331.0	156.0	420.7	27.0	203.0	373.7	230.0	346.7	237.0	339.7	0.0	0.0	-5.0	-5.0		
100/15-26-077-09W4	15-26-077-09W4	6173195	482236	581.9	360.0	161.5	420.4	31.0	206.0	375.9	237.0	344.9	244.0	337.9	0.0	18.5	-5.0	18.5		
100/10-27-077-09W4	10-27-077-09W4	6172797	480607	589.4	345.0	174.0	415.4	33.0	217.0	372.4	250.0	339.4	255.0	334.4	0.0	0.0	-5.0	-5.0		
100/14-28-077-09W4	14-28-077-09W4	6173211	478576	587.6	375.5	172.0	415.6						253.0	334.6						
102/07-29-077-09W4	07-29-077-09W4	6172408	477353	585.2	393.0	166.0	419.2	34.0	208.0	377.2	242.0	343.2	249.0	336.2	0.0	20.0	-5.0	20.0		
100/04-30-077-09W4	04-30-077-09W4	6172016	474910	611.5	408.0	195.0	416.5						280.0	331.5						
100/10-31-077-09W4	10-31-077-09W4	6174441	475737	607.8	399.0	192.0	415.8	35.0	234.0	373.8	269.0	338.8	275.0	332.8	0.0	25.0	-5.0	25.0		
100/10-32-077-09W4	10-32-077-09W4	6174432	477363	599.1	398.0	182.0	417.1	31.0	221.0	378.1	252.0	347.1	265.0	334.1	0.0	0.0	-5.0	-5.0		
100/10-33-077-09W4	10-33-077-09W4	6174424	478989	568.5	360.0	146.5	422.0	36.0	187.0	381.5	223.0	345.5	230.0	338.5	0.0	18.0	-5.0	18.0		
100/13-33-077-09W4	13-33-077-09W4	6174833	478178	585.3	402.0	175.0	410.3	34.0	217.0	368.3	251.0	334.3	262.0	323.3	0.0	21.0	-5.0	21.0		
100/07-34-077-09W4	07-34-077-09W4	6174012	480613	591.4	389.0	168.5	422.9	32.0	212.0	379.4	244.0	347.4	250.0	341.4	0.0	0.0	-5.0	-5.0		
100/10-35-077-09W4	10-35-077-09W4	6174410	482240	596.9	350.0	175.0	421.9	32.0	219.0	377.9	251.0	345.9	257.0	339.9	0.0	0.0	-5.0	-5.0		
100/06-36-077-09W4	06-36-077-09W4	6174000	483458	589.8	342.0	168.0	421.8	28.0	214.0	375.8	242.0	347.8	250.0	339.8	0.0	0.0	-5.0	-5.0		
100/11-02-077-10W4	11-02-077-10W4	6166364	472025	664.2	479.0	260.0	404.2	40.5	302.0	362.2	342.5	321.7	343.0	321.2	0.0	32.0	-5.0	32.0		
100/10-06-077-10W4	10-06-077-10W4	6166407	465917	683.9	507.0	282.0	401.9	10.0	344.0	339.9	354.0	329.9	363.0	320.9	0.0	31.0	-5.0	31.0		

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Upper Clearwater Watersand Base (m bKB)	Upper Clearwater Watersand Base (m asl)	Middle Clearwater Watersand Top (m bKB)	Middle Clearwater Watersand Top (m asl)	Middle Clearwater Watersand Base (m bKB)	Middle Clearwater Watersand Base (m asl)	Top Wabiskaw (m bKB)	Top Wabiskaw (m asl)	Top McMurray (m bKB)	Top McMurray (m asl)	Paleo Surface (m bKB)	Paleo Surface (m asl)	Watersand Thickness (m)	Watersand Thickness (Surfer) (m)	Watersand Surface Elevation (m asl)	Log Analysis Notes:
100/06-20-077-07 W4/00	06-20-077-07 W4	235.0	325.6	257.0	303.6	278.0	282.6	293.0	267.6	305.0	255.6	352.0	208.6	0.0	-5.0	208.6	
100/11-21-077-07 W4/00	11-21-077-07 W4			257.0	302.6	274.0	285.6	294.0	265.6	305.0	254.6	354.0	205.6	0.0	-5.0	205.6	
1AA/11-23-077-07 W4/00	11-23-077-07 W4	251.0	317.6					298.0	270.6	310.0	258.6	367.0	201.6	0.0	-5.0	201.6	
100/06-24-077-07 W4/00	06-24-077-07 W4	255.0	312.2	275.0	292.2	286.0	281.2	300.0	267.2	312.0	255.2	362.0	205.2	0.0	-5.0	205.2	
100/10-25-077-07 W4/00	10-25-077-07 W4	265.0	315.6					314.0	266.6	325.0	255.6	375.0	205.6	0.0	-5.0	205.6	
100/05-28-077-07 W4/00	05-28-077-07 W4	235.0	323.4					283.0	275.4	295.0	263.4	345.0	213.4	0.0	-5.0	213.4	
100/10-29-077-07 W4/00	10-29-077-07 W4	230.0	325.0					282.0	273.0	292.0	263.0	345.0	210.0	0.0	-5.0	210.0	
1AA/14-30-077-07 W4/00	14-30-077-07 W4							287.0	266.0	298.0	255.0	345.0	208.0	0.0	-5.0	208.0	gamma runs high
1AA/15-32-077-07 W4/00	15-32-077-07 W4							281.0	274.6	294.0	261.6	342.0	213.6	0.0	-5.0	213.6	gamma runs high
100/16-32-077-07 W4/00	16-32-077-07 W4	234.0	322.5					283.0	273.5	295.0	261.5	343.0	213.5	0.0	-5.0	213.5	
1AA/06-34-077-07 W4/00	06-34-077-07 W4							287.0	275.7	299.0	263.7	353.0	209.7	0.0	-5.0	209.7	gamma runs high
1AA/11-36-077-07 W4/00	11-36-077-07 W4	256.0	315.9					304.0	267.9	316.0	255.9	368.0	203.9	0.0	-5.0	203.9	
100/11-01-077-08 W4/00	11-01-077-08W4			266.0	304.0	287.0	283.0	302.0	268.0	312.9	257.1	365.2	204.8	0.0	-5.0	204.8	porosity ran low
100/11-02-077-08 W4/00	11-02-077-08W4			275.0	303.6	301.0	277.6	314.5	264.1	325.0	253.6	376.1	202.5	0.0	-5.0	202.5	
100/10-03-077-08 W4/00	10-03-077-08W4			282.0	304.4	312.0	274.4	324.4	262.0	335.3	251.1	393.0	193.4	3.0	3.0	196.4	
100/02-08-077-08 W4/00	02-08-077-08W4			281.0	303.0	310.0	274.0	324.0	260.0	336.0	248.0	391.0	193.0	5.0	5.0	198.0	
1AA/10-11-077-08 W4/00	10-11-077-08W4			267.0	303.4	291.0	279.4	306.0	264.4	317.0	253.4	380.0	190.4	2.0	2.0	192.4	
100/03-12-077-08 W4/00	03-12-077-08W4			263.0	304.8	297.0	270.8	311.1	256.7	321.9	245.9	361.7	206.1	0.0	-5.0	206.1	
100/08-17-077-08 W4/00	08-17-077-08W4			264.0	303.5	290.0	277.5	304.7	262.8	316.0	251.5	365.0	202.5	0.0	-5.0	202.5	
100/12-21-077-08 W4/00	12-21-077-08W4			265.0	302.3	287.0	280.3	301.5	265.8	313.0	254.3	360.9	206.4	0.0	-5.0	206.4	
1AA/06-23-077-08 W4/00	06-23-077-08W4							291.0	260.1	301.5	249.6	350.0	201.1	0.0	-5.0	201.1	gamma runs high
1AA/14-24-077-08 W4/00	14-24-077-08W4							290.5	265.4	302.0	253.9	351.0	204.9	0.0	-5.0	204.9	gamma runs high
1AA/07-26-077-08 W4/00	07-26-077-08W4			252.0	303.3	270.0	285.3	285.7	269.6	297.1	258.2	347.5	207.8	0.0	-5.0	207.8	
100/09-34-077-08 W4/00	09-34-077-08W4							290.5	271.6	303.0	259.1	350.5	211.6	0.0	-5.0	211.6	gamma runs high
100/11-06-077-09 W4	11-06-077-09W4			330.0	301.0	359.0	272.0	376.0	255.0	388.0	243.0	415.0	216.0	0.0	-5.0	216.0	
100/07-09-077-09 W4	07-09-077-09W4			320.0	301.9	350.0	271.9	367.0	254.9	379.0	242.9						
100/16-10-077-09 W4	16-10-077-09W4			312.0	299.9	340.0	271.9	356.0	255.9	368.0	243.9						
100/06-11-077-09 W4	06-11-077-09W4			334.0	302.1	358.5	277.6	380.0	256.1	392.0	244.1	436.5	199.6	0.0	-5.0	199.6	
100/08-13-077-09 W4	08-13-077-09W4			279.5	301.4	302.0	278.9	318.0	262.9	330.0	250.9	382.0	198.9				
100/09-14-077-09 W4	09-14-077-09W4			289.0	302.2	318.0	273.2	333.0	258.2	345.0	246.2						
100/07-15-077-09 W4	07-15-077-09W4			280.0	296.0	306.0	270.0	323.0	253.0	335.0	241.0						
100/06-16-077-09 W4	06-16-077-09W4			294.0	303.2	322.0	275.2	339.0	258.2								
100/12-17-077-09 W4	12-17-077-09W4							347.0	262.3	359.0	250.3	394.0	215.3	3.0	3.0	218.3	gamma runs high
100/11-18-077-09 W4	11-18-077-09W4							359.0	260.7	371.0	248.7						gamma runs high
100/07-20-077-09 W4	07-20-077-09W4			284.0	302.9	304.0	282.9	324.0	262.9	336.0	250.9						
100/15-21-077-09 W4	15-21-077-09W4			278.0	303.4	302.0	279.4	319.0	262.4	331.0	250.4						
100/10-22-077-09 W4	10-22-077-09W4							321.0	264.8	334.0	251.8	380.0	205.8	9.0	9.0	214.8	
100/12-22-077-09W4	12-22-077-09W4			284.0	303.4	308.0	279.4	324.0	263.4	336.0	251.4	382.0	205.4	3.0	3.0	208.4	
102/15-23-077-09W4	15-23-077-09W4							325.0	266.9	337.0	254.9	379.0	212.9	0.0	-5.0	212.9	gamma runs high
100/16-23-077-09W4	16-23-077-09W4			284.0	303.8	306.0	281.8										
100/06-24-077-09W4	06-24-077-09W4							311.0	262.3	322.0	251.3						
100/10-25-077-09W4	10-25-077-09W4							308.0	268.7	321.0	255.7						
100/15-26-077-09W4	15-26-077-09W4			279.0	302.9	297.5	284.4	314.0	267.9	327.0	254.9						
100/10-27-077-09W4	10-27-077-09W4							327.0	262.4								
100/14-28-077-09W4	14-28-077-09W4							324.0	263.6	337.0	250.6						gamma runs high
102/07-29-077-09W4	07-29-077-09W4			281.0	304.2	301.0	284.2	320.0	265.2	333.0	252.2	375.0	210.2	5.0	5.0	215.2	
100/04-30-077-09W4	04-30-077-09W4							353.0	258.5	365.0	246.5						gamma runs high
100/10-31-077-09W4	10-31-077-09W4			303.0	304.8	328.0	279.8	347.0	260.8	358.0	249.8						
100/10-32-077-09W4	10-32-077-09W4							335.0	264.1	347.0	252.1						
100/10-33-077-09W4	10-33-077-09W4			263.0	305.5	281.0	287.5	299.0	269.5	311.0	257.5						
100/13-33-077-09W4	13-33-077-09W4			291.5	293.8	312.5	272.8	330.5	254.8	342.0	243.3	389.0	196.3	5.0	5.0	201.3	
100/07-34-077-09W4	07-34-077-09W4							320.0	271.4	332.0	259.4						
100/10-35-077-09W4	10-35-077-09W4							326.0	270.9	338.0	258.9						
100/06-36-077-09W4	06-36-077-09W4							319.0	270.8	331.0	258.8						
100/11-02-077-10W4	11-02-077-10W4			368.0	296.2	400.0	264.2	417.0	247.2	429.0	235.2	468.0	196.2	0.0	-5.0	196.2	
100/10-06-077-10W4	10-06-077-10W4			389.0	294.9	420.0	263.9	436.0	247.9	448.0	235.9	502.0	181.9	4.0	4.0	185.9	

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Northing (m) NAD 27	Easting (m) NAD 27	KB (m asl)	TD (m)	Top Grand Rapids (m bKB)	Top Grand Rapids (m asl)	Grand Rapids Watersand Thickness (m)	Grand Rapids Watersand Top (m bKB)	Grand Rapids Watersand Top (m asl)	Grand Rapids Watersand Base (m bKB)	Grand Rapids Watersand Base (m asl)	Top Clearwater (m bKB)	Top Clearwater (m asl)	Upper Clearwater Watersand Thickness (m)	Middle Clearwater Watersand Thickness (m)	Upper Clearwater Watersand Thickness (Surfer) (m)	Middle Clearwater Watersand Thickness (Surfer) (m)	Upper Clearwater Watersand Top (m bKB)	Upper Clearwater Watersand Top (m asl)
1AA/05-07-077-10W4	05-07-077-10W4	6167635	465134	687.9	511.6	283.0	404.9	33.0	327.0	360.9	360.0	327.9	368.0	319.9	0.0	30.0	-5.0	30.0		
1AA/07-07-077-10W4	07-07-077-10W4	6167629	465938	687.6	514.0	282.0	405.6	39.0	326.0	361.6	365.0	322.6	367.0	320.6	0.0	32.0	-5.0	32.0		
100/09-07-077-10W4	09-07-077-10W4	6168024	466337	688.6	509.0	285.0	403.6	38.0	322.0	366.6	360.0	328.6	368.0	320.6	0.0	30.0	-5.0	30.0		
1AA/13-07-077-10W4	13-07-077-10W4	6168440	465141	685.6	517.0	277.0	408.6	34.0	328.0	357.6	362.0	323.6	362.0	323.6	0.0	31.0	-5.0	31.0		
1AA/15-07-077-10W4	15-07-077-10W4	6168433	465944	690.6	512.0	285.0	405.6	31.0	330.0	360.6	361.0	329.6	371.0	319.6	0.0	30.0	-5.0	30.0		
100/12-09-077-10W4	12-09-077-10W4	6168009	468372	687.7	510.0	285.0	402.7	29.0	328.0	359.7	357.0	330.7	369.0	318.7	0.0	31.0	-5.0	31.0		
100/08-12-077-10W4	08-12-077-10W4	6167564	474476	628.3	326.1	217.0	411.3	32.0	257.0	371.3	289.0	339.3	299.0	329.3						
100/10-14-077-10W4	10-14-077-10W4	6169601	472453	635.0	470.0	225.0	410.0	42.0	265.0	370.0	307.0	328.0	307.0	328.0	0.0	36.0	-5.0	36.0		
100/11-16-077-10W4	11-16-077-10W4	6169626	468791	684.3	508.0	280.0	404.3	29.0	325.0	359.3	354.0	330.3	362.0	322.3	0.0	31.0	-5.0	31.0		
1AA/03-17-077-10W4	03-17-077-10W4	6168846	467173	693.7	515.0	286.0	407.7	40.0	331.0	362.7	371.0	322.7	371.0	322.7	0.0	29.0	-5.0	29.0		
05-17-077-10W4	05-17-077-10W4	6169236	466753	694.0	527.0	288.0	406.0	40.0	329.0	365.0	369.0	325.0	369.0	325.0	0.0	29.0	-5.0	29.0		
1AA/05-18-077-10W4	05-18-077-10W4	6169264	465147	692.3	520.0	282.0	410.3	34.0	335.0	357.3	369.0	323.3	369.0	323.3	0.0	31.0	-5.0	31.0		
1AA/07-18-077-10W4	07-18-077-10W4	6169258	465951	694.4	521.0	290.0	404.4	32.0	333.0	361.4	365.0	329.4	373.0	321.4	0.0	29.0	-5.0	29.0		
11-19-077-10W4	11-19-077-10W4	6171270	465549	695.8	537.0	289.0	406.8	29.0	334.0	361.8	363.0	332.8	377.0	318.8	0.0	28.0	-5.0	28.0		
03-20-077-10W4	03-20-077-10W4	6170447	467170	689.3	513.0	281.0	408.3	30.0	336.0	353.3	366.0	323.3	366.0	323.3	0.0	29.0	-5.0	29.0		
11-22-077-10W4	11-22-077-10W4	6171234	470430	645.6	468.0	235.0	410.6	44.0	278.0	367.6	322.0	323.6	322.0	323.6	0.0	29.0	-5.0	29.0		
02-25-077-10W4	02-25-077-10W4	6172021	474095	613.6	450.0	204.0	409.6	30.0	246.0	367.6	276.0	337.6	286.0	327.6	0.0	29.0	-5.0	29.0		
05-26-077-10W4	05-26-077-10W4	6172441	471658	625.9	440.0	214.0	411.9	33.1	257.0	368.9	290.1	335.8	297.0	328.9	0.0	28.0	-5.0	28.0		
08-29-077-10W4	08-29-077-10W4	6172466	467998	665.4	489.2	257.0	408.4	31.5	301.5	363.9	333.0	332.4	343.0	322.4	0.0	29.0	-5.0	29.0		
06-33-077-10W4	06-33-077-10W4	6174080	468823	651.3	469.0	238.0	413.3	42.5	281.5	369.8	324.0	327.3	324.0	327.3	0.0	25.0	-5.0	25.0		
07-34-077-10W4	07-34-077-10W4	6174066	470855	627.3	443.0	216.0	411.3	18.0	272.0	355.3	290.0	337.3	300.0	327.3	0.0	25.0	-5.0	25.0		
1F1/10-35-077-10W4	10-35-077-10W4	6174460	472494	625.6	443.0	213.0	412.6	24.0	263.0	362.6	287.0	338.6	297.0	328.6	0.0	26.0	-5.0	26.0		
1AA/12-36-077-10W4	12-36-077-10W4	6174455	473297	622.2	430.3	211.0	411.2	32.0	256.0	366.2	288.0	334.2	295.0	327.2	0.0	27.0	-5.0	27.0		
100/01-02-077-11W4	01-02-077-11W4	6165621	463065	677.8	514.0	275.0	402.8	31.0	320.0	357.8	351.0	326.8	355.0	322.8	0.0	35.0	-5.0	35.0		
100/09-03-077-11W4	09-03-077-11W4	6166444	461443	676.7	518.0	274.0	402.7	35.0	318.0	358.7	353.0	323.7	358.0	318.7	0.0	35.0	-5.0	35.0		
100/10-10-077-11W4	10-10-077-11W4	6168068	461050	677.0	521.0	277.0	400.0	34.0	320.0	357.0	354.0	323.0	361.0	316.0	0.0	36.0	-5.0	36.0		
100/09-11-077-11W4	09-11-077-11W4	6168050	463085	681.6	515.0	280.0	401.6	29.0	323.0	358.6	352.0	329.6	363.0	318.6	0.0	35.0	-5.0	35.0		
100/09-12-077-11W4	09-12-077-11W4	6168037	464713	683.2	508.0	278.0	405.2	32.0	320.0	363.2	352.0	331.2	360.0	323.2	0.0	32.0	-5.0	32.0		
100/09-13-077-11W4	09-13-077-11W4	6169657	464726	692.2	521.0	287.0	405.2	40.0	329.0	363.2	369.0	323.2	370.0	322.2	0.0	30.0	-5.0	30.0		
100/08-14-077-11W4	08-14-077-11W4	6169265	463095	688.3	535.0	286.0	402.3	32.0	328.0	360.3	360.0	328.3	369.0	319.3	0.0	31.0	-5.0	31.0		
100/11-15-077-11W4	11-15-077-11W4	6169691	460657	682.5	521.4	280.0	402.5	26.0	324.0	358.5	350.0	332.5	360.0	322.5	0.0	29.0	-5.0	29.0		
100/10-22-077-11W4	10-22-077-11W4	6171307	461079	690.4	525.8	290.0	400.4	23.0	335.0	355.4	358.0	332.4	371.0	319.4	0.0	29.0	-5.0	29.0		
100/11-24-077-11W4	11-24-077-11W4	6171283	463926	695.1	520.0	291.0	404.1	30.0	334.0	361.1	364.0	331.1	373.0	322.1	0.0	28.0	-5.0	28.0		
1AA/13-24-077-11W4	13-24-077-11W4	6171689	463543	695.9	523.0	293.0	402.9	26.0	338.0	357.9	364.0	331.9	376.0	319.9	0.0	30.0	-5.0	30.0		
1AA/15-24-077-11W4	15-24-077-11W4	6171683	464346	694.2	525.0	290.0	404.2	30.0	334.0	360.2	364.0	330.2	373.0	321.2	0.0	29.0	-5.0	29.0		
1AA/07-26-077-11W4	07-26-077-11W4	6172521	462727	695.8	519.0	293.0	402.8	33.0	327.0	368.8	360.0	335.8	375.0	320.8	0.0	28.0	-5.0	28.0		
100/09-26-077-11W4	09-26-077-11W4	6172910	463126	700.4	525.0	295.0	405.4	22.0	340.0	360.4	362.0	338.4	377.0	323.4	0.0	27.0	-5.0	27.0		
100/05-27-077-11W4	05-27-077-11W4	6172530	460276	690.3	528.0	287.0	403.3	25.0	332.0	358.3	357.0	333.3	367.0	323.3	0.0	34.0	-5.0	34.0		
100/11-32-077-11W4	11-32-077-11W4	6174581	457450	690.7	509.3	288.0	402.7	32.0	331.0	359.7	363.0	327.7	371.0	319.7	0.0	27.0	-5.0	27.0		
100/06-35-077-11W4	06-35-077-11W4	6174131	462324	696.4	522.0	289.0	407.4	17.0	343.0	353.4	360.0	336.4	371.0	325.4	0.0	27.0	-5.0	27.0		
100/10-02-077-12W400	10-02-077-12W4	6166661	452698	666.2	531.0	279.7	386.5	24.0	321.0	345.2	345.0	321.2	352.7	313.5	0.0	33.0	-5.0	33.0		
100/12-03-077-12W400	12-03-077-12W4	6166630	450605	670.0	507.0	279.5	390.5	29.0	325.0	345.0	354.0	316.0	360.7	309.3	0.0	33.0	-5.0	33.0		
100/06-04-077-12W400	06-04-077-12W4	6166314	449077	678.2	521.2	288.2	390.0						368.4	309.8						
100/08-06-077-12W400	08-06-077-12W4	6166607	446607	686.8	527.0	299.0	387.8	36.0	340.0	346.8	376.0	310.8	381.4	305.5	0.0	37.0	-5.0	37.0		
100/16-08-077-12W400	16-08-077-12W4	6168991	448535	674.8	517.0	282.1	392.7						364.9	309.9						
100/01-09-077-12W400	01-09-077-12W4	6167638	449899	664.3	509.0	270.2	394.1	21.0	314.0	350.3	335.0	329.3	348.7	315.6	0.0	31.0	-5.0	31.0		
102/01-09-077-12W400	01-09-077-12W4	6167625	449902	666.0	514.0	271.6	394.4	21.0	315.0	351.0	336.0	330.0	350.0	316.0	0.0	29.0	-5.0	29.0		
100/04-10-077-12W400	04-10-077-12W4	6167492	450405	670.8	517.0	276.4	394.5	18.0	321.0	349.8	339.0	331.8	356.3	314.5	0.0	31.0	-5.0	31.0		
100/12-10-077-12W400	12-10-077-12W4	6168526	450628	671.2	507.0	275.5	395.7	30.0	319.0	352.2	349.0	322.2	354.0	317.2	0.0	35.0	-5.0	35.0		
100/10-11-077-12W400	10-11-077-12W4	6168425	453008	669.3	504.0	274.5	394.8						355.7	313.6						
100/05-14-077-12W400	05-14-077-12W4	6169747	452236	639.0	492.0	245.5	393.5	30.0	287.0	352.0	317.0	322.0	322.9	316.1	0.0	29.0	-5.0	29.0		
100/07-15-077-12W400	07-15-077-12W4	6169432	451353	639.2	472.4	246.9	392.3	31.0	290.0	349.2	321.0	318.2	324.9	314.3	0.0	32.0	-5.0	32.0		
100/14-15-077-12W400	14-15-077-12W4	6170624	450702	680.0	526.0	280.7	399.3						364.1	315.9						
100/04-16-077-12W400	04-16-077-12W4	6169198	448811	674.5	510.0	280.9	393.6	27.0	324.0	350.5	351.0	323.5	364.5	310.0	0.0	32.0	-5.0	32.0		
100/13-16-077-12W400	13-16-077-12W4	6170397	448833	676.3	515.5	276.8	399.5	32.0	320.0	356.3	352.0	324.3	363.9	312.4	0.0	32.0	-5.0	32.0		
100/07-17-077-12W400	07-17-077-12W4	6169791	447927	679.8	515.0	283.2	396.6	40.0	324.0	355.8	364.0	315.8	368.2	311.6	0.0	32.0	-5.0	32.0		

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Upper Clearwater Watersand Base (m bKB)	Upper Clearwater Watersand Base (m asl)	Middle Clearwater Watersand Top (m bKB)	Middle Clearwater Watersand Top (m asl)	Middle Clearwater Watersand Base (m bKB)	Middle Clearwater Watersand Base (m asl)	Top Wabiskaw (m bKB)	Top Wabiskaw (m asl)	Top McMurray (m bKB)	Top McMurray (m asl)	Paleo Surface (m bKB)	Paleo Surface (m asl)	Watersand Thickness (m)	Watersand Thickness (Surfer) (m)	Watersand Surface Elevation (m asl)	Log Analysis Notes:
1AA/05-07-077-10W4	05-07-077-10W4			391.0	296.9	421.0	266.9	443.0	244.9	456.0	231.9	505.0	182.9	8.0	8.0	190.9	
1AA/07-07-077-10W4	07-07-077-10W4			392.0	295.6	424.0	263.6	440.0	247.6	452.0	235.6	503.0	184.6	6.0	6.0	190.6	
100/09-07-077-10W4	09-07-077-10W4			393.0	295.6	423.0	265.6	440.0	248.6	452.0	236.6	505.0	183.6	0.0	-5.0	183.6	
1AA/13-07-077-10W4	13-07-077-10W4			388.0	297.6	419.0	266.6	435.0	250.6	448.0	237.6	502.0	183.6	7.0	7.0	190.6	
1AA/15-07-077-10W4	15-07-077-10W4			396.0	294.6	426.0	264.6	444.0	246.6	456.0	234.6	506.0	184.6	6.0	6.0	190.6	
100/12-09-077-10W4	12-09-077-10W4			395.0	292.7	426.0	261.7	444.0	243.7	457.0	230.7	504.0	183.7	0.0	-5.0	183.7	
100/08-12-077-10W4	08-12-077-10W4																
100/10-14-077-10W4	10-14-077-10W4			333.0	302.0	369.0	266.0	380.0	255.0	393.0	242.0	434.5	200.5	0.0	-5.0	200.5	
100/11-16-077-10W4	11-16-077-10W4			389.0	295.3	420.0	264.3	437.0	247.3	450.0	234.3	500.0	184.3	0.0	-5.0	184.3	
1AA/03-17-077-10W4	03-17-077-10W4			396.0	297.7	425.0	268.7	442.0	251.7	455.0	238.7	509.0	184.7	2.0	2.0	186.7	
05-17-077-10W4	05-17-077-10W4			396.0	298.0	425.0	269.0	441.0	253.0	454.0	240.0	510.0	184.0	6.0	6.0	190.0	
1AA/05-18-077-10W4	05-18-077-10W4			395.0	297.3	426.0	266.3	442.0	250.3	455.0	237.3	515.0	177.3	4.0	4.0	181.3	
1AA/07-18-077-10W4	07-18-077-10W4			399.0	295.4	428.0	266.4	447.0	247.4	460.0	234.4	512.0	182.4	6.0	6.0	188.4	
11-19-077-10W4	11-19-077-10W4			401.0	294.8	429.0	266.8	447.0	248.8	459.0	236.8	514.0	181.8	16.0	16.0	197.8	
03-20-077-10W4	03-20-077-10W4			392.0	297.3	421.0	268.3	438.0	251.3	450.0	239.3	505.0	184.3	11.0	11.0	195.3	
11-22-077-10W4	11-22-077-10W4			348.0	297.6	377.0	268.6	395.0	250.6	407.0	238.6	457.0	188.6	6.0	6.0	194.6	
02-25-077-10W4	02-25-077-10W4			314.0	299.6	343.0	270.6	360.0	253.6	372.0	241.6	422.0	191.6	5.0	5.0	196.6	
05-26-077-10W4	05-26-077-10W4			324.0	301.9	352.0	273.9	371.0	254.9	383.0	242.9	431.0	194.9	3.0	3.0	197.9	
08-29-077-10W4	08-29-077-10W4			372.0	293.4	401.0	264.4	419.0	246.4	432.0	233.4	484.0	181.4	0.0	-5.0	181.4	
06-33-077-10W4	06-33-077-10W4			352.0	299.3	377.0	274.3	396.0	255.3	407.0	244.3	461.0	190.3	17.0	17.0	207.3	
07-34-077-10W4	07-34-077-10W4			329.0	298.3	354.0	273.3	374.0	253.3	386.0	241.3	434.0	193.3	3.0	3.0	196.3	
1F1/10-35-077-10W4	10-35-077-10W4			324.0	301.6	350.0	275.6	369.0	256.6	382.0	243.6	431.0	194.6	0.0	-5.0	194.6	
1AA/12-36-077-10W4	12-36-077-10W4			322.0	300.2	349.0	273.2	368.0	254.2	381.0	241.2	426.0	196.2	0.0	-5.0	196.2	
100/01-02-077-11W4	01-02-077-11W4			387.0	290.8	422.0	255.8	436.0	241.8	448.0	229.8	499.0	178.8	0.0	-5.0	178.8	
100/09-03-077-11W4	09-03-077-11W4			387.0	289.7	422.0	254.7	436.0	240.7	448.0	228.7	504.0	172.7	2.0	2.0	174.7	
100/10-10-077-11W4	10-10-077-11W4			388.0	289.0	424.0	253.0	440.0	237.0	451.0	226.0	509.0	168.0	0.0	-5.0	168.0	
100/09-11-077-11W4	09-11-077-11W4			390.0	291.6	425.0	256.6	440.0	241.6	452.0	229.6	507.0	174.6	2.0	2.0	176.6	
100/09-12-077-11W4	09-12-077-11W4			385.0	298.2	417.0	266.2	432.0	251.2	444.0	239.2	500.5	182.7	3.0	3.0	185.7	
100/09-13-077-11W4	09-13-077-11W4			397.0	295.2	427.0	265.2	442.5	249.7	454.0	238.2						
100/08-14-077-11W4	08-14-077-11W4			397.0	291.3	428.0	260.3	444.0	244.3	455.0	233.3	516.0	172.3	16.0	16.0	188.3	
100/11-15-077-11W4	11-15-077-11W4			389.0	293.5	418.0	264.5	434.0	248.5	448.0	234.5	506.0	176.5	0.0	-5.0	176.5	
100/10-22-077-11W4	10-22-077-11W4			399.0	291.4	428.0	262.4	445.0	245.4	457.0	233.4	510.0	180.4	5.0	5.0	185.4	
100/11-24-077-11W4	11-24-077-11W4			401.0	294.1	429.0	266.1	446.0	249.1	458.0	237.1	512.0	183.1	8.0	8.0	191.1	
1AA/13-24-077-11W4	13-24-077-11W4			403.0	292.9	433.0	262.9	451.0	244.9	463.0	232.9	517.0	178.9	5.0	5.0	183.9	
1AA/15-24-077-11W4	15-24-077-11W4			400.0	294.2	429.0	265.2	448.0	246.2	460.0	234.2	511.0	183.2	5.0	5.0	188.2	
1AA/07-26-077-11W4	07-26-077-11W4			402.0	293.8	430.0	265.8	450.0	245.8	462.0	233.8	512.0	183.8	0.0	-5.0	183.8	
100/09-26-077-11W4	09-26-077-11W4			404.0	296.4	431.0	269.4	451.0	249.4	463.0	237.4	514.0	186.4	8.0	8.0	194.4	
100/05-27-077-11W4	05-27-077-11W4			396.0	294.3	430.0	260.3	442.0	248.3	453.0	237.3	505.0	185.3	4.0	4.0	189.3	
100/11-32-077-11W4	11-32-077-11W4			399.5	291.2	426.5	264.2	444.0	246.7	455.0	235.7	501.0	189.7	0.0	-5.0	189.7	
100/06-35-077-11W4	06-35-077-11W4			399.0	297.4	426.0	270.4	444.0	252.4	455.0	241.4	506.0	190.4	0.0	-5.0	190.4	
100/10-02-077-12W400	10-02-077-12W4			384.0	282.2	417.0	249.2	432.5	233.7	445.1	221.1	515.1	151.2	0.0	-5.0	151.2	
100/12-03-077-12W400	12-03-077-12W4			391.0	279.0	424.0	246.0	440.2	229.8	452.2	217.8	503.9	166.1	2.9	2.9	169.0	
100/06-04-077-12W400	06-04-077-12W4							447.8	230.4	459.0	219.2	513.3	164.9	0.0	-5.0	164.9	gamma ran high
100/08-06-077-12W400	08-06-077-12W4			412.0	274.8	449.0	237.8	462.7	224.2	474.9	211.9	521.3	165.5	0.0	-5.0	165.5	
100/16-08-077-12W400	16-08-077-12W4							441.5	233.3	453.2	221.6	502.2	172.6	2.3	2.3	174.9	gamma ran high
100/01-09-077-12W400	01-09-077-12W4			382.0	282.3	413.0	251.3	425.5	238.9	437.6	226.7	497.5	166.8	11.2	11.2	178.0	
102/01-09-077-12W400	01-09-077-12W4			383.0	283.0	412.0	254.0	426.6	239.4	438.5	227.5	498.6	167.4	11.8	11.8	179.2	
100/04-10-077-12W400	04-10-077-12W4			386.0	284.8	417.0	253.8	433.1	237.7	445.0	225.8	502.0	168.8	0.0	-5.0	168.8	
100/12-10-077-12W400	12-10-077-12W4			384.0	287.2	419.0	252.2	429.1	242.1	440.8	230.5	498.0	173.2	13.0	13.0	186.2	
100/10-11-077-12W400	10-11-077-12W4							434.2	235.1	447.0	222.3	498.3	171.0				gamma ran high
100/05-14-077-12W400	05-14-077-12W4			355.0	284.0	384.0	255.0	401.2	237.8	413.1	225.9	463.9	175.2	11.6	11.6	186.7	
100/07-15-077-12W400	07-15-077-12W4			356.0	283.2	388.0	251.2	405.1	234.1	416.8	222.4	465.0	174.2	5.0	5.0	179.2	
100/14-15-077-12W400	14-15-077-12W4							441.9	238.1	453.4	226.6	508.5	171.5				gamma ran high
100/04-16-077-12W400	04-16-077-12W4			395.0	279.5	427.0	247.5	442.9	231.6	454.6	219.9	503.8	170.7				
100/13-16-077-12W400	13-16-077-12W4			394.0	282.3	426.0	250.3	441.6	234.8	452.8	223.5	509.0	167.3	10.4	10.4	177.7	
100/07-17-077-12W400	07-17-077-12W4			399.0	280.8	431.0	248.8	447.0	232.8	458.3	221.6	509.6	170.3	2.0	2.0	172.3	

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Northing (m) NAD 27	Easting (m) NAD 27	KB (m asl)	TD (m)	Top Grand Rapids (m bKB)	Top Grand Rapids (m asl)	Grand Rapids Watersand Thickness (m)	Grand Rapids Watersand Top (m bKB)	Grand Rapids Watersand Top (m asl)	Grand Rapids Watersand Base (m bKB)	Grand Rapids Watersand Base (m asl)	Top Clearwater (m bKB)	Top Clearwater (m asl)	Upper Clearwater Watersand Thickness (m)	Middle Clearwater Watersand Thickness (m)	Upper Clearwater Watersand Thickness (Surfer) (m)	Middle Clearwater Watersand Thickness (Surfer) (m)	Upper Clearwater Watersand Top (m bKB)	Upper Clearwater Watersand Top (m asl)
100/15-18-077-12W400	15-18-077-12W4	6170639	446567	677.0	508.0	280.1	396.9	38.0	319.0	358.0	357.0	320.0	365.0	312.0	0.0	34.0	-5.0	34.0		
100/11-19-077-12W400	11-19-077-12W4	6171833	445873	675.9	502.0	278.1	397.9	40.0	319.0	356.9	359.0	316.9	363.9	312.0	0.0	35.0	-5.0	35.0		
100/12-20-077-12W400	12-20-077-12W4	6171875	447334	675.6	495.0	278.9	396.8	39.0	316.0	359.6	355.0	320.6	358.9	316.7	0.0	36.0	-5.0	36.0		
100/16-21-077-12W400	16-21-077-12W4	6172245	449992	669.4	493.0	269.9	399.5						352.6	316.8						
100/06-22-077-12W400	06-22-077-12W4	6171324	450821	677.8	530.0	277.1	400.8	28.0	318.0	359.8	346.0	331.8	360.1	317.7	0.0	32.0	-5.0	32.0		
100/15-22-077-12W400	15-22-077-12W4	6171925	451315	672.5	511.0	276.6	395.9	36.0	315.0	357.5	351.0	321.5	354.0	318.5	0.0	30.0	-5.0	30.0		
100/13-28-077-12W400	13-28-077-12W4	6173698	448686	670.0	490.0	267.1	402.9	34.0	305.0	365.0	339.0	331.0	347.7	322.3	0.0	30.0	-5.0	30.0		
100/07-29-077-12W400	07-29-077-12W4	6172805	447907	670.3	505.0	274.2	396.2						351.7	318.6						
100/01-30-077-12W400	01-30-077-12W4	6172693	446940	674.6	480.0	270.2	404.4	37.0	314.0	360.6	351.0	323.6	356.2	318.4	0.0	31.0	-5.0	31.0		
100/06-30-077-12W400	06-30-077-12W4	6172723	445930	673.6	492.0	269.2	404.4	40.0	312.0	361.6	352.0	321.6	356.0	317.6	0.0	37.0	-5.0	37.0		
100/10-32-077-12W400	10-32-077-12W4	6175016	448162	672.7	475.5	265.0	407.7	39.0	307.0	365.7	346.0	326.7	349.6	323.2	0.0	28.0	-5.0	28.0		
100/02-34-077-12W400	02-34-077-12W4	6174212	451306	675.3	500.0	269.9	405.4	37.0	311.0	364.3	348.0	327.3	353.0	322.3	0.0	29.0	-5.0	29.0		
100/06-35-077-12W400	06-35-077-12W4	6174366	452503	676.0	490.0	272.5	403.5	39.0	313.0	363.0	352.0	324.0	354.9	321.1	0.0	29.0	-5.0	29.0		
100/04-01-077-13W400	04-01-077-13W4	6166123	443990	687.2	530.0	296.7	390.5	40.0	333.0	354.2	373.0	314.2	377.9	309.3	0.0	31.0	-5.0	31.0		
100/10-02-077-13W400	10-02-077-13W4	6167072	442941	689.9	526.0	297.5	392.4						379.9	310.0						
100/09-03-077-13W400	09-03-077-13W4	6167008	441843	680.4	521.0	290.3	390.1	41.0	330.0	350.4	371.0	309.4	375.8	304.6	0.0	34.0	-5.0	34.0		
100/01-06-077-13W400	01-06-077-13W4	6166071	436776	682.1	534.0	294.7	387.4	37.0	330.0	352.1	367.0	315.1	377.8	304.3	0.0	31.0	-5.0	31.0		
100/07-08-077-13W400	07-08-077-13W4	6168337	438182	686.3	517.0	291.7	394.6	34.0	330.0	356.3	364.0	322.3	372.6	313.8	0.0	32.0	-5.0	32.0		
100/16-09-077-13W400	16-09-077-13W4	6168862	440375	679.8	518.0	287.4	392.4	40.0	326.0	353.8	366.0	313.8	371.8	308.0	0.0	32.0	-5.0	32.0		
100/03-10-077-13W400	03-10-077-13W4	6167767	441241	690.3	530.0	299.1	391.2	33.0	340.0	350.3	373.0	317.3	383.2	307.1	0.0	33.0	-5.0	33.0		
100/06-11-077-13W400	06-11-077-13W4	6168044	442592	681.2	524.3	290.9	390.3	36.0	330.0	351.2	366.0	315.2	373.1	308.1	0.0	34.0	-5.0	34.0		
100/09-11-077-13W400	09-11-077-13W4	6168655	443328	684.7	526.0	290.4	394.3	28.0	329.0	355.7	357.0	327.7	372.3	312.4	0.0	31.0	-5.0	31.0		
100/15-12-077-13W400	15-12-077-13W4	6169030	444758	687.9	529.0	294.0	393.9	37.0	333.0	354.9	370.0	317.9	378.5	309.5	0.0	33.0	-5.0	33.0		
100/10-13-077-13W400	10-13-077-13W4	6170023	444677	686.7	516.0	291.6	395.1	34.0	329.0	357.7	363.0	323.7	375.3	311.5	0.0	34.0	-5.0	34.0		
100/16-16-077-13W400	16-16-077-13W4	6170447	440468	684.9	516.0	285.4	399.5	39.0	328.0	356.9	367.0	317.9	371.5	313.4	0.0	32.0	-5.0	32.0		
100/02-18-077-13W400	02-18-077-13W4	6169597	436631	691.0	541.0	302.2	388.8	36.0	339.0	352.0	375.0	316.0	383.4	307.6	0.0	31.0	-5.0	31.0		
100/10-19-077-13W400	10-19-077-13W4	6171865	436472	683.0	525.0	288.6	394.4	39.0	329.0	354.0	368.0	315.0	374.5	308.5	0.0	32.0	-5.0	32.0		
100/01-20-077-13W400	01-20-077-13W4	6171069	438612	683.4	521.0	289.1	394.3	37.0	330.0	353.4	367.0	316.4	373.4	310.0	0.0	31.0	-5.0	31.0		
100/07-22-077-13W400	07-22-077-13W4	6171235	441627	691.3	519.7	296.6	394.8	43.0	333.0	358.3	376.0	315.3	379.6	311.7	0.0	29.0	-5.0	29.0		
100/11-23-077-13W400	11-23-077-13W4	6171928	442803	685.9	510.0	291.0	394.9	39.0	329.0	356.9	368.0	317.9	375.1	310.8	0.0	30.0	-5.0	30.0		
100/11-24-077-13W400	11-24-077-13W4	6171874	444508	674.6	512.0	278.9	395.7	35.0	318.0	356.6	353.0	321.6	361.6	313.0	0.0	30.0	-5.0	30.0		
100/16-25-077-13W400	16-25-077-13W4	6173616	445077	669.3	476.0	268.9	400.4	41.0	305.0	364.3	346.0	323.3	352.1	317.2	0.0	30.0	-5.0	30.0		
100/15-26-077-13W400	15-26-077-13W4	6173654	443320	677.6	498.0	279.6	398.0	35.0	315.0	362.6	350.0	327.6	360.6	317.1	0.0	26.0	-5.0	26.0		
100/14-27-077-13W400	14-27-077-13W4	6173679	441228	666.3	492.5	271.2	395.2	35.0	307.0	359.3	342.0	324.3	349.1	317.2	0.0	29.0	-5.0	29.0		
100/03-28-077-13W400	03-28-077-13W4	6172732	439354	675.8	509.0	284.1	391.7	32.0	323.0	352.8	355.0	320.8	358.3	317.5	0.0	31.0	-5.0	31.0		
100/09-29-077-13W400	09-29-077-13W4	6173534	438871	671.6	509.0	278.4	393.2	36.0	316.0	355.6	352.0	319.6	358.6	313.0	0.0	29.0	-5.0	29.0		
100/10-30-077-13W400	10-30-077-13W4	6173409	436822	669.7	515.0	277.5	392.2						357.3	312.4						
100/11-31-077-13W400	11-31-077-13W4	6175035	436279	674.2	508.0	283.1	391.1	38.0	321.0	353.2	359.0	315.2	363.7	310.6	0.0	30.0	-5.0	30.0		
100/10-32-077-13W400	10-32-077-13W4	6174949	438490	669.0	503.0	274.0	395.0	34.0	315.0	354.0	349.0	320.0	354.6	314.4	0.0	30.0	-5.0	30.0		
100/01-33-077-13W400	01-33-077-13W4	6174232	440141	672.9	500.0	276.4	396.5	37.0	313.0	359.9	350.0	322.9	355.8	317.1	0.0	28.0	-5.0	28.0		
100/08-34-077-13W400	08-34-077-13W4	6174598	441789	673.9	503.0	277.0	396.9	37.0	313.0	360.9	350.0	323.9	355.8	318.1	0.0	27.0	-5.0	27.0		
100/07-07-077-14 W4/00	07-07-077-14 W4	6168108	426869	660.0	535.0	277.0	383.0	35.0	316.0	344.0	351.0	309.0	357.0	303.0	0.0	30.0	-5.0	30.0		
100/07-08-077-14 W4/00	07-08-077-14 W4	6168081	428497	679.9	525.0	294.0	385.9	40.0	331.0	348.9	371.0	308.9	378.0	301.9	0.0	28.0	-5.0	28.0		
100/07-10-077-14 W4/00	07-10-077-14 W4	6168029	431753	671.8	517.0	285.0	386.8						368.0	303.8						
100/06-14-077-14 W4/00	06-14-077-14 W4	6169639	433004	692.9	554.0	304.0	388.9	39.0	341.0	351.9	380.0	312.9	387.0	305.9	0.0	33.0	-5.0	33.0		
100/02-15-077-14 W4/00	02-15-077-14 W4	6169256	431772	696.5	547.0	308.0	388.5						390.0	306.5						
100/07-16-077-14 W4/00	07-16-077-14 W4	6169684	430151	686.6	528.0	299.0	387.6	40.0	336.0	350.6	376.0	310.6	383.0	303.6	0.0	33.0	-5.0	33.0		
100/11-17-077-14 W4/00	11-17-077-14 W4	6170119	428129	680.6	531.9	293.0	387.6	36.0	337.0	343.6	373.0	307.6	379.0	301.6	0.0	33.0	-5.0	33.0		
100/07-28-077-14 W4/00	07-28-077-14 W4	6172921	430203	677.4	544.0	287.0	390.4	40.0	328.0	349.4	368.0	309.4	371.0	306.4	0.0	33.0	-5.0	33.0		
100/07-01-077-14W400	07-01-077-14W4	6166519	434820	676.3	526.1	284.9	391.4						370.6	305.8						
100/08-02-077-14W400	08-02-077-14W4	6166749	433538	683.4	522.3	296.5	386.9	37.0	334.0	349.4	371.0	312.4	379.0	304.4	0.0	31.0	-5.0	31.0		
100/10-23-077-14W400	10-23-077-14W4	6171883	433299	668.3	507.0	278.2	390.1	39.0	315.0	353.3	354.0	314.3	361.4	306.9	0.0	31.0	-5.0	31.0		
100/03-25-077-14W400	03-25-077-14W4	6172660	434805	683.5	527.0	286.7	396.8	38.0	328.0	355.5	366.0	317.5	372.2	311.3	0.0	32.0	-5.0	32.0		
100/11-26-077-14W400	11-26-077-14W4	6173484	433076	673.9	520.0	277.8	396.1	36.0	322.0	351.9	358.0	315.9	365.1	308.8	0.0	32.0	-5.0	32.0		
100/02-35-077-14W400	02-35-077-14W4	6174389	433504	670.2	504.0	278.0	392.2						357.7	312.5						

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Upper Clearwater Watersand Base (m bKB)	Upper Clearwater Watersand Base (m asl)	Middle Clearwater Watersand Top (m bKB)	Middle Clearwater Watersand Top (m asl)	Middle Clearwater Watersand Base (m bKB)	Middle Clearwater Watersand Base (m asl)	Top Wabiskaw (m bKB)	Top Wabiskaw (m asl)	Top McMurray (m bKB)	Top McMurray (m asl)	Paleo Surface (m bKB)	Paleo Surface (m asl)	Watersand Thickness (m)	Watersand Thickness (Surfer) (m)	Watersand Surface Elevation (m asl)	Log Analysis Notes:
100/15-18-077-12W400	15-18-077-12W4			395.0	282.0	429.0	248.0	441.9	235.1	453.0	224.0	501.8	175.2	4.7	4.7	180.0	
100/11-19-077-12W400	11-19-077-12W4			395.0	280.9	430.0	245.9	441.6	234.4	454.4	221.5	494.8	181.2	9.0	9.0	190.2	
100/12-20-077-12W400	12-20-077-12W4			390.0	285.6	426.0	249.6	436.8	238.8	449.2	226.4	490.7	185.0	0.9	0.9	185.9	
100/16-21-077-12W400	16-21-077-12W4							431.7	237.7	444.9	224.5	491.2	178.3				gamma ran high
100/06-22-077-12W400	06-22-077-12W4			391.0	286.8	423.0	254.8	438.0	239.8	451.4	226.4	505.2	172.6	11.0	11.0	183.6	
100/15-22-077-12W400	15-22-077-12W4			387.0	285.5	417.0	255.5	432.9	239.6	446.2	226.3	496.1	176.5	10.0	10.0	186.5	
100/13-28-077-12W400	13-28-077-12W4			381.0	289.0	411.0	259.0	427.6	242.4	438.3	231.7	470.4	199.6	0.0	-5.0	199.6	
100/07-29-077-12W400	07-29-077-12W4							430.7	239.7	441.9	228.5	484.9	185.4	0.0	-5.0	185.4	gamma ran high
100/01-30-077-12W400	01-30-077-12W4			389.0	285.6	420.0	254.6	436.2	238.4	446.8	227.8						
100/06-30-077-12W400	06-30-077-12W4			388.0	285.6	425.0	248.6	433.1	240.5	444.0	229.6	485.9	187.7	2.0	2.0	189.7	
100/10-32-077-12W400	10-32-077-12W4			383.0	289.7	411.0	261.7	426.4	246.3	437.1	235.6	466.0	206.7	0.0	-5.0	206.7	
100/02-34-077-12W400	02-34-077-12W4			385.0	290.3	414.0	261.3	429.8	245.6	440.4	234.9	482.0	193.3	2.3	2.3	195.5	
100/06-35-077-12W400	06-35-077-12W4			387.0	289.0	416.0	260.0	431.0	245.0	441.8	234.3	484.8	191.2				
100/04-01-077-13W400	04-01-077-13W4			408.0	279.2	439.0	248.2	454.0	233.2	465.8	221.5	521.9	165.3	5.2	5.2	170.4	
100/10-02-077-13W400	10-02-077-13W4							457.4	232.5	469.1	220.8	517.6	172.3	3.0	3.0	175.3	gamma ran high
100/09-03-077-13W400	09-03-077-13W4			406.0	274.4	440.0	240.4	455.9	224.5	467.3	213.1	511.9	168.5	0.0	-5.0	168.5	
100/01-06-077-13W400	01-06-077-13W4			411.0	271.1	442.0	240.1	457.5	224.6	469.5	212.7	530.0	152.1	9.3	9.3	161.3	
100/07-08-077-13W400	07-08-077-13W4			407.0	279.3	439.0	247.3	455.9	230.4	467.6	218.7	514.4	172.0	5.0	5.0	177.0	
100/16-09-077-13W400	16-09-077-13W4			403.0	276.8	435.0	244.8	450.9	228.9	462.1	217.7	508.8	171.0	1.9	1.9	172.9	
100/03-10-077-13W400	03-10-077-13W4			414.0	276.3	447.0	243.3	462.6	227.8	474.7	215.6	520.9	169.4	0.0	-5.0	169.4	
100/06-11-077-13W400	06-11-077-13W4			405.0	276.2	439.0	242.2	453.4	227.9	466.0	215.2	510.0	171.2	5.0	5.0	176.2	
100/09-11-077-13W400	09-11-077-13W4			403.0	281.7	434.0	250.7	449.4	235.3	461.3	223.4	510.3	174.5	7.5	7.5	181.9	
100/15-12-077-13W400	15-12-077-13W4			408.0	279.9	441.0	246.9	456.0	231.9	467.9	220.0	519.2	168.8	8.6	8.6	177.3	
100/10-13-077-13W400	10-13-077-13W4			405.0	281.7	439.0	247.7	451.1	235.7	461.9	224.8	506.2	180.5	5.3	5.3	185.8	
100/16-16-077-13W400	16-16-077-13W4			404.0	280.9	436.0	248.9	451.8	233.1	462.7	222.2	507.9	177.0	4.1	4.1	181.1	
100/02-18-077-13W400	02-18-077-13W4			416.0	275.0	447.0	244.0	464.5	226.5	475.6	215.4	529.4	161.6	4.7	4.7	166.3	
100/10-19-077-13W400	10-19-077-13W4			408.0	275.0	440.0	243.0	457.5	225.5	468.0	215.1	519.7	163.3	4.0	4.0	167.3	
100/01-20-077-13W400	01-20-077-13W4			409.0	274.4	440.0	243.4	455.8	227.6	469.7	213.7	515.3	168.1	0.0	-5.0	168.1	
100/07-22-077-13W400	07-22-077-13W4			412.0	279.3	441.0	250.3	458.0	233.3	469.0	222.3	510.0	181.3	0.0	-5.0	181.3	
100/11-23-077-13W400	11-23-077-13W4			405.0	280.9	435.0	250.9	450.6	235.3	463.1	222.8	500.5	185.4	0.0	-5.0	185.4	
100/11-24-077-13W400	11-24-077-13W4			393.0	281.6	423.0	251.6	438.0	236.6	451.2	223.4	496.8	177.8	2.9	2.9	180.7	
100/16-25-077-13W400	16-25-077-13W4			383.0	286.3	413.0	256.3	428.0	241.3	441.4	228.0	469.9	199.4	0.0	-5.0	199.4	
100/15-26-077-13W400	15-26-077-13W4			392.0	285.6	418.0	259.6	434.9	242.7	449.3	228.3	488.6	189.0	0.0	-5.0	189.0	
100/14-27-077-13W400	14-27-077-13W4			382.0	284.3	411.0	255.3	427.0	239.3	440.2	226.1	486.2	180.2	4.4	4.4	184.6	
100/03-28-077-13W400	03-28-077-13W4			398.0	277.8	429.0	246.8	445.5	230.3	459.0	216.8	501.7	174.1	0.0	-5.0	174.1	
100/09-29-077-13W400	09-29-077-13W4			394.0	277.6	423.0	248.6	438.9	232.7	453.6	218.0	499.5	172.1	0.0	-5.0	172.1	
100/10-30-077-13W400	10-30-077-13W4							437.6	232.1	451.3	218.4	504.3	165.4	4.7	4.7	170.1	no gamma or porosity for GDRD and CLWT
100/11-31-077-13W400	11-31-077-13W4			400.0	274.2	430.0	244.2	446.1	228.1	457.5	216.7						
100/10-32-077-13W400	10-32-077-13W4			388.0	281.0	418.0	251.0	433.8	235.2	446.3	222.7	496.3	172.8	6.0	6.0	178.8	
100/01-33-077-13W400	01-33-077-13W4			391.0	281.9	419.0	253.9	434.9	238.0	448.2	224.8	493.0	179.9	3.7	3.7	183.6	
100/08-34-077-13W400	08-34-077-13W4			391.0	282.9	418.0	255.9	433.6	240.4	448.2	225.7	489.8	184.1	0.8	0.8	185.0	
100/07-07-077-14 W4/00	07-07-077-14 W4			395.0	265.0	425.0	235.0	442.0	218.0	452.0	208.0	496.0	164.0	16.0	16.0	180.0	
100/07-08-077-14 W4/00	07-08-077-14 W4			415.0	264.9	443.0	236.9	462.0	217.9	473.0	206.9	523.0	156.9	5.0	5.0	161.9	
100/07-10-077-14 W4/00	07-10-077-14 W4							452.0	219.8	463.0	208.8	515.0	156.8	5.0	5.0	161.8	gamma ran high
100/06-14-077-14 W4/00	06-14-077-14 W4			420.0	272.9	453.0	239.9	470.0	222.9	481.0	211.9	535.0	157.9	12.0	12.0	169.9	
100/02-15-077-14 W4/00	02-15-077-14 W4							477.0	219.5	487.0	209.5	539.0	157.5	0.0	-5.0	157.5	gamma ran high
100/07-16-077-14 W4/00	07-16-077-14 W4			417.0	269.6	450.0	236.6	468.0	218.6	478.0	208.6	527.0	159.6	0.0	-5.0	159.6	
100/11-17-077-14 W4/00	11-17-077-14 W4			415.0	265.6	448.0	232.6	464.0	216.6	472.0	208.6	525.0	155.6	0.0	-5.0	155.6	
100/07-28-077-14 W4/00	07-28-077-14 W4			407.0	270.4	440.0	237.4	457.0	220.4	466.0	211.4	523.0	154.4	0.0	-5.0	154.4	
100/07-01-077-14W400	07-01-077-14W4							451.5	224.8	462.7	213.6	522.6	153.7	3.0	3.0	156.7	gamma ran high
100/08-02-077-14W400	08-02-077-14W4			414.0	269.4	445.0	238.4	464.1	219.3	475.3	208.1						
100/10-23-077-14W400	10-23-077-14W4			395.0	273.3	426.0	242.3	443.3	225.1	456.5	211.8						
100/03-25-077-14W400	03-25-077-14W4			408.0	275.5	440.0	243.5	455.0	228.5	469.4	214.1	521.2	162.3	3.7	3.7	166.0	
100/11-26-077-14W400	11-26-077-14W4			398.0	275.9	430.0	243.9	445.9	228.0	460.1	213.8	514.1	159.9	0.0	-5.0	159.9	
100/02-35-077-14W400	02-35-077-14W4							444.3	225.9	457.0	213.2						no res or neutron porosity

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Northing (m) NAD 27	Easting (m) NAD 27	KB (m asl)	TD (m)	Top Grand Rapids (m bKB)	Top Grand Rapids (m asl)	Grand Rapids Watersand Thickness (m)	Grand Rapids Watersand Top (m bKB)	Grand Rapids Watersand Top (m asl)	Grand Rapids Watersand Base (m bKB)	Grand Rapids Watersand Base (m asl)	Top Clearwater (m bKB)	Top Clearwater (m asl)	Upper Clearwater Watersand Thickness (m)	Middle Clearwater Watersand Thickness (m)	Upper Clearwater Watersand Thickness (Surfer) (m)	Middle Clearwater Watersand Thickness (Surfer) (m)	Upper Clearwater Watersand Top (m bKB)	Upper Clearwater Watersand Top (m asl)
100/02-02-078-06 W4/00	02-02-078-06 W4	6175205	511514	593.8	417.0	177.0	416.8	14.0	238.0	355.8	252.0	341.8	256.0	337.8	14.0	0.0	14.0	-5.0	272.0	321.8
100/03-03-078-06 W4/00	03-03-078-06 W4	6175200	509487	606.6	426.7	191.0	415.6	19.0	250.0	356.6	269.0	337.6	267.0	339.6	14.0	8.0	14.0		287.0	319.6
100/11-05-078-06 W4/00	11-05-078-06 W4	6175998	506236	593.0	396.0	171.0	422.0	19.0	231.0	362.0	250.0	343.0	250.0	343.0	8.0	0.0	8.0	-5.0	270.0	323.0
100/02-06-078-06 W4/00	02-06-078-06 W4	6175192	505013	578.4	393.0	154.0	424.4	20.0	211.0	367.4	231.0	347.4	231.0	347.4	11.0	0.0	11.0	-5.0	247.0	331.4
100/11-08-078-06 W4/00	11-08-078-06 W4	6177607	506233	578.4	383.0	157.0	421.4	20.0	216.0	362.4	236.0	342.4	236.0	342.4	6.0	0.0	6.0	-5.0	254.0	324.4
100/12-11-078-06 W4/00	12-11-078-06 W4	6177616	510705	610.5	455.0	196.0	414.5	20.0	256.0	354.5	276.0	334.5	276.0	334.5	9.0	0.0	9.0	-5.0	295.0	315.5
100/11-14-078-06 W4/00	11-14-078-06 W4	6179246	511102	596.3	430.0	178.0	418.3	18.0	238.0	358.3	256.0	340.3	256.0	340.3	0.0	0.0	-5.0	-5.0		
100/09-16-078-06 W4/00	09-16-078-06 W4	6179240	508656	569.7	385.0	151.0	418.7	14.0	212.0	357.7	226.0	343.7	230.0	339.7	0.0	0.0	-5.0	-5.0		
100/07-17-078-06 W4/00	07-17-078-06 W4	6178834	506633	566.8	367.0	149.0	417.8	19.0	203.0	363.8	222.0	344.8	222.0	344.8	5.0	0.0	5.0	-5.0	243.0	323.8
100/09-20-078-06 W4/00	09-20-078-06 W4	6180846	507030	537.0	345.0	116.0	421.0	21.0	176.0	361.0	197.0	340.0	200.0	337.0	0.0	0.0	-5.0	-5.0		
100/09-21-078-06 W4/00	09-21-078-06 W4	6180849	508653	539.3	359.0	121.0	418.3	18.0	183.0	356.3	201.0	338.3	207.0	332.3	2.0	0.0	2.0	-5.0	224.0	315.3
100/13-27-078-06 W4/00	13-27-078-06 W4	6182881	509070	549.3	371.0	132.0	417.3						207.0	342.3						
100/10-28-078-06 W4/00	10-28-078-06 W4	6182477	508249	547.5	363.0	125.0	422.5	20.0	186.0	361.5	206.0	341.5	210.0	337.5	0.0	0.0	-5.0	-5.0		
100/07-33-078-06 W4/00	07-33-078-06 W4	6183683	508247	553.5	373.0	131.0	422.5	18.0	193.0	360.5	211.0	342.5	214.0	339.5	0.0	0.0	-5.0	-5.0		
100/14-35-078-06 W4/00	14-35-078-06 W4	6184494	511089	540.3	376.0	120.0	420.3	16.0	185.0	355.3	201.0	339.3	210.0	330.3	0.0	0.0	-5.0	-5.0		
100/11-36-078-06 W4/00	11-36-078-06 W4	6184096	512711	536.7	381.0	116.0	420.7	19.0	182.0	354.7	201.0	335.7	205.0	331.7	2.0	0.0	2.0	-5.0	226.0	310.7
100/06-03-078-07 W4/00	06-03-078-07 W4	6175601	499728	554.9	365.0	125.0	429.9	26.0	177.0	377.9	203.0	351.9	203.0	351.9						
100/06-11-078-07 W4/00	06-11-078-07 W4	6177210	501352	536.8	347.5	113.0	423.8	23.0	162.0	374.8	185.0	351.8	190.0	346.8	2.0	0.0	2.0	-5.0	210.0	326.8
100/12-14-078-07 W4/00	12-14-078-07 W4	6179241	500951	535.0	334.0			25.0	163.0	372.0	188.0	347.0	190.0	345.0	5.0	0.0	5.0	-5.0	209.0	326.0
100/05-15-078-07 W4/00	05-15-078-07 W4	6178839	499327	535.8	335.0			28.0	159.0	376.8	187.0	348.8	187.0	348.8	6.0	0.0	6.0	-5.0	206.0	329.8
100/10-19-078-07 W4/00	10-19-078-07 W4	6180852	495260	550.9	343.0	125.0	425.9	27.0	176.0	374.9	203.0	347.9	205.0	345.9	1.0	0.0	1.0	-5.0	226.0	324.9
100/10-20-078-07 W4/00	10-20-078-07 W4	6180851	496883	549.3	337.0	124.0	425.3	29.0	172.0	377.3	201.0	348.3	201.0	348.3	2.0	0.0	2.0	-5.0	221.0	328.3
100/07-29-078-07 W4/00	07-29-078-07 W4	6182078	496883	548.6	446.2			26.0	174.0	374.6	200.0	348.6	204.0	344.6	0.0	0.0	-5.0	-5.0		
100/05-34-078-07 W4/00	05-34-078-07 W4	6183685	499328	553.7	356.0			30.0	176.0	377.7	206.0	347.7	206.0	347.7	0.0	0.0	-5.0	-5.0		
100/11-34-078-07 W4/00	11-34-078-07 W4	6184087	499728	549.6	356.0	121.0	428.6	28.0	175.0	374.6	203.0	346.6	206.0	343.6	0.0	0.0	-5.0	-5.0		
100/16-34-078-07 W4/00	16-34-078-07 W4	6184490	500529	552.0	352.0	123.0	429.0	30.0	176.0	376.0	206.0	346.0	206.0	346.0	0.0	0.0	-5.0	-5.0		
100/13-36-078-07 W4/00	13-36-078-07 W4	6184490	502571	550.7	344.8	129.0	421.7	22.0	189.0	361.7	211.0	339.7	211.0	339.7	0.0	0.0	-5.0	-5.0		
100/01-05-078-08 W4/00	01-05-078-08W4	6175216	487533	569.9	354.0	145.0	424.9	29.0	193.0	376.9	222.0	347.9	222.0	347.9	0.0	10.0	-5.0	10.0		
1AA/11-08-078-08 W4/00	11-08-078-08W4	6177631	486737	591.5	378.6	169.7	421.8						247.8	343.7						
100/03-09-078-08 W4/00	03-09-078-08W4	6176822	488359	579.9	368.0	156.0	423.9	24.0	204.0	375.9	228.0	351.9	231.1	348.8	7.0	0.0	7.0	-5.0	246.0	333.9

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Upper Clearwater Watersand Base (m bKB)	Upper Clearwater Watersand Base (m asl)	Middle Clearwater Watersand Top (m bKB)	Middle Clearwater Watersand Top (m asl)	Middle Clearwater Watersand Base (m bKB)	Middle Clearwater Watersand Base (m asl)	Top Wabiskaw (m bKB)	Top Wabiskaw (m asl)	Top McMurray (m bKB)	Top McMurray (m asl)	Paleo Surface (m bKB)	Paleo Surface (m asl)	Watersand Thickness (m)	Watersand Thickness (Surfer) (m)	Watersand Surface Elevation (m asl)	Log Analysis Notes:
100/02-02-078-06 W4/00	02-02-078-06 W4	286.0	307.8					330.0	263.8	345.0	248.8	402.0	191.8	0.0	-5.0	191.8	
100/03-03-078-06 W4/00	03-03-078-06 W4	301.0	305.6	317.0	289.6	325.0	281.6	346.0	260.6	363.0	243.6	417.0	189.6	0.0	-5.0	189.6	gamma runs low
100/11-05-078-06 W4/00	11-05-078-06 W4	278.0	315.0					326.0	267.0	338.0	255.0	384.0	209.0	0.0	-5.0	209.0	top 8 m of LGDRP was > 60 API
100/02-06-078-06 W4/00	02-06-078-06 W4	258.0	320.4					306.0	272.4	316.0	262.4	370.0	208.4	0.0	-5.0	208.4	
100/11-08-078-06 W4/00	11-08-078-06 W4	260.0	318.4					308.0	270.4	320.0	258.4	371.0	207.4	0.0	-5.0	207.4	
100/12-11-078-06 W4/00	12-11-078-06 W4	304.0	306.5					347.0	263.5	360.0	250.5	430.0	180.5	13.0	13.0	193.5	
100/11-14-078-06 W4/00	11-14-078-06 W4							326.0	270.3	338.0	258.3	417.0	179.3	12.0	12.0	191.3	
100/09-16-078-06 W4/00	09-16-078-06 W4							301.0	268.7	314.0	255.7	380.0	189.7	0.0	-5.0	189.7	
100/07-17-078-06 W4/00	07-17-078-06 W4	248.0	318.8					295.0	271.8	308.0	258.8	356.0	210.8	0.0	-5.0	210.8	
100/09-20-078-06 W4/00	09-20-078-06 W4							267.0	270.0	280.0	257.0	340.0	197.0	0.0	-5.0	197.0	
100/09-21-078-06 W4/00	09-21-078-06 W4	226.0	313.3					272.0	267.3	283.0	256.3	349.0	190.3	3.0	3.0	193.3	
100/13-27-078-06 W4/00	13-27-078-06 W4							276.0	273.3	288.0	261.3	360.0	189.3	27.0	27.0	216.3	gamma runs high
100/10-28-078-06 W4/00	10-28-078-06 W4							277.0	270.5	290.0	257.5	347.0	200.5	20.0	20.0	220.5	
100/07-33-078-06 W4/00	07-33-078-06 W4							280.0	273.5	295.0	258.5	354.0	199.5	11.0	11.0	210.5	
100/14-35-078-06 W4/00	14-35-078-06 W4							272.0	268.3	283.0	257.3	370.0	170.3	17.0	17.0	187.3	
100/11-36-078-06 W4/00	11-36-078-06 W4	228.0	308.7					269.0	267.7	281.0	255.7	369.0	167.7	30.0	30.0	197.7	
100/06-03-078-07 W4/00	06-03-078-07 W4							278.0	276.9	289.0	265.9	343.0	211.9	0.0	-5.0	211.9	gamma runs low
100/06-11-078-07 W4/00	06-11-078-07 W4	212.0	324.8					264.0	272.8	275.0	261.8	340.0	196.8	0.0	-5.0	196.8	
100/12-14-078-07 W4/00	12-14-078-07 W4	214.0	321.0					263.0	272.0	275.0	260.0	325.0	210.0	0.0	-5.0	210.0	
100/05-15-078-07 W4/00	05-15-078-07 W4	212.0	323.8					259.0	276.8	274.0	261.8	324.0	211.8	0.0	-5.0	211.8	
100/10-19-078-07 W4/00	10-19-078-07 W4	227.0	323.9					275.0	275.9	286.0	264.9	335.0	215.9	0.0	-5.0	215.9	
100/10-20-078-07 W4/00	10-20-078-07 W4	223.0	326.3					270.0	279.3	283.0	266.3	333.0	216.3	0.0	-5.0	216.3	
100/07-29-078-07 W4/00	07-29-078-07 W4							273.0	275.6	285.0	263.6	337.0	211.6	0.0	-5.0	211.6	
100/05-34-078-07 W4/00	05-34-078-07 W4							273.0	280.7	288.0	265.7	341.0	212.7	0.0	-5.0	212.7	
100/11-34-078-07 W4/00	11-34-078-07 W4							273.0	276.6	284.0	265.6	339.0	210.6	3.0	3.0	213.6	
100/16-34-078-07 W4/00	16-34-078-07 W4							272.0	280.0	283.0	269.0	342.0	210.0	4.0	4.0	214.0	
100/13-36-078-07 W4/00	13-36-078-07 W4							278.0	272.7	289.0	261.7	335.0	215.7	0.0	-5.0	215.7	
100/01-05-078-08 W4/00	01-05-078-08W4			268.0	301.9	278.0	291.9	297.0	272.9	310.0	259.9	334.0	235.9	0.0	-5.0	235.9	
1AA/11-08-078-08 W4/00	11-08-078-08W4							321.0	270.5	330.0	261.5	373.7	217.8	0.0	-5.0	217.8	gamma runs high
100/03-09-078-08 W4/00	03-09-078-08W4	253.0	326.9					321.0	258.9	330.0	249.9	352.5	227.4	0.0	-5.0	227.4	

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Northing (m) NAD 27	Easting (m) NAD 27	KB (m asl)	TD (m)	Top Grand Rapids (m bKB)	Top Grand Rapids (m asl)	Grand Rapids Watersand Thickness (m)	Grand Rapids Watersand Top (m bKB)	Grand Rapids Watersand Top (m asl)	Grand Rapids Watersand Base (m bKB)	Grand Rapids Watersand Base (m asl)	Top Clearwater (m bKB)	Top Clearwater (m asl)	Upper Clearwater Watersand Thickness (m)	Middle Clearwater Watersand Thickness (m)	Upper Clearwater Watersand Thickness (Surfer) (m)	Middle Clearwater Watersand Thickness (Surfer) (m)	Upper Clearwater Watersand Top (m bKB)	Upper Clearwater Watersand Top (m asl)
1AA/10-11-078-08 W4/00	10-11-078-08W4	6177618	492011	567.0	391.0	147.0	420.0	28.0	194.0	373.0	222.0	345.0	222.0	345.0	8.0	0.0	8.0	-5.0	238.0	329.0
100/10-12-078-08 W4/00	10-12-078-08W4	6177616	493635	559.4	361.0	133.5	425.9	29.0	184.0	375.4	213.0	346.4	213.0	346.4	3.0	0.0	3.0	-5.0	230.0	329.4
100/03-14-078-08 W4/00	03-14-078-08W4	6178443	491612	566.3	362.0	139.0	427.3	24.0	193.0	373.3	217.0	349.3	217.0	349.3	0.0	0.0	-5.0	-5.0		
100/05-15-078-08 W4/00	05-15-078-08W4	6178850	489588	561.6	357.0	137.0	424.6	27.0	188.0	373.6	215.0	346.6	215.0	346.6	4.0	0.0	4.0	-5.0	235.0	326.6
100/02-16-078-08 W4/00	02-16-078-08W4	6178450	488765	560.4	350.0	139.0	421.4	25.0	188.0	372.4	213.0	347.4	217.0	343.4	0.0	0.0	-5.0	-5.0		
100/02-17-078-08 W4/00	02-17-078-08W4	6178454	487141	578.7	373.0	162.0	416.7	25.0	206.0	372.7	231.0	347.7	237.0	341.7	0.0	0.0	-5.0	-5.0		
100/15-20-078-08 W4/00	15-20-078-08W4	6181270	487149	573.1	364.0	160.0	413.1	33.0	194.0	379.1	227.0	346.1	229.0	344.1	0.0	0.0	-5.0	-5.0		
100/12-22-078-08 W4/00	12-22-078-08W4	6180861	489593	573.0	386.0	148.0	425.0	27.0	199.0	374.0	226.0	347.0	230.0	343.0	0.0	0.0	-5.0	-5.0		
100/11-23-078-08 W4/00	11-23-078-08W4	6180857	491616	565.4	346.5	139.0	426.4	28.0	191.0	374.4	219.0	346.4	219.0	346.4	3.0	0.0	3.0	-5.0	237.0	328.4
100/10-25-078-08 W4/00	10-25-078-08W4	6182482	493642	563.9	355.0	140.0	423.9	23.0	192.0	371.9	215.0	348.9	217.0	346.9	0.0	0.0	-5.0	-5.0		
100/06-28-078-08 W4/00	06-28-078-08W4	6182091	488374	573.1	376.5	150.0	423.1	28.0	197.0	376.1	225.0	348.1	228.0	345.1	0.0	0.0	-5.0	-5.0		
100/08-29-078-08 W4/00	08-29-078-08W4	6182093	487552	574.9	367.0	149.0	425.9	39.0	190.0	384.9	229.0	345.9	231.0	343.9	0.0	0.0	-5.0	-5.0		
100/12-33-078-08 W4/00	12-33-078-08W4	6184103	487978	579.5	374.0	154.0	425.5	30.0	199.0	380.5	229.0	350.5	233.0	346.5	0.0	0.0	-5.0	-5.0		
100/09-34-078-08 W4/00	09-34-078-08W4	6184096	490802	570.7	342.0	147.0	423.7	33.0	188.0	382.7	221.0	349.7	221.0	349.7	0.0	0.0	-5.0	-5.0		
100/08-01-078-09W4	08-01-078-09W4	6175602	484277	588.1	380.0	168.0	420.1	31.0	211.0	377.1	242.0	346.1	244.0	344.1	0.0	14.0	-5.0	14.0		
100/01-02-078-09W4	01-02-078-09W4	6175204	482650	576.5	334.5	155.0	421.5	26.0	205.0	371.5	231.0	345.5	231.0	345.5	0.0	0.0	-5.0	-5.0		
100/09-03-078-09W4	09-03-078-09W4	6176020	481028	580.6	401.0	162.0	418.6	36.0	204.0	376.6	240.0	340.6	240.0	340.6	0.0	0.0	-5.0	-5.0		
100/11-04-078-09W4	11-04-078-09W4	6176032	478590	589.6	390.0	171.0	418.6	30.0	215.0	374.6	245.0	344.6	247.0	342.6	0.0	17.0	-5.0	17.0		
100/11-05-078-09W4	11-05-078-09W4	6176040	476965	609.6	422.0	191.0	418.6	30.0	239.0	370.6	269.0	340.6	272.0	337.6	0.0	13.0	-5.0	13.0		
100/09-06-078-09W4	09-06-078-09W4	6176044	476153	606.7	390.0	189.0	417.7	30.0	236.0	370.7	266.0	340.7	269.0	337.7	0.0	0.0	-5.0	-5.0		
100/04-07-078-09W4	04-07-078-09W4	6176861	474938	626.0	430.0	210.0	416.0						289.0	337.0						
100/10-09-078-09W4	10-09-078-09W4	6177650	479004	602.6	417.6	185.0	417.6	31.0	231.0	371.6	262.0	340.6	265.0	337.6	0.0	18.0	-5.0	18.0		
100/01-10-078-09W4	01-10-078-09W4	6176830	481032	588.4	375.0	168.0	420.4	33.0	211.0	377.4	244.0	344.4	246.0	342.4	0.0	0.0	-5.0	-5.0		
100/01-11-078-09W4	01-11-078-09W4	6176824	482657	584.7	357.0	167.0	417.7						242.0	342.7						
100/07-11-078-09W4	07-11-078-09W4	6177230	482252	600.5	405.4	181.0	419.5	24.5	226.5	374.0	251.0	349.5	262.0	338.5	0.0	0.0	-5.0	-5.0		
100/02-12-078-09W4	02-12-078-09W4	6176819	483875	589.9	344.0	177.0	412.9	29.0	216.0	373.9	245.0	344.9	249.0	340.9	0.0	7.0	-5.0	7.0		
100/10-17-078-09W4	10-17-078-09W4	6179278	477388	636.7	440.0	220.0	416.7	27.0	268.0	368.7	295.0	341.7	300.0	336.7	0.0	13.0	-5.0	13.0		
100/10-18-078-09W4	10-18-078-09W4	6179286	475764	632.9	440.0	211.0	421.9	32.0	258.0	374.9	290.0	342.9	294.0	338.9	0.0	0.0	-5.0	-5.0		
100/12-19-078-09W4	12-19-078-09W4	6180911	474962	644.9	440.0	224.0	420.9	28.0	271.0	373.9	299.0	345.9	305.0	339.9	0.0	0.0	-5.0	-5.0		
100/11-21-078-09W4	11-21-078-09W4	6180891	478614	628.9	443.0	208.0	420.9	27.0	260.0	368.9	287.0	341.9	292.0	336.9	0.0	0.0	-5.0	-5.0		
100/11-22-078-09W4	11-22-078-09W4	6180884	480238	638.0	445.0	217.0	421.0	23.0	271.0	367.0	294.0	344.0	301.0	337.0	0.0	0.0	-5.0	-5.0		
100/10-24-078-09W4	10-24-078-09W4	6180868	483890	596.4	390.0	176.0	420.4	30.0	223.0	373.4	253.0	343.4	257.0	339.4	0.0	0.0	-5.0	-5.0		
100/10-27-078-09W4	10-27-078-09W4	6182502	480651	629.1	419.1	205.0	424.1	28.5	258.5	370.6	287.0	342.1	287.0	342.1	0.0	0.0	-5.0	-5.0		
100/16-28-078-09W4	16-28-078-09W4	6182912	479436	645.5	445.0	218.0	427.5	34.0	265.0	380.5	299.0	346.5	300.0	345.5	0.0	0.0	-5.0	-5.0		
100/07-29-078-09W4	07-29-078-09W4	6182112	477403	655.7	443.0	235.0	420.7	31.0	282.0	373.7	313.0	342.7	317.0	338.7	0.0	0.0	-5.0	-5.0		
100/05-30-078-09W4	05-30-078-09W4	6182126	474969	640.1	453.0	226.0	414.1						304.0	336.1						
100/07-31-078-09W4	07-31-078-09W4	6183741	475789	651.9	475.0	233.5	418.4						322.0	329.9						
100/07-32-078-09W4	07-32-078-09W4	6183732	477411	662.5	464.0	244.0	418.5						327.0	335.5						
100/07-33-078-09W4	07-33-078-09W4	6183724	479034	662.0	475.5	237.5	424.5	29.0	287.0	375.0	316.0		322.0	340.0	0.0	0.0	-5.0	-5.0		
100/06-01-078-10W4	06-01-078-10W4	6175653	473710	618.4	373.4	204.0	414.4	24.0	253.0	365.4	277.0	341.4	287.0	331.4	0.0	19.0	-5.0	19.0		
100/09-02-078-10W4	09-02-078-10W4	6176063	472900	631.1	443.0	215.0	416.1	32.0	258.0	373.1	290.0	341.1	300.0	331.1	0.0	24.0	-5.0	24.0		
100/10-04-078-10W4	10-04-078-10W4	6176088	469244	649.5	453.8	238.0	411.5	21.0	285.0	364.5	306.0	343.5	323.0	326.5	0.0	20.0	-5.0	20.0		
1AA/06-05-078-10W4	06-05-078-10W4	6175715	467225	666.5	491.5	260.0	406.5	36.0	305.0	361.5	341.0	325.5	342.0	324.5	0.0	26.0	-5.0	26.0		
100/06-08-078-10W4	06-08-078-10W4	6177317	467221	655.0	470.0	248.0	407.0	19.0	295.0	360.0	314.0	341.0	331.0	324.0	0.0	20.0	-5.0	20.0		
1AA/11-08-078-10W4	11-08-078-10W4	6177726	467240	653.7	483.0	246.0	407.7	19.0	293.0	360.7	312.0	341.7	330.0	323.7	0.0	11.0	-5.0	11.0		
100/07-09-078-10W4	07-09-078-10W4	6177303	469252	641.3	394.7	228.0	413.3						313.0	328.3						
100/04-11-078-10W4	04-11-078-10W4	6176881	471687	620.2	429.9	207.0	413.2	32.0	251.0	369.2	283.0	337.2	286.0	334.2	0.0	19.0	-5.0	19.0		
100/10-11-078-10W4	10-11-078-10W4	6177686	472504	622.1	432.5	206.5	415.6	32.5	251.5	370.6	284.0	338.1	288.0	334.1	0.0	14.0	-5.0	14.0		
100/12-12-078-10W4	12-12-078-10W4	6177681	473316	623.3	434.0	208.0	415.3	34.0	252.0	371.3	286.0	337.3	290.0	333.3	0.0	0.0	-5.0	-5.0		
100/05-14-078-10W4	05-14-078-10W4	6178906	471700	635.3	444.0	223.0	412.3	24.0	268.0	367.3	292.0	343.3	303.0	332.3	0.0	16.0	-5.0	16.0		
100/07-14-078-10W4	07-14-078-10W4	6178901	472512	631.6	442.0	218.0	413.6	21.0	265.0	366.6	286.0	345.6	300.0	331.6	0.0	10.0	-5.0	10.0		
1AA/03-15-078-10W4	03-15-078-10W4	6178509	470479	631.3	441.0	218.0	413.3	24.0	266.0	365.3	290.0	341.3	301.0	330.3	0.0	21.0	-5.0	21.0		
100/08-15-078-10W4	08-15-078-10W4	6178909	471294	638.8	450.0	225.0	413.8	21.5	271.5	367.3	293.0	345.8	307.0	331.8	0.0	13.0	-5.0	13.0		
100/08-16-078-10W4	08-16-078-10W4	6178920	469670	642.4	454.0	230.0	412.4						313.0	329.4						
1AA/11-16-078-10W4	11-16-078-10W4	6179330	468860	654.4	477.2	247.0	407.4	22.0	293.0	361.4	315.0	339.4	327.0	327.4	0.0	26.0	-5.0	26.0		
100/06-17-078-10W4	06-17-078-10W4	6178937	467233	661.5	473.0	251.0	410.5	23.0	300.0	361.5	323.0	338.5	334.0	327.5	0.0	15.0	-5.0	15.0		

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Upper Clearwater Watersand Base (m bKB)	Upper Clearwater Watersand Base (m asl)	Middle Clearwater Watersand Top (m bKB)	Middle Clearwater Watersand Top (m asl)	Middle Clearwater Watersand Base (m bKB)	Middle Clearwater Watersand Base (m asl)	Top Wabiskaw (m bKB)	Top Wabiskaw (m asl)	Top McMurray (m bKB)	Top McMurray (m asl)	Paleo Surface (m bKB)	Paleo Surface (m asl)	Watersand Thickness (m)	Watersand Thickness (Surfer) (m)	Watersand Surface Elevation (m asl)	Log Analysis Notes:
1AA/10-11-078-08 W4/00	10-11-078-08W4	246.0	321.0					294.7	272.3	307.0	260.0	366.2	200.8	0.0	-5.0	200.8	
100/10-12-078-08 W4/00	10-12-078-08W4	233.0	326.4					283.4	276.0	295.7	263.7	352.2	207.2	5.0	5.0	212.2	
100/03-14-078-08 W4/00	03-14-078-08W4							290.8	275.5	302.9	263.4	355.5	210.8	0.0	-5.0	210.8	
100/05-15-078-08 W4/00	05-15-078-08W4	239.0	322.6					286.8	274.8	299.2	262.4	351.9	209.7	0.0	-5.0	209.7	
100/02-16-078-08 W4/00	02-16-078-08W4							286.1	274.4	299.2	261.2	343.0	217.4	2.0	2.0	219.4	
100/02-17-078-08 W4/00	02-17-078-08W4							307.5	271.2	320.0	258.7	365.0	213.7	0.0	-5.0	213.7	
100/15-20-078-08 W4/00	15-20-078-08W4							299.0	274.1	311.0	262.1	356.5	216.6	2.0	2.0	218.6	
100/12-22-078-08 W4/00	12-22-078-08W4							300.0	273.0	312.0	261.0	378.0	195.0	17.0	17.0	212.0	
100/11-23-078-08 W4/00	11-23-078-08W4	240.0	325.4					284.5	280.9	296.5	268.9	327.0	238.4	0.0	-5.0	238.4	
100/10-25-078-08 W4/00	10-25-078-08W4							287.0	276.9	298.0	265.9	347.0	216.9	0.0	-5.0	216.9	
100/06-28-078-08 W4/00	06-28-078-08W4							297.0	276.1	309.5	263.6	369.0	204.1	6.0	6.0	210.1	
100/08-29-078-08 W4/00	08-29-078-08W4							300.0	274.9	314.0	260.9	358.0	216.9	0.0	-5.0	216.9	
100/12-33-078-08 W4/00	12-33-078-08W4							301.0	278.5	312.5	267.0	369.0	210.5	8.0	8.0	218.5	
100/09-34-078-08 W4/00	09-34-078-08W4							287.0	283.7	299.0	271.7	334.0	236.7	0.0	-5.0	236.7	
100/08-01-078-09W4	08-01-078-09W4			286.0	302.1	300.0	288.1	318.0	270.1	330.0	258.1	360.5	227.6	0.0	-5.0	227.6	
100/01-02-078-09W4	01-02-078-09W4							305.0	271.5	317.0	259.5						
100/09-03-078-09W4	09-03-078-09W4							314.0	266.6	326.0	254.6	362.0	218.6	0.0	-5.0	218.6	
100/11-04-078-09W4	11-04-078-09W4			287.0	302.6	304.0	285.6	325.0	264.6	337.0	252.6						
100/11-05-078-09W4	11-05-078-09W4			306.0	303.6	319.0	290.6	347.0	262.6	359.0	250.6	405.0	204.6	2.0	2.0	206.6	
100/09-06-078-09W4	09-06-078-09W4							341.5	265.2	353.0	253.7						
100/04-07-078-09W4	04-07-078-09W4							362.0	264.0	375.0	251.0						
100/10-09-078-09W4	10-09-078-09W4			302.5	300.1	320.5	282.1	341.0	261.6	352.0	250.6	398.0	204.6	8.0	8.0	212.6	
100/01-10-078-09W4	01-10-078-09W4							320.0	268.4	331.0	257.4						
100/01-11-078-09W4	01-11-078-09W4							315.0	269.7	327.0	257.7						
100/07-11-078-09W4	07-11-078-09W4							337.5	263.0	349.0	251.5	394.0	206.5	5.0	5.0	211.5	
100/02-12-078-09W4	02-12-078-09W4			289.0	300.9	296.0	293.9	321.0	268.9	333.0	256.9						
100/10-17-078-09W4	10-17-078-09W4			339.0	297.7	352.0	284.7	372.0	264.7	384.0	252.7	432.5	204.2	0.0	-5.0	204.2	
100/10-18-078-09W4	10-18-078-09W4							367.0	265.9	378.0	254.9	430.0	202.9	8.0	8.0	210.9	
100/12-19-078-09W4	12-19-078-09W4							373.0	271.9	384.0	260.9	438.0	206.9	0.0	-5.0	206.9	
100/11-21-078-09W4	11-21-078-09W4							361.0	267.9	372.0	256.9	425.0	203.9	3.0	3.0	206.9	
100/11-22-078-09W4	11-22-078-09W4							370.0	268.0	379.0	259.0	426.0	212.0	4.0	4.0	216.0	
100/10-24-078-09W4	10-24-078-09W4							329.0	267.4	338.0	258.4	384.0	212.4	2.0	2.0	214.4	
100/10-27-078-09W4	10-27-078-09W4							359.0	270.1	368.0	261.1	415.0	214.1	0.0	-5.0	214.1	
100/16-28-078-09W4	16-28-078-09W4							368.0	277.5	377.0	268.5	432.0	213.5	3.0	3.0	216.5	
100/07-29-078-09W4	07-29-078-09W4							384.0	271.7	395.0	260.7						
100/05-30-078-09W4	05-30-078-09W4							370.0	270.1	382.0	258.1	433.0	207.1	3.0	3.0	210.1	
100/07-31-078-09W4	07-31-078-09W4							391.0	260.9	402.0	249.9	443.0	208.9	0.0	-5.0	208.9	
100/07-32-078-09W4	07-32-078-09W4							392.0	270.5	400.0	262.5	453.0	209.5	0.0	-5.0	209.5	
100/07-33-078-09W4	07-33-078-09W4							386.5	275.5	395.0	267.0	450.0	212.0	0.0	-5.0	212.0	
100/06-01-078-10W4	06-01-078-10W4			317.0	301.4	336.0	282.4	356.0	262.4	368.0	250.4						
100/09-02-078-10W4	09-02-078-10W4			328.0	303.1	352.0	279.1	369.0	262.1	380.0	251.1	435.0	196.1	11.0	11.0	207.1	
100/10-04-078-10W4	10-04-078-10W4			350.0	299.5	370.0	279.5	396.5	253.0	407.0	242.5						
1AA/06-05-078-10W4	06-05-078-10W4			368.0	298.5	394.0	272.5	415.0	251.5	427.0	239.5	482.0	184.5	5.0	5.0	189.5	
100/06-08-078-10W4	06-08-078-10W4			360.0	295.0	380.0	275.0	399.0	256.0	411.0	244.0	467.0	188.0	5.0	5.0	193.0	
1AA/11-08-078-10W4	11-08-078-10W4			360.0	293.7	371.0	282.7	397.0	256.7	407.0	246.7	467.0	186.7	3.0	3.0	189.7	
100/07-09-078-10W4	07-09-078-10W4							381.0	260.3								gamma runs high
100/04-11-078-10W4	04-11-078-10W4			319.0	301.2	338.0	282.2	360.0	260.2	370.0	250.2	425.0	195.2	0.0	-5.0	195.2	
100/10-11-078-10W4	10-11-078-10W4			322.0	300.1	336.0	286.1	359.0	263.1	371.0	251.1	424.0	198.1	2.0	2.0	200.1	
100/12-12-078-10W4	12-12-078-10W4							362.0	261.3	373.0	250.3	426.0	197.3	8.0	8.0	205.3	
100/05-14-078-10W4	05-14-078-10W4			336.0	299.3	352.0	283.3	373.0	262.3	384.0	251.3	436.0	199.3	3.0	3.0	202.3	
100/07-14-078-10W4	07-14-078-10W4			333.0	298.6	343.0	288.6	369.0	262.6	380.0	251.6	433.0	198.6	8.0	8.0	206.6	
1AA/03-15-078-10W4	03-15-078-10W4			331.0	300.3	352.0	279.3	371.0	260.3	382.0	249.3	434.0	197.3	7.0	7.0	204.3	
100/08-15-078-10W4	08-15-078-10W4			340.0	298.8	353.0	285.8	375.5	263.3	387.0	251.8	442.5	196.3	8.0	8.0	204.3	
100/08-16-078-10W4	08-16-078-10W4							381.5	260.9	392.0	250.4	448.0	194.4	0.0	-5.0	194.4	gamma runs high
1AA/11-16-078-10W4	11-16-078-10W4			361.0	293.4	387.0	267.4	399.0	255.4	410.0	244.4	470.0	184.4	2.0	2.0	186.4	
100/06-17-078-10W4	06-17-078-10W4			365.0	296.5	380.0	281.5	403.0	258.5	414.0	247.5	468.0	193.5	10.0	10.0	203.5	

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Northing (m) NAD 27	Easting (m) NAD 27	KB (m asl)	TD (m)	Top Grand Rapids (m bKB)	Top Grand Rapids (m asl)	Grand Rapids Watersand Thickness (m)	Grand Rapids Watersand Top (m bKB)	Grand Rapids Watersand Top (m asl)	Grand Rapids Watersand Base (m bKB)	Grand Rapids Watersand Base (m asl)	Top Clearwater (m bKB)	Top Clearwater (m asl)	Upper Clearwater Watersand Thickness (m)	Middle Clearwater Watersand Thickness (m)	Upper Clearwater Watersand Thickness (Surfer) (m)	Middle Clearwater Watersand Thickness (Surfer) (m)	Upper Clearwater Watersand Top (m bKB)	Upper Clearwater Watersand Top (m asl)
100/10-18-078-10W4	10-18-078-10W4	6179352	466019	666.3	487.7	255.0	411.3	25.0	303.5	362.8	328.5	337.8	337.0	329.3	0.0	15.0	-5.0	15.0		
100/08-19-078-10W4	08-19-078-10W4	6180563	466434	672.0	476.0	255.5	416.5	28.5	300.5	371.5	329.0	343.0	330.0	342.0	0.0	15.0	-5.0	15.0		
100/05-20-078-10W4	05-20-078-10W4	6180560	466840	670.5	476.0	252.0	418.5	25.0	301.0	369.5	326.0	344.5	334.0	336.5	0.0	12.0	-5.0	12.0		
100/06-21-078-10W4	06-21-078-10W4	6180545	468869	654.2	467.5	241.0	413.2	27.0	284.0	370.2	311.0	343.2	322.0	332.2	0.0	8.0	-5.0	8.0		
1F1/16-21-078-10W4	16-21-078-10W4	6181348	469692	644.9	456.0	235.0	409.9	15.0	284.0	360.9	299.0	345.9	312.0	332.9	0.0	8.0	-5.0	8.0		
100/07-22-078-10W4	07-22-078-10W4	6180531	470899	636.3	445.0	218.0	418.3	17.0	269.0	367.3	286.0	350.3	302.0	334.3	0.0	5.0	-5.0	5.0		
1F1/13-22-078-10W4	13-22-078-10W4	6181345	470113	641.4	456.7	228.0	413.4	15.0	280.0	361.4	295.0	346.4	309.0	332.4	0.0	8.0	-5.0	8.0		
1AA/03-27-078-10W4	03-27-078-10W4	6181765	470516	634.5	451.0	222.0	412.5	20.0	268.0	366.5	288.0	346.5	300.0	334.5	0.0	10.0	-5.0	10.0		
100/04-27-078-10W4	04-27-078-10W4	6181751	470095	639.1	459.0	221.0	418.1	19.0	272.0	367.1	291.0	348.1	305.0	334.1	0.0	10.0	-5.0	10.0		
1AB/05-27-078-10W4	05-27-078-10W4	6182170	470118	638.7	449.0	223.0	415.7	20.0	271.0	367.7	291.0	347.7	306.0	332.7	0.0	7.0	-5.0	7.0		
100/07-27-078-10W4	07-27-078-10W4	6182151	470909	636.5	458.0	222.0	414.5	22.0	265.0	371.5	287.0	349.5	302.0	334.5	0.0	0.0	-5.0	-5.0		
100/12-27-078-10W4	12-27-078-10W4	6182561	470101	635.9	441.0	219.0	416.9	18.0	269.0	366.9	287.0	348.9	302.0	333.9	0.0	0.0	-5.0	-5.0		
100/01-28-078-10W4	01-28-078-10W4	6181770	469695	642.5	471.0	230.0	412.5	26.0	275.0	367.5	301.0	341.5	312.0	330.5	0.0	10.0	-5.0	10.0		
100/07-28-078-10W4	07-28-078-10W4	6182162	469287	642.5	473.0	231.0	411.5	27.0	278.0	364.5	305.0	337.5	314.0	328.5	0.0	0.0	-5.0	-5.0		
1AA/09-28-078-10W4	09-28-078-10W4	6182564	469695	638.9	456.8	226.0	412.9	24.0	275.0	363.9	299.0	339.9	308.0	330.9	0.0	10.0	-5.0	10.0		
100/06-31-078-10W4	06-31-078-10W4	6183809	465648	676.4	490.7	258.0	418.4	23.0	320.0	356.4	343.0	333.4	349.0	327.4	0.0	0.0	-5.0	-5.0		
100/08-32-078-10W4	08-32-078-10W4	6183791	468081	656.4	476.0	242.0	414.4	32.0	288.0	368.4	320.0	336.4	327.0	329.4	0.0	6.0	-5.0	6.0		
1AA/01-33-078-10W4	01-33-078-10W4	6183379	469706	638.7	460.0	225.0	413.7	24.0	276.0	362.7	300.0	338.7	309.0	329.7	0.0	7.0	-5.0	7.0		
100/05-33-078-10W4	05-33-078-10W4	6183788	468487	653.3	463.0	236.0	417.3	30.0	285.0	368.3	315.0	338.3	322.0	331.3	0.0	6.0	-5.0	6.0		
100/08-33-078-10W4	08-33-078-10W4	6183779	469704	645.1	470.0	226.0	419.1	17.0	277.0	368.1	294.0	351.1	309.0	336.1	0.0	5.0	-5.0	5.0		
100/16-33-078-10W4	16-33-078-10W4	6184589	469709	654.7	483.0	240.0	414.7	20.0	291.0	363.7	311.0	343.7	324.0	330.7	0.0	0.0	-5.0	-5.0		
1AA/02-34-078-10W4	02-34-078-10W4	6183371	470928	644.0	446.9	228.0	416.0	22.0	279.0	365.0	301.0	343.0	312.0	332.0	0.0	0.0	-5.0	-5.0		
1AB/03-34-078-10W4	03-34-078-10W4	6183373	470527	637.7	451.0	224.0	413.7	21.0	273.0	364.7	294.0	343.7	306.0	331.7	0.0	0.0	-5.0	-5.0		
1AF/04-34-078-10W4	04-34-078-10W4	6183376	470127	636.3	442.0	220.0	416.3	14.0	270.0	366.3	284.0	352.3	303.0	333.3	0.0	0.0	-5.0	-5.0		
100/06-34-078-10W4	06-34-078-10W4	6183773	470515	641.6	448.0	226.0	415.6	17.0	277.0	364.6	294.0	347.6	311.0	330.6	0.0	0.0	-5.0	-5.0		
100/10-34-078-10W4	10-34-078-10W4	6184176	470923	647.4	463.0	233.0	414.4	12.0	285.0	362.4	297.0	350.4	316.0	331.4	0.0	0.0	-5.0	-5.0		
1AA/12-34-078-10W4	12-34-078-10W4	6184180	470132	646.4	465.0	230.0	416.4	19.0	283.0	363.4	302.0	344.4	317.0	329.4	0.0	0.0	-5.0	-5.0		
100/07-35-078-10W4	07-35-078-10W4	6183760	472543	661.4	475.5	244.0	417.4	15.0	299.0	362.4	314.0	347.4	332.0	329.4	0.0	0.0	-5.0	-5.0		
100/06-36-078-10W4	06-36-078-10W4	6183753	473759	651.4	451.0	231.0	420.4	16.0	284.0	367.4	300.0	351.4	317.0	334.4	0.0	0.0	-5.0	-5.0		
100/05-10-078-11W4	05-10-078-11W4	6177375	460321	705.3	502.9	294.0	411.3	31.5	339.0	366.3	370.5	334.8	379.0	326.3	0.0	0.0	-5.0	-5.0		
100/11-11-078-11W4	11-11-078-11W4	6177762	462355	687.0	498.0	271.0	416.0	31.0	322.0	365.0	353.0	334.0	362.0	325.0	0.0	27.0	-5.0	27.0		
100/06-20-078-11W4	06-20-078-11W4	6180641	457509	691.0	498.3	275.0	416.0	42.0	319.0	372.0	361.0	330.0	364.0	327.0	0.0	0.0	-5.0	-5.0		
100/12-30-078-11W4	12-30-078-11W4	6182686	455500	687.9	488.0	264.0	423.9	36.0	316.0	371.9	352.0	335.9	354.0	333.9	0.0	17.0	-5.0	17.0		
100/10-33-078-11W4	10-33-078-11W4	6184267	459572	699.7	502.0	285.0	414.7	42.0	329.0	370.7	371.0	328.7	374.0	325.7	0.0	0.0	-5.0	-5.0		
100/02-06-078-12W400	02-06-078-12W4	6175887	446604	669.8	473.0	259.2	410.6	35.0	299.0	370.8	334.0	335.8	345.1	324.7	0.0	29.0	-5.0	29.0		
100/07-07-078-12W400	07-07-078-12W4	6177587	446467	677.3	474.0	266.6	410.7	29.0	311.0	366.3	340.0	337.3	350.1	327.2	0.0	28.0	-5.0	28.0		
100/10-08-078-12W400	10-08-078-12W4	6178268	448151	673.4	479.0	260.1	413.4	36.0	304.0	369.4	340.0	333.4	347.0	326.4	0.0	22.0	-5.0	22.0		
100/02-10-078-12W400	02-10-078-12W4	6177143	451254	672.6	478.0	262.1	410.5	39.0	304.0	368.6	343.0	329.6	346.4	326.2	0.0	24.0	-5.0	24.0		
100/05-10-078-12W400	05-10-078-12W4	6177786	450530	676.0	484.6	263.7	412.3						352.3	323.7						
100/07-17-078-12W400	07-17-078-12W4	6179458	448198	674.3	471.0	264.8	409.5	30.0	313.0	361.3	343.0	331.3	350.5	323.8	0.0	22.0	-5.0	22.0		
100/10-18-078-12W400	10-18-078-12W4	6179859	446553	676.4	477.3	264.7	411.7	23.0	319.0	357.4	342.0	334.4	350.7	325.7	0.0	22.0	-5.0	22.0		
100/11-18-078-12W400	11-18-078-12W4	6179883	446049	677.0	471.0	255.9	421.1	25.0	316.0	361.0	341.0	336.0	348.6	328.4	0.0	22.0	-5.0	22.0		
100/05-19-078-12W400	05-19-078-12W4	6181115	445776	674.8	466.3	253.7	421.1	27.0	311.0	363.8	338.0	336.8	342.5	332.3	0.0	13.0	-5.0	13.0		
102/05-19-078-12W400	05-19-078-12W4	6181134	445770	678.4	457.0	261.7	416.7	27.0	315.0	363.4	342.0	336.4	346.5	331.9	0.0	0.0	-5.0	-5.0		
100/12-20-078-12W400	12-20-078-12W4	6181434	447258	677.8	477.0	264.2	413.6	30.0	314.0	363.8	344.0	333.8	349.0	328.9	0.0	5.0	-5.0	5.0		
100/07-22-078-12W400	07-22-078-12W4	6180893	451205	680.0	490.7	265.4	414.6	27.0	316.0	364.0	343.0	337.0	351.0	329.0	0.0	15.0	-5.0	15.0		
100/06-30-078-12W400	06-30-078-12W4	6182791	446088	677.1	477.5	264.0	413.1	26.0	314.0	363.1	340.0	337.1	349.0	328.1	0.0	0.0	-5.0	-5.0		
100/07-31-078-12W400	07-31-078-12W4	6184234	446613	676.5	474.0	269.9	406.7	28.0	314.0	362.5	342.0	334.5	346.7	329.8	0.0	0.0	-5.0	-5.0		
100/10-32-078-12W400	10-32-078-12W4	6184720	448257	679.6	470.0	261.9	417.7	28.0	312.0	367.6	340.0	339.6	345.0	334.6	0.0	0.0	-5.0	-5.0		
100/07-36-078-12W400	07-36-078-12W4	6183996	454544	680.0	500.0	259.5	420.5	31.0	314.0	366.0	345.0	335.0	351.4	328.6	0.0	14.0	-5.0	14.0		
100/12-01-078-13W400	12-01-078-13W4	6176514	443843	670.4	483.0	264.9	405.5	38.0	303.0	367.4	341.0	329.4	346.8	323.7	0.0	26.0	-5.0	26.0		
100/07-02-078-13W400	07-02-078-13W4	6176372	443317	668.5	481.0	263.8	404.7	37.0	304.0	364.5	341.0	327.5	345.9	322.6	0.0	27.0	-5.0	27.0		
100/14-03-078-13W400	14-03-078-13W4	6176904	441246	677.4	500.0	272.1	405.3	34.0	315.0	362.4	349.0	328.4	356.0	321.5	0.0	28.0	-5.0	28.0		
100/05-06-078-13W400	05-06-078-13W4	6176456	435918	675.5	524.0	278.5	397.0	33.0	327.0	348.5	360.0	315.5	365.3	310.3	0.0	31.0	-5.0	31.0		
100/11-07-078-13W400	11-07-078-13W4	6178171	436456	673.6	521.0	278.4	395.2	34.0	324.0	349.6	358.0	315.6	363.4	310.2	0.0	27.0	-5.0	27.0		
100/08-08-078-13W400	08-08-078-13W4	6177859	438568	670.6	535.0	269.3	401.3	33.0	315.0	355.6	348.0	322.6	352.3	318.3	0.0	29.0	-5.0	29.0		

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Upper Clearwater Watersand Base (m bKB)	Upper Clearwater Watersand Base (m asl)	Middle Clearwater Watersand Top (m bKB)	Middle Clearwater Watersand Top (m asl)	Middle Clearwater Watersand Base (m bKB)	Middle Clearwater Watersand Base (m asl)	Top Wabiskaw (m bKB)	Top Wabiskaw (m asl)	Top McMurray (m bKB)	Top McMurray (m asl)	Paleo Surface (m bKB)	Paleo Surface (m asl)	Watersand Thickness (m)	Watersand Thickness (Surfer) (m)	Watersand Surface Elevation (m asl)	Log Analysis Notes:
100/10-18-078-10W4	10-18-078-10W4			371.0	295.3	386.0	280.3	407.0	259.3	418.0	248.3	470.0	196.3	2.0	2.0	198.3	
100/08-19-078-10W4	08-19-078-10W4			372.0	300.0	387.0	285.0	407.0	265.0	417.0	255.0	471.0	201.0	6.0	6.0	207.0	
100/05-20-078-10W4	05-20-078-10W4			370.0	300.5	382.0	288.5	403.0	267.5	414.0	256.5	471.0	199.5	3.0	3.0	202.5	
100/06-21-078-10W4	06-21-078-10W4			357.0	297.2	365.0	289.2	391.0	263.2	402.0	252.2	460.0	194.2	0.0	-5.0	194.2	
1F1/16-21-078-10W4	16-21-078-10W4			351.0	293.9	359.0	285.9	383.0	261.9	393.0	251.9	448.0	196.9	8.0	8.0	204.9	
100/07-22-078-10W4	07-22-078-10W4			340.0	296.3	345.0	291.3	370.0	266.3	381.0	255.3	439.0	197.3	7.0	7.0	204.3	
1F1/13-22-078-10W4	13-22-078-10W4			347.0	294.4	355.0	286.4	380.0	261.4	391.0	250.4	450.0	191.4	5.0	5.0	196.4	
1AA/03-27-078-10W4	03-27-078-10W4			337.0	297.5	347.0	287.5	367.0	267.5	379.0	255.5	435.0	199.5	4.0	4.0	203.5	
100/04-27-078-10W4	04-27-078-10W4			341.0	298.1	351.0	288.1	371.5	267.6	383.0	256.1	440.0	199.1	4.0	4.0	203.1	
1AB/05-27-078-10W4	05-27-078-10W4			343.0	295.7	350.0	288.7	372.0	266.7	383.0	255.7	447.0	191.7	6.0	6.0	197.7	
100/07-27-078-10W4	07-27-078-10W4							369.0	267.5	379.0	257.5	435.0	201.5	8.0	8.0	209.5	
100/12-27-078-10W4	12-27-078-10W4							367.0	268.9	378.0	257.9	433.0	202.9	0.0	-5.0	202.9	
100/01-28-078-10W4	01-28-078-10W4			349.0	293.5	359.0	283.5	379.0	263.5	391.0	251.5	454.0	188.5	11.0	11.0	199.5	
100/07-28-078-10W4	07-28-078-10W4							381.5	261.0	393.0	249.5	456.5	186.0	11.5	11.5	197.5	
1AA/09-28-078-10W4	09-28-078-10W4			346.0	292.9	356.0	282.9	374.0	264.9	385.0	253.9	451.5	187.4	11.0	11.0	198.4	
100/06-31-078-10W4	06-31-078-10W4							414.0	262.4	424.0	252.4	477.0	199.4	0.0	-5.0	199.4	
100/08-32-078-10W4	08-32-078-10W4			366.0	290.4	372.0	284.4	392.0	264.4	402.0	254.4	468.0	188.4	15.0	15.0	203.4	
1AA/01-33-078-10W4	01-33-078-10W4			348.0	290.7	355.0	283.7	375.0	263.7	386.0	252.7	450.0	188.7	8.0	8.0	196.7	
100/05-33-078-10W4	05-33-078-10W4			361.0	292.3	367.0	286.3	387.0	266.3	397.0	256.3	456.0	197.3	9.0	9.0	206.3	
100/08-33-078-10W4	08-33-078-10W4			350.0	295.1	355.0	290.1	374.5	270.6	386.0	259.1	450.0	195.1	15.0	15.0	210.1	
100/16-33-078-10W4	16-33-078-10W4							389.0	265.7	400.0	254.7	464.0	190.7	16.0	16.0	206.7	
1AA/02-34-078-10W4	02-34-078-10W4							376.0	268.0	388.0	256.0	440.0	204.0	4.0	4.0	208.0	
1AB/03-34-078-10W4	03-34-078-10W4							372.0	265.7	381.0	256.7	435.0	202.7	0.0	-5.0	202.7	
1AF/04-34-078-10W4	04-34-078-10W4							370.0	266.3	380.0	256.3	435.0	201.3	0.0	-5.0	201.3	
100/06-34-078-10W4	06-34-078-10W4							374.0	267.6	385.0	256.6	441.0	200.6	0.0	-5.0	200.6	
100/10-34-078-10W4	10-34-078-10W4							382.0	265.4	392.0	255.4	442.5	204.9	0.0	-5.0	204.9	
1AA/12-34-078-10W4	12-34-078-10W4							380.0	266.4	391.0	255.4	456.0	190.4	4.0	4.0	194.4	
100/07-35-078-10W4	07-35-078-10W4							398.0	263.4	407.0	254.4	460.0	201.4	0.0	-5.0	201.4	
100/06-36-078-10W4	06-36-078-10W4							381.0	270.4	392.0	259.4	446.0	205.4	7.0	7.0	212.4	
100/05-10-078-11W4	05-10-078-11W4							449.0	256.3	460.0	245.3	495.5	209.8	0.0	-5.0	209.8	
100/11-11-078-11W4	11-11-078-11W4			396.0	291.0	423.0	264.0	432.0	255.0	443.0	244.0	492.0	195.0	0.0	-5.0	195.0	
100/06-20-078-11W4	06-20-078-11W4							435.5	255.5	448.0	243.0	492.0	199.0	0.0	-5.0	199.0	
100/12-30-078-11W4	12-30-078-11W4			391.0	296.9	408.0	279.9	425.0	262.9	435.0	252.9	480.0	207.9	0.0	-5.0	207.9	
100/10-33-078-11W4	10-33-078-11W4							442.0	257.7	453.0	246.7	497.0	202.7	0.0	-5.0	202.7	
100/02-06-078-12W400	02-06-078-12W4			377.0	292.8	406.0	263.8	420.6	249.2	432.8	237.0	458.2	211.6	0.0	-5.0	211.6	
100/07-07-078-12W400	07-07-078-12W4			382.0	295.3	410.0	267.3	424.7	252.6	435.3	242.0	458.1	219.2	0.0	-5.0	219.2	
100/10-08-078-12W400	10-08-078-12W4			384.0	289.4	406.0	267.4	421.7	251.7	432.3	241.1	461.8	211.6	0.0	-5.0	211.6	
100/02-10-078-12W400	02-10-078-12W4			378.0	294.6	402.0	270.6	420.2	252.4	432.6	240.0	472.1	200.5	0.0	-5.0	200.5	
100/05-10-078-12W400	05-10-078-12W4							426.3	249.7	436.3	239.7						gamma ran high
100/07-17-078-12W400	07-17-078-12W4			385.0	289.3	407.0	267.3	422.9	251.5	433.3	241.0	464.9	209.4	0.0	-5.0	209.4	
100/10-18-078-12W400	10-18-078-12W4			387.0	289.4	409.0	267.4	422.9	253.5	433.2	243.2	461.8	214.6	0.0	-5.0	214.6	
100/11-18-078-12W400	11-18-078-12W4			383.0	294.0	405.0	272.0	420.3	256.7	430.4	246.6	453.4	223.6	0.0	-5.0	223.6	
100/05-19-078-12W400	05-19-078-12W4			379.0	295.8	392.0	282.8	416.6	258.2	426.2	248.6	448.7	226.2	0.0	-5.0	226.2	
102/05-19-078-12W400	05-19-078-12W4							420.1	258.3	429.9	248.5						
100/12-20-078-12W400	12-20-078-12W4			385.0	292.8	390.0	287.8	422.1	255.7	432.2	245.6	460.9	216.9	0.0	-5.0	216.9	
100/07-22-078-12W400	07-22-078-12W4			389.0	291.0	404.0	276.0	423.5	256.5	433.9	246.1	472.9	207.1	0.0	-5.0	207.1	
100/06-30-078-12W400	06-30-078-12W4							423.8	253.3	433.6	243.5	463.8	213.3	0.0	-5.0	213.3	
100/07-31-078-12W400	07-31-078-12W4							420.2	256.3	430.4	246.2	461.1	215.4	0.0	-5.0	215.4	
100/10-32-078-12W400	10-32-078-12W4							417.5	262.1	431.1	248.5	449.0	230.6	0.0	-5.0	230.6	
100/07-36-078-12W400	07-36-078-12W4			392.0	288.0	406.0	274.0	419.6	260.4	430.3	249.8	477.3	202.7	0.0	-5.0	202.7	
100/12-01-078-13W400	12-01-078-13W4			383.0	287.4	409.0	261.4	423.3	247.1	436.6	233.8	482.5	187.9	0.0	-5.0	187.9	
100/07-02-078-13W400	07-02-078-13W4			380.0	288.5	407.0	261.5	421.7	246.8	433.7	234.8	472.5	196.0	0.0	-5.0	196.0	
100/14-03-078-13W400	14-03-078-13W4			390.0	287.4	418.0	259.4	433.9	243.5	447.1	230.3	491.8	185.6	12.0	12.0	197.6	
100/05-06-078-13W400	05-06-078-13W4			399.0	276.5	430.0	245.5	445.2	230.4	459.0	216.5	514.7	160.8	4.1	4.1	164.8	
100/11-07-078-13W400	11-07-078-13W4			399.0	274.6	426.0	247.6	441.9	231.7	451.8	221.8	512.8	160.8	10.2	10.2	171.0	
100/08-08-078-13W400	08-08-078-13W4			387.0	283.6	416.0	254.6	429.8	240.8	439.7	230.9	493.9	176.7	10.8	10.8	187.6	

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Northing (m) NAD 27	Easting (m) NAD 27	KB (m asl)	TD (m)	Top Grand Rapids (m bKB)	Top Grand Rapids (m asl)	Grand Rapids Watersand Thickness (m)	Grand Rapids Watersand Top (m bKB)	Grand Rapids Watersand Top (m asl)	Grand Rapids Watersand Base (m bKB)	Grand Rapids Watersand Base (m asl)	Top Clearwater (m bKB)	Top Clearwater (m asl)	Upper Clearwater Watersand Thickness (m)	Middle Clearwater Watersand Thickness (m)	Upper Clearwater Watersand Thickness (Surfer) (m)	Middle Clearwater Watersand Thickness (Surfer) (m)	Upper Clearwater Watersand Top (m bKB)	Upper Clearwater Watersand Top (m asl)
100/07-11-078-13W400	07-11-078-13W4	6177781	443029	668.5	480.0	258.8	409.7						341.9	326.6						
100/08-12-078-13W400	08-12-078-13W4	6177818	445142	671.7	468.0	258.7	413.0	25.0	308.0	363.7	333.0	338.7	342.4	329.3	0.0	21.0	-5.0	21.0		
100/07-14-078-13W400	07-14-078-13W4	6179545	443379	685.5	492.3	273.9	411.7	27.0	327.0	358.5	354.0	331.5	359.7	325.8	0.0	18.0	-5.0	18.0		
100/05-15-078-13W400	05-15-078-13W4	6179593	440989	666.9	488.0	263.5	403.4	28.0	312.0	354.9	340.0	326.9	349.1	317.8	0.0	23.0	-5.0	23.0		
100/11-15-078-13W400	11-15-078-13W4	6179900	441248	667.4	488.0	264.1	403.3	32.0	313.0	354.4	345.0	322.4	350.0	317.4	0.0	24.0	-5.0	24.0		
100/10-16-078-13W400	10-16-078-13W4	6180025	440162	668.6	500.0	264.8	403.8	30.0	315.0	353.6	345.0	323.6	349.6	319.0	0.0	24.0	-5.0	24.0		
100/05-17-078-13W400	05-17-078-13W4	6179662	437687	674.3	540.0	275.8	398.5	31.0	327.0	347.3	358.0	316.3	362.3	312.0	0.0	26.0	-5.0	26.0		
100/15-17-078-13W400	15-17-078-13W4	6180233	438195	671.6	507.0	271.4	400.2	31.0	324.0	347.6	355.0	316.6	357.1	314.5	0.0	24.0	-5.0	24.0		
100/05-19-078-13W400	05-19-078-13W4	6181161	436021	676.6	517.5	276.7	399.9	33.0	328.0	348.6	361.0	315.6	364.7	311.9	0.0	23.0	-5.0	23.0		
100/07-20-078-13W400	07-20-078-13W4	6181271	438212	670.5	499.0	269.2	401.3	33.0	320.0	350.5	353.0	317.5	356.9	313.6	0.0	18.0	-5.0	18.0		
100/05-24-078-13W400	05-24-078-13W4	6181185	444205	668.0	482.5	259.4	408.6	29.0	310.0	358.0	339.0	329.0	344.0	324.0	0.0	15.0	-5.0	15.0		
100/11-25-078-13W400	11-25-078-13W4	6182946	444620	672.4	486.2	261.1	411.3	31.0	312.0	360.4	343.0	329.4	346.6	325.8	0.0	5.0	-5.0	5.0		
100/08-27-078-13W400	08-27-078-13W4	6182551	442032	667.4	484.0	259.2	408.3	30.0	311.0	356.4	341.0	326.4	346.0	321.4	0.0	13.0	-5.0	13.0		
100/06-28-078-13W400	06-28-078-13W4	6182640	439512	671.2	516.0	264.5	406.7	33.0	315.0	356.2	348.0	323.2	352.2	319.0	0.0	0.0	-5.0	-5.0		
100/12-29-078-13W400	12-29-078-13W4	6183196	437573	677.1	510.0	273.1	404.0	33.0	326.0	351.1	359.0	318.1	362.4	314.7	0.0	13.0	-5.0	13.0		
1AA/12-29-078-13W400	12-29-078-13W4	6183210	437573	679.5	490.0	274.4	405.1	32.0	326.0	353.5	358.0	321.5	362.8	316.8	0.0	10.0	-5.0	10.0		
100/04-30-078-13W400	04-30-078-13W4	6182198	435938	678.6	507.0	275.6	403.1	30.0	330.0	348.6	360.0	318.6	364.1	314.5	0.0	10.0	-5.0	10.0		
100/07-31-078-13W400	07-31-078-13W4	6184286	436741	683.1	518.0	278.9	404.3	39.0	328.0	355.1	367.0	316.1	369.7	313.4	0.0	0.0	-5.0	-5.0		
100/08-31-078-13W400	08-31-078-13W4	6184336	437091	683.2	512.0	270.7	412.5	36.0	328.0	355.2	364.0	319.2	366.8	316.4	0.0	4.0	-5.0	4.0		
100/05-33-078-13W400	05-33-078-13W4	6184325	439136	677.6	496.0	269.5	408.1	36.0	321.0	356.6	357.0	320.6	361.2	316.4	0.0	0.0	-5.0	-5.0		
100/06-34-078-13W400	06-34-078-13W4	6184260	441251	668.0	473.0	266.4	401.6	36.0	315.0	353.0	351.0	317.0	354.2	313.8	0.0	0.0	-5.0	-5.0		
100/05-35-078-13W400	05-35-078-13W4	6184290	442413	673.7	486.0	261.8	411.9	32.0	316.0	357.7	348.0	325.7	352.0	321.7	0.0	0.0	-5.0	-5.0		
100/06-36-078-13W400	06-36-078-13W4	6184376	444574	674.7	486.0	271.7	403.0	30.0	313.0	361.7	343.0	331.7	351.9	322.8	0.0	0.0	-5.0	-5.0		
100/07-06-078-14 W4/00	07-06-078-14 W4	6176202	427005	673.6	512.0	285.0	388.6	39.0	325.0	348.6	364.0	309.6	368.0	305.6	0.0	30.0	-5.0	30.0		
100/10-22-078-14 W4/00	10-22-078-14 W4	6181372	431961	689.1	665.0	294.0	395.1	37.0	340.0	349.1	377.0	312.1	380.0	309.1	0.0	23.0	-5.0	23.0		
100/02-02-078-14W400	02-02-078-14W4	6175892	433552	685.9	520.0	294.4	391.5						374.9	311.1						
100/10-11-078-14W400	10-11-078-14W4	6178516	433574	685.9	635.0	289.3	396.6	26.0	343.0	342.9	369.0	316.9	376.1	309.8	0.0	22.0	-5.0	22.0		
100/07-13-078-14W400	07-13-078-14W4	6179702	435238	676.6	508.0	278.5	398.2	29.0	332.0	344.6	361.0	315.6	365.6	311.0	0.0	23.0	-5.0	23.0		
100/16-23-078-14W400	16-23-078-14W4	6181959	434096	683.5	521.0	282.0	401.5	33.0	334.0	349.5	367.0	316.5	370.1	313.4	0.0	20.0	-5.0	20.0		
100/06-24-078-14W400	06-24-078-14W4	6181045	434886	676.1	517.0	276.1	400.0	33.0	327.0	349.1	360.0	316.1	364.2	311.9	0.0	17.0	-5.0	17.0		
100/06-25-078-14W400	06-25-078-14W4	6182656	434648	681.7	515.0	278.1	403.6	28.0	335.0	346.7	363.0	318.7	365.8	315.9	0.0	16.0	-5.0	16.0		
100/10-26-078-14W400	10-26-078-14W4	6183325	433469	689.2	500.0	288.0	401.2	39.0	334.0	355.2	373.0	316.2	376.3	312.9	0.0	11.0	-5.0	11.0		
100/06-36-078-14W400	06-36-078-14W4	6184480	434829	679.6	512.0	275.1	404.5	35.0	325.0	354.6	360.0	319.6	363.2	316.4	0.0	6.0	-5.0	6.0		
100/12-03-079-06 W4/00	12-03-079-06 W4	6185719	508611	506.6	320.0			19.0	142.0	364.6	161.0	345.6	161.0	345.6	0.0	0.0	-5.0	-5.0		
100/08-04-079-06 W4/00	08-04-079-06 W4	6185316	508188	512.4	331.0	92.0	420.4	20.0	152.0	360.4	172.0	340.4	172.0	340.4	0.0	0.0	-5.0	-5.0		
100/11-06-079-06 W4/00	11-06-079-06 W4	6185712	504108	554.9	365.5	130.0	424.9	28.0	186.0	368.9	214.0	340.9	214.0	340.9	0.0	0.0	-5.0	-5.0		
100/11-08-079-06 W4/00	11-08-079-06 W4	6187323	505742	510.5	330.0								168.0	342.5						
100/07-10-079-06 W4/00	07-10-079-06 W4	6186927	509417	477.6	301.0			22.0	115.0	362.6	137.0	340.6	137.0	340.6	0.0	0.0	-5.0	-5.0		
100/05-11-079-06 W4/00	05-11-079-06 W4	6186929	510244	474.4	302.0	54.0	420.4						136.0	338.4						
100/10-11-079-06 W4/00	10-11-079-06 W4	6187333	511051	494.5	319.0			21.0	130.0	364.5	151.0	343.5	152.0	342.5	0.0	0.0	-5.0	-5.0		
100/06-12-079-06 W4/00	06-12-079-06 W4	6186934	512284	479.3	313.0			17.0	122.0	357.3	139.0	340.3	139.0	340.3	0.0	0.0	-5.0	-5.0		
100/08-13-079-06 W4/00	08-13-079-06 W4	6188565	513086	475.9	322.0			21.0	119.0	356.9	140.0	335.9	140.0	335.9	0.0	0.0	-5.0	-5.0		
100/04-14-079-06 W4/00	04-14-079-06 W4	6188156	510242	474.7	300.0			21.0	113.0	361.7	134.0	340.7	134.0	340.7	0.0	0.0	-5.0	-5.0		
100/08-14-079-06 W4/00	08-14-079-06 W4	6188561	511451	470.8	304.5			19.0	111.0	359.8	130.0	340.8	130.0	340.8	0.0	0.0	-5.0	-5.0		
100/07-15-079-06 W4/00	07-15-079-06 W4	6188556	509413	468.3	296.0			23.0	103.0	365.3	126.0	342.3	126.0	342.3	0.0	0.0	-5.0	-5.0		
100/10-16-079-06 W4/00	10-16-079-06 W4	6188955	507778	491.4	330.0								153.0	338.4						
100/11-27-079-06 W4/00	11-27-079-06 W4	6192195	509002	492.3	316.0			24.0	127.0	365.3	151.0	341.3	155.0	337.3	0.0	0.0	-5.0	-5.0		
100/11-28-079-06 W4/00	11-28-079-06 W4	6192192	507369	516.8	341.0	87.0	429.8	26.0	149.0	367.8	175.0	341.8	175.0	341.8	0.0	0.0	-5.0	-5.0		
100/07-32-079-06 W4/00	07-32-079-06 W4	6193396	506137	550.4	365.0	121.0	429.4	28.0	182.0	368.4	210.0	340.4	210.0	340.4	0.0	0.0	-5.0	-5.0		
100/13-34-079-06 W4/00	13-34-079-06 W4	6194205	508595	508.0	321.0			21.0	144.0	364.0	165.0	343.0	165.0	343.0	0.0	0.0	-5.0	-5.0		
100/11-03-079-07 W4/00	11-03-079-07 W4	6185706	499200	557.5	361.0	129.0	428.5	23.0	184.0	373.5	207.0	350.5	207.0	350.5	0.0	0.0	-5.0	-5.0		
100/01-04-079-07 W4/00	01-04-079-07 W4	6184902	498372	558.2	380.0	129.0	429.2	20.0	186.0	372.2	206.0	352.2	212.0	346.2	0.0	0.0	-5.0	-5.0		
100/10-05-079-07 W4/00	10-05-079-07 W4	6185707	496332	566.4	360.5	127.0	439.4	23.0	193.0	373.4	216.0	350.4	216.0	350.4	0.0	0.0	-5.0	-5.0		
102/09-06-079-07 W4/00	09-06-079-07 W4	6185708	495100	567.2	344.0	136.0	431.2	24.0	190.0	377.2	214.0	353.2	214.0	353.2	0.0	0.0	-5.0	-5.0		
100/11-08-079-07 W4/00	11-08-079-07 W4	6187316	495930	572.1	346.0	139.0	433.1	16.0	194.0	378.1	210.0	362.1	222.0	350.1	0.0	0.0	-5.0	-5.0		

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Upper Clearwater Watersand Base (m bKB)	Upper Clearwater Watersand Base (m asl)	Middle Clearwater Watersand Top (m bKB)	Middle Clearwater Watersand Top (m asl)	Middle Clearwater Watersand Base (m bKB)	Middle Clearwater Watersand Base (m asl)	Top Wabiskaw (m bKB)	Top Wabiskaw (m asl)	Top McMurray (m bKB)	Top McMurray (m asl)	Paleo Surface (m bKB)	Paleo Surface (m asl)	Watersand Thickness (m)	Watersand Thickness (Surfer) (m)	Watersand Surface Elevation (m asl)	Log Analysis Notes:
100/07-11-078-13W400	07-11-078-13W4							419.6	249.0	429.6	238.9	469.6	198.9	0.0	-5.0	198.9	gamma ran high
100/08-12-078-13W400	08-12-078-13W4			378.0	293.7	399.0	272.7	418.1	253.6	431.7	240.0	450.1	221.6	0.0	-5.0	221.6	
100/07-14-078-13W400	07-14-078-13W4			395.0	290.5	413.0	272.5	434.2	251.3	444.1	241.4	483.1	202.4	0.0	-5.0	202.4	
100/05-15-078-13W400	05-15-078-13W4			385.0	281.9	408.0	258.9	425.3	241.6	439.0	227.9	481.7	185.2	2.0	2.0	187.1	
100/11-15-078-13W400	11-15-078-13W4			386.0	281.4	410.0	257.4	425.9	241.5	439.4	228.0	479.4	188.0	0.0	-5.0	188.0	
100/10-16-078-13W400	10-16-078-13W4			386.0	282.6	410.0	258.6	423.8	244.8	436.2	232.4	484.9	183.8	3.3	3.3	187.1	
100/05-17-078-13W400	05-17-078-13W4			397.0	277.3	423.0	251.3	437.5	236.8	447.3	227.0	502.9	171.4	2.7	2.7	174.2	
100/15-17-078-13W400	15-17-078-13W4			393.0	278.6	417.0	254.6	432.9	238.7	442.7	228.9	500.0	171.6	4.5	4.5	176.0	
100/05-19-078-13W400	05-19-078-13W4			402.0	274.6	425.0	251.6	439.0	237.6	449.1	227.5	515.7	160.9	4.0	4.0	164.9	
100/07-20-078-13W400	07-20-078-13W4			393.0	277.5	411.0	259.5	432.8	237.7	446.7	223.8	493.6	176.9	0.0	-5.0	176.9	
100/05-24-078-13W400	05-24-078-13W4			381.0	287.0	396.0	272.0	418.2	249.9	431.7	236.3	468.2	199.8	2.9	2.9	202.7	
100/11-25-078-13W400	11-25-078-13W4			391.0	281.4	396.0	276.4	421.2	251.2	431.2	241.2	470.8	201.7	4.0	4.0	205.7	
100/08-27-078-13W400	08-27-078-13W4			385.0	282.4	398.0	269.4	421.8	245.6	431.7	235.7	500.0	167.4	7.0	7.0	174.4	minimum basal mcmurray thickness selected
100/06-28-078-13W400	06-28-078-13W4							428.3	242.9	438.3	232.9						
100/12-29-078-13W400	12-29-078-13W4			400.0	277.1	413.0	264.1	436.7	240.4	448.4	228.7	504.3	172.8	0.0	-5.0	172.8	
1AA/12-29-078-13W400	12-29-078-13W4			402.0	277.5	412.0	267.5	437.5	242.0	451.1	228.4						
100/04-30-078-13W400	04-30-078-13W4			401.0	277.6	411.0	267.6	438.1	240.5	451.5	227.1	505.2	173.4	2.0	2.0	175.4	
100/07-31-078-13W400	07-31-078-13W4							444.5	238.7	453.9	229.2	514.7	168.4	4.0	4.0	172.4	
100/08-31-078-13W400	08-31-078-13W4			414.0	269.2	418.0	265.2	440.3	242.9	450.0	233.2	510.3	172.9				
100/05-33-078-13W400	05-33-078-13W4							435.0	242.6	445.0	232.6						
100/06-34-078-13W400	06-34-078-13W4							429.5	238.5	439.4	228.6						
100/05-35-078-13W400	05-35-078-13W4							425.1	248.6	435.3	238.4	485.0	188.7	11.0	11.0	199.7	
100/06-36-078-13W400	06-36-078-13W4							427.0	247.7	436.3	238.5	475.1	199.6	2.9	2.9	202.5	
100/07-06-078-14 W4/00	07-06-078-14 W4			406.0	267.6	436.0	237.6	452.0	221.6	461.0	212.6	501.0	172.6	0.0	-5.0	172.6	
100/10-22-078-14 W4/00	10-22-078-14 W4			417.0	272.1	440.0	249.1	456.0	233.1	465.0	224.1	516.0	173.1	1.0	1.0	174.1	
100/02-02-078-14W400	02-02-078-14W4							456.2	229.7	470.4	215.5	513.1	172.8	3.6	3.6	176.4	gamma ran high
100/10-11-078-14W400	10-11-078-14W4			415.0	270.9	437.0	248.9	453.1	232.8	464.6	221.3	509.2	176.7	0.0	-5.0	176.7	
100/07-13-078-14W400	07-13-078-14W4			400.0	276.6	423.0	253.6	438.3	238.3	451.8	224.8	505.0	171.6	16.0	16.0	187.6	
100/16-23-078-14W400	16-23-078-14W4			408.0	275.5	428.0	255.5	444.8	238.7	458.7	224.8	513.1	170.4	9.6	9.6	180.0	
100/06-24-078-14W400	06-24-078-14W4			400.0	276.1	417.0	259.1	439.0	237.2	448.6	227.5	513.2	162.9	5.7	5.7	168.6	
100/06-25-078-14W400	06-25-078-14W4			405.0	276.7	421.0	260.7	438.5	243.2	451.5	230.2	512.0	169.7	12.0	12.0	181.7	
100/10-26-078-14W400	10-26-078-14W4			414.0	275.2	425.0	264.2	449.7	239.5	462.3	226.9						
100/06-36-078-14W400	06-36-078-14W4			406.0	273.6	412.0	267.6	434.9	244.8	444.2	235.4	498.0	181.6	15.0	15.0	196.6	
100/12-03-079-06 W4/00	12-03-079-06 W4							227.0	279.6	241.0	265.6	311.0	195.6	20.0	20.0	215.6	
100/08-04-079-06 W4/00	08-04-079-06 W4							240.0	272.4	251.0	261.4	321.0	191.4	26.0	26.0	217.4	
100/11-06-079-06 W4/00	11-06-079-06 W4							281.0	273.9	292.0	262.9	355.0	199.9	8.0	8.0	207.9	
100/11-08-079-06 W4/00	11-08-079-06 W4							233.0	277.5	244.0	266.5	318.0	192.5	18.0	18.0	210.5	gamma runs high
100/07-10-079-06 W4/00	07-10-079-06 W4							205.0	272.6	215.0	262.6	280.0	197.6	10.0	10.0	207.6	
100/05-11-079-06 W4/00	05-11-079-06 W4							205.0	269.4	217.0	257.4	289.0	185.4	8.0	8.0	193.4	gamma runs high
100/10-11-079-06 W4/00	10-11-079-06 W4							223.0	271.5	236.0	258.5	306.0	188.5	11.0	11.0	199.5	
100/06-12-079-06 W4/00	06-12-079-06 W4							208.0	271.3	223.0	256.3	300.0	179.3	6.0	6.0	185.3	
100/08-13-079-06 W4/00	08-13-079-06 W4							206.0	269.9	218.0	257.9	300.0	175.9	3.0	3.0	178.9	
100/04-14-079-06 W4/00	04-14-079-06 W4							201.0	273.7	216.0	258.7	283.0	191.7	27.0	27.0	218.7	
100/08-14-079-06 W4/00	08-14-079-06 W4							201.0	269.8	216.0	254.8	280.0	190.8	11.0	11.0	201.8	
100/07-15-079-06 W4/00	07-15-079-06 W4							195.0	273.3	208.0	260.3	285.0	183.3	21.0	21.0	204.3	
100/10-16-079-06 W4/00	10-16-079-06 W4							219.0	272.4	234.0	257.4	316.0	175.4	18.0	18.0	193.4	gamma runs high
100/11-27-079-06 W4/00	11-27-079-06 W4							220.0	272.3	235.0	257.3	310.0	182.3	29.0	29.0	211.3	
100/11-28-079-06 W4/00	11-28-079-06 W4							239.0	277.8	253.0	263.8	330.0	186.8	44.0	44.0	230.8	
100/07-32-079-06 W4/00	07-32-079-06 W4							275.0	275.4	289.0	261.4	357.0	193.4	5.0	5.0	198.4	
100/13-34-079-06 W4/00	13-34-079-06 W4							233.0	275.0	248.0	260.0	315.0	193.0	30.0	30.0	223.0	
100/11-03-079-07 W4/00	11-03-079-07 W4							278.0	279.5	289.0	268.5	352.0	205.5	0.0	-5.0	205.5	
100/01-04-079-07 W4/00	01-04-079-07 W4							278.0	280.2	289.0	269.2	350.0	208.2	3.0	3.0	211.2	
100/10-05-079-07 W4/00	10-05-079-07 W4							286.0	280.4	297.0	269.4	348.0	218.4	0.0	-5.0	218.4	
102/09-06-079-07 W4/00	09-06-079-07 W4							282.0	285.2	295.0	272.2	337.0	230.2	0.0	-5.0	230.2	
100/11-08-079-07 W4/00	11-08-079-07 W4							288.0	284.1	298.0	274.1	334.0	238.1	0.0	-5.0	238.1	

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Northing (m) NAD 27	Easting (m) NAD 27	KB (m asl)	TD (m)	Top Grand Rapids (m bKB)	Top Grand Rapids (m asl)	Grand Rapids Watersand Thickness (m)	Grand Rapids Watersand Top (m bKB)	Grand Rapids Watersand Top (m asl)	Grand Rapids Watersand Base (m bKB)	Grand Rapids Watersand Base (m asl)	Top Clearwater (m bKB)	Top Clearwater (m asl)	Upper Clearwater Watersand Thickness (m)	Middle Clearwater Watersand Thickness (m)	Upper Clearwater Watersand Thickness (Surfer) (m)	Middle Clearwater Watersand Thickness (Surfer) (m)	Upper Clearwater Watersand Top (m bKB)	Upper Clearwater Watersand Top (m asl)
100/02-10-079-07 W4/00	02-10-079-07 W4	6186510	499604	561.2	367.0	130.0	431.2	22.0	187.0	374.2	209.0	352.2	209.0	352.2	0.0	0.0	-5.0	-5.0		
100/10-11-079-07 W4/00	10-11-079-07 W4	6187314	501239	553.7	349.0	126.0	427.7						204.0	349.7						
100/10-12-079-07 W4/00	10-12-079-07 W4	6187315	502874	549.9	356.0	123.0	426.9	19.0	188.0	361.9	207.0	342.9	207.0	342.9	0.0	0.0	-5.0	-5.0		
100/04-13-079-07 W4/00	04-13-079-07 W4	6188139	502066	554.0	353.0	125.0	429.0	28.0	182.0	372.0	210.0	344.0	210.0	344.0	0.0	0.0	-5.0	-5.0		
100/01-15-079-07 W4/00	01-15-079-07 W4	6188139	500008	564.0	370.0	134.0	430.0	21.0	193.0	371.0	214.0	350.0	216.0	348.0	0.0	0.0	-5.0	-5.0		
100/06-15-079-07 W4/00	06-15-079-07 W4	6188541	499200	570.9	368.0	142.0	428.9	22.0	203.0	367.9	225.0	345.9	225.0	345.9	0.0	0.0	-5.0	-5.0		
100/13-16-079-07 W4/00	13-16-079-07 W4	6189346	497163	581.5	362.0	147.0	434.5	27.0	202.0	379.5	229.0	352.5	229.0	352.5	0.0	0.0	-5.0	-5.0		
100/09-18-079-07 W4/00	09-18-079-07 W4	6188946	495104	577.1	353.0	141.0	436.1	28.0	195.0	382.1	223.0	354.1	223.0	354.1	0.0	0.0	-5.0	-5.0		
100/05-20-079-07 W4/00	05-20-079-07 W4	6190152	495529	577.2	367.0	143.0	434.2	33.0	192.0	385.2	225.0	352.2	225.0	352.2	0.0	0.0	-5.0	-5.0		
100/04-21-079-07 W4/00	04-21-079-07 W4	6189748	497163	583.5	370.0	150.0	433.5	27.0	206.0	377.5	233.0	350.5	233.0	350.5	0.0	0.0	-5.0	-5.0		
100/07-21-079-07 W4/00	07-21-079-07 W4	6190150	497970	584.2	402.0	155.0	429.2	27.0	207.0	377.2	234.0	350.2	234.0	350.2	0.0	0.0	-5.0	-5.0		
100/12-22-079-07 W4/00	12-22-079-07 W4	6190552	498797	581.6	384.5	152.0	429.6	24.0	211.0	370.6	235.0	346.6	235.0	346.6	0.0	0.0	-5.0	-5.0		
100/10-25-079-07 W4/00	10-25-079-07 W4	6192181	502871	569.3	391.0	139.0	430.3	23.0	196.0	373.3	219.0	350.3	219.0	350.3	0.0	0.0	-5.0	-5.0		
100/06-26-079-07 W4/00	06-26-079-07 W4	6191778	500835	569.1	365.0	139.0	430.1	23.0	201.0	368.1	224.0	345.1	224.0	345.1	0.0	0.0	-5.0	-5.0		
100/04-27-079-07 W4/00	04-27-079-07 W4	6191376	498798	578.1	377.0	153.0	425.1	27.0	202.0	376.1	229.0	349.1	229.0	349.1	0.0	0.0	-5.0	-5.0		
102/04-28-079-07 W4/00	04-28-079-07 W4	6191377	497164	581.0	380.0	150.0	431.0	33.0	199.0	382.0	232.0	349.0	232.0	349.0	0.0	0.0	-5.0	-5.0		
100/11-33-079-07 W4/00	11-33-079-07 W4	6193790	497569	593.5	406.0	160.0	433.5	31.0	213.0	380.5	244.0	349.5	244.0	349.5	0.0	0.0	-5.0	-5.0		
100/10-01-079-08 W4/00	10-01-079-08W4	6185711	493064	568.8	349.0	143.0	425.8	31.0	189.0	379.8	220.0	348.8	220.0	348.8	0.0	0.0	-5.0	-5.0		
100/10-02-079-08 W4/00	10-02-079-08W4	6185714	491428	573.4	352.0	141.0	432.4	35.0	188.0	385.4	223.0	350.4	223.0	350.4	0.0	0.0	-5.0	-5.0		
100/07-03-079-08 W4/00	07-03-079-08W4	6185315	489792	580.4	370.0	151.0	429.4	34.0	195.0	385.4	229.0	351.4	229.0	351.4	0.0	0.0	-5.0	-5.0		
100/04-10-079-08 W4/00	04-10-079-08W4	6186524	488987	591.8	382.0	159.0	432.8	30.0	208.0	383.8	238.0	353.8	238.0	353.8	0.0	0.0	-5.0	-5.0		
1AA/10-11-079-08 W4/00	10-11-079-08W4	6187322	491431	577.4	374.0	146.0	431.4	31.0	194.0	383.4	225.0	352.4	223.0	354.4	0.0	0.0	-5.0	-5.0		
100/11-11-079-08 W4/00	11-11-079-08W4	6187323	491028	582.2	367.0	147.0	435.2	29.0	200.0	382.2	229.0	353.2	232.0	350.2	0.0	0.0	-5.0	-5.0		
100/10-12-079-08 W4/00	10-12-079-08W4	6187320	493067	572.5	355.0	138.0	434.5	37.0	187.0	385.5	224.0	348.5	224.0	348.5	0.0	0.0	-5.0	-5.0		
100/13-13-079-08 W4/00	13-13-079-08W4	6189352	492263	584.7	385.0	150.0	434.7	28.0	202.0	382.7	230.0	354.7	233.0	351.7	0.0	0.0	-5.0	-5.0		
100/01-14-079-08 W4/00	01-14-079-08W4	6188146	491837	582.2	381.0	146.0	436.2	30.0	199.0	383.2	229.0	353.2	231.0	351.2	0.0	0.0	-5.0	-5.0		
100/12-14-079-08 W4/00	12-14-079-08W4	6188953	490628	593.7	381.8	161.0	432.7	29.0	210.0	383.7	239.0	354.7	239.0	354.7	0.0	0.0	-5.0	-5.0		
100/11-15-079-08 W4/00	11-15-079-08W4	6188956	489397	611.5	392.0	177.0	434.5	31.0	229.0	382.5	260.0	351.5	260.0	351.5	0.0	0.0	-5.0	-5.0		
100/13-15-079-08 W4/00	13-15-079-08W4	6189359	488994	614.6	405.0	177.0	437.6	13.0	233.0	381.6	246.0	368.6	254.0	360.6	0.0	0.0	-5.0	-5.0		
100/11-16-079-08 W4/00	11-16-079-08W4	6188960	487762	617.1	397.0	181.0	436.1	24.0	233.0	384.1	257.0	360.1	266.0	351.1	0.0	0.0	-5.0	-5.0		
100/10-18-079-08 W4/00	10-18-079-08W4	6188969	484896	628.3	420.0	196.0	432.3	31.0	247.0	381.3	278.0	350.3	284.0	344.3	0.0	0.0	-5.0	-5.0		
100/12-19-079-08 W4/00	12-19-079-08W4	6190581	484095	654.1	454.0	223.0	431.1	26.0	272.0	382.1	298.0	356.1	307.0	347.1	0.0	0.0	-5.0	-5.0		
100/03-20-079-08 W4/00	03-20-079-08W4	6189769	486130	624.3	400.0	187.0	437.3	37.0	235.0	389.3	272.0	352.3	277.0	347.3	0.0	0.0	-5.0	-5.0		
100/01-21-079-08 W4/00	01-21-079-08W4	6189762	488571	610.4	401.0	174.0	436.4	24.0	228.0	382.4	252.0	358.4	260.0	350.4	0.0	0.0	-5.0	-5.0		
100/16-22-079-08 W4/00	16-22-079-08W4	6190965	490208	624.1	414.0	188.0	436.1	21.0	243.0	381.1	264.0	360.1	264.0	360.1	0.0	0.0	-5.0	-5.0		
100/12-23-079-08 W4/00	12-23-079-08W4	6190562	490631	610.0	389.0	175.0	435.0	23.0	227.0	383.0	250.0	360.0	258.0	352.0	0.0	0.0	-5.0	-5.0		
100/11-24-079-08 W4/00	11-24-079-08W4	6190558	492668	586.9	377.0	150.0	436.9	28.0	197.0	389.9	225.0	361.9	230.0	356.9	0.0	0.0	-5.0	-5.0		
1AA/10-26-079-08 W4/00	10-26-079-08W4	6192189	491441	617.9	407.0	187.0	430.9	20.0	242.0	375.9	262.0	355.9	262.0	355.9	0.0	0.0	-5.0	-5.0		
100/04-29-079-08 W4/00	04-29-079-08W4	6191399	485732	647.6	426.0	217.0	430.6	22.0	271.0	376.6	293.0	354.6	293.0	354.6	0.0	0.0	-5.0	-5.0		
100/11-31-079-08 W4/00	11-31-079-08W4	6193817	484510	674.9	466.0	244.0	430.9						321.0	353.9						
100/09-32-079-08 W4/00	09-32-079-08W4	6193809	486949	665.8	450.0	233.0	432.8	23.0	286.0	379.8	309.0	356.8	320.0	345.8	0.0	0.0	-5.0	-5.0		
100/11-35-079-08 W4/00	11-35-079-08W4	6193798	491041	640.6	426.0	201.0	439.6	28.0	259.0	381.6	287.0	353.6	287.0	353.6	0.0	0.0	-5.0	-5.0		
100/06-02-079-09W4	06-02-079-09W4	6185320	481199	641.7	438.0	213.0	428.7	33.0	265.0	376.7	298.0	343.7	302.0	339.7	0.0	0.0	-5.0	-5.0		
100/06-03-079-09W4	06-03-079-09W4	6185327	479564	658.1	449.3	240.0	418.1						319.0	339.1						
1AA/12-04-079-09W4	12-04-079-09W4	6185768	477537	656.3	452.0	235.0	421.3	19.0	289.0	367.3	308.0	348.3	322.0	334.3	0.0	0.0	-5.0	-5.0		
100/07-05-079-09W4	07-05-079-09W4	6185342	476702	657.2	462.0	236.0	421.2						324.0	333.2						
100/06-07-079-09W4	06-07-079-09W4	6186973	474668	657.2	463.0	236.0	421.2	22.0	289.0	368.2	311.0	346.2	322.0	335.2	0.0	0.0	-5.0	-5.0		
100/08-08-079-09W4	08-08-079-09W4	6186959	477120	663.8	465.0	241.0	422.8	20.0	293.0	370.8	313.0	350.8	326.0	337.8	0.0	0.0	-5.0	-5.0		
100/06-10-079-09W4	06-10-079-09W4	6186947	479572	664.0	444.0	241.0	423.0	19.5	294.0	370.0	313.5	350.5	325.0	339.0	0.0	0.0	-5.0	-5.0		
100/06-11-079-09W4	06-11-079-09W4	6186940	481206	640.4	431.3	215.0	425.4	22.5	267.0	373.4	289.5	350.9	299.0	341.4	0.0	0.0	-5.0	-5.0		
100/08-13-079-09W4	08-13-079-09W4	6188550	483665	630.1	409.5	199.5	430.6	34.0	247.0	383.1	281.0	349.1	288.0	342.1	0.0	0.0	-5.0	-5.0		
100/10-14-079-09W4	10-14-079-09W4	6188963	481624	682.1	464.0	257.0	425.1						341.0	341.1						
100/11-15-079-09W4	11-15-079-09W4	6188972	479581	678.5	458.0	254.0	424.5	19.0	306.0	372.5	325.0	353.5	338.0	340.5	0.0	0.0	-5.0	-5.0		
100/10-16-079-09W4	10-16-079-09W4	6188978	478356	680.0	478.5	256.0	424.0						343.0	337.0						
100/11-16-079-09W4	11-16-079-09W4	6188980	477947	683.3	486.0	253.0	430.3	20.0	312.0	371.3	332.0	351.3	344.0	339.3	0.0	0.0	-5.0	-5.0		
100/12-16-079-09W4	12-16-079-09W4	6188982	477539	684.3	654.0	261.0	423.3	20.5	314.0	370.3	334.5	349.8	347.0	337.3	0.0	0.0	-5.0	-5.0		

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Upper Clearwater Watersand Base (m bKB)	Upper Clearwater Watersand Base (m asl)	Middle Clearwater Watersand Top (m bKB)	Middle Clearwater Watersand Top (m asl)	Middle Clearwater Watersand Base (m bKB)	Middle Clearwater Watersand Base (m asl)	Top Wabiskaw (m bKB)	Top Wabiskaw (m asl)	Top McMurray (m bKB)	Top McMurray (m asl)	Paleo Surface (m bKB)	Paleo Surface (m asl)	Watersand Thickness (m)	Watersand Thickness (Surfer) (m)	Watersand Surface Elevation (m asl)	Log Analysis Notes:
100/02-10-079-07 W4/00	02-10-079-07 W4							278.0	283.2	284.0	277.2	352.0	209.2	0.0	-5.0	209.2	
100/10-11-079-07 W4/00	10-11-079-07 W4							274.0	279.7	285.0	268.7	337.0	216.7	0.0	-5.0	216.7	gamma runs high
100/10-12-079-07 W4/00	10-12-079-07 W4							272.0	277.9	283.0	266.9	338.0	211.9	0.0	-5.0	211.9	
100/04-13-079-07 W4/00	04-13-079-07 W4							274.0	280.0	285.0	269.0	336.0	218.0	0.0	-5.0	218.0	
100/01-15-079-07 W4/00	01-15-079-07 W4							284.0	280.0	295.0	269.0	355.0	209.0	0.0	-5.0	209.0	
100/06-15-079-07 W4/00	06-15-079-07 W4							294.0	276.9	305.0	265.9	357.0	213.9	0.0	-5.0	213.9	
100/13-16-079-07 W4/00	13-16-079-07 W4							297.0	284.5	307.0	274.5	346.0	235.5	0.0	-5.0	235.5	
100/09-18-079-07 W4/00	09-18-079-07 W4							290.0	287.1	301.0	276.1	343.0	234.1	0.0	-5.0	234.1	
100/05-20-079-07 W4/00	05-20-079-07 W4							292.0	285.2	302.0	275.2	344.0	233.2	0.0	-5.0	233.2	
100/04-21-079-07 W4/00	04-21-079-07 W4							299.0	284.5	310.0	273.5	357.0	226.5	0.0	-5.0	226.5	
100/07-21-079-07 W4/00	07-21-079-07 W4							303.0	281.2	313.0	271.2	370.0	214.2	0.0	-5.0	214.2	
100/12-22-079-07 W4/00	12-22-079-07 W4							303.0	278.6	314.0	267.6	367.0	214.6	0.0	-5.0	214.6	
100/10-25-079-07 W4/00	10-25-079-07 W4							289.0	280.3	298.0	271.3	357.0	212.3	0.0	-5.0	212.3	
100/06-26-079-07 W4/00	06-26-079-07 W4							290.0	279.1	301.0	268.1	358.0	211.1	0.0	-5.0	211.1	
100/04-27-079-07 W4/00	04-27-079-07 W4							296.0	282.1	307.0	271.1	362.0	216.1	0.0	-5.0	216.1	
102/04-28-079-07 W4/00	04-28-079-07 W4							298.0	283.0	310.0	271.0	366.0	215.0	0.0	-5.0	215.0	
100/11-33-079-07 W4/00	11-33-079-07 W4							310.0	283.5	320.0	273.5	376.0	217.5	0.0	-5.0	217.5	
100/10-01-079-08 W4/00	10-01-079-08W4							286.0	282.8	298.0	270.8	342.0	226.8	0.0	-5.0	226.8	
100/10-02-079-08 W4/00	10-02-079-08W4							291.0	282.4	302.0	271.4	344.0	229.4	0.0	-5.0	229.4	
100/07-03-079-08 W4/00	07-03-079-08W4							292.0	288.4	310.0	270.4	357.0	223.4	0.0	-5.0	223.4	
100/04-10-079-08 W4/00	04-10-079-08W4							319.0	272.8	322.0	269.8	375.0	216.8	3.0	3.0	219.8	
1AA/10-11-079-08 W4/00	10-11-079-08W4							294.0	283.4	306.0	271.4	362.0	215.4	5.0	5.0	220.4	
100/11-11-079-08 W4/00	11-11-079-08W4							297.0	285.2	308.0	274.2	362.0	220.2	0.0	-5.0	220.2	
100/10-12-079-08 W4/00	10-12-079-08W4							288.0	284.5	300.0	272.5	343.0	229.5	0.0	-5.0	229.5	
100/13-13-079-08 W4/00	13-13-079-08W4							299.0	285.7	310.0	274.7	369.0	215.7	0.0	-5.0	215.7	
100/01-14-079-08 W4/00	01-14-079-08W4							296.0	286.2	307.0	275.2	366.0	216.2	0.0	-5.0	216.2	
100/12-14-079-08 W4/00	12-14-079-08W4							312.0	281.7	323.0	270.7	374.0	219.7	4.0	4.0	223.7	
100/11-15-079-08 W4/00	11-15-079-08W4							326.0	285.5	338.0	273.5	385.0	226.5	0.0	-5.0	226.5	
100/13-15-079-08 W4/00	13-15-079-08W4							328.0	286.6	339.0	275.6	390.0	224.6	2.0	2.0	226.6	
100/11-16-079-08 W4/00	11-16-079-08W4							332.0	285.1	343.0	274.1	393.0	224.1	3.0	3.0	227.1	
100/10-18-079-08 W4/00	10-18-079-08W4							345.0	283.3	356.0	272.3	405.0	223.3	0.0	-5.0	223.3	
100/12-19-079-08 W4/00	12-19-079-08W4							368.0	286.1	380.0	274.1	432.0	222.1	4.0	4.0	226.1	
100/03-20-079-08 W4/00	03-20-079-08W4							337.0	287.3	348.0	276.3	398.0	226.3	0.0	-5.0	226.3	
100/01-21-079-08 W4/00	01-21-079-08W4							325.0	285.4	336.0	274.4	386.0	224.4	2.0	2.0	226.4	
100/16-22-079-08 W4/00	16-22-079-08W4							337.0	287.1	349.0	275.1	398.0	226.1	0.0	-5.0	226.1	
100/12-23-079-08 W4/00	12-23-079-08W4							323.0	287.0	335.0	275.0	383.0	227.0	0.0	-5.0	227.0	
100/11-24-079-08 W4/00	11-24-079-08W4							301.0	285.9	313.0	273.9	367.0	219.9	0.0	-5.0	219.9	
1AA/10-26-079-08 W4/00	10-26-079-08W4							335.0	282.9	347.0	270.9	392.0	225.9	0.0	-5.0	225.9	
100/04-29-079-08 W4/00	04-29-079-08W4							364.0	283.6	374.0	273.6	424.0	223.6	0.0	-5.0	223.6	
100/11-31-079-08 W4/00	11-31-079-08W4							389.0	285.9	402.0	272.9	449.0	225.9	0.0	-5.0	225.9	gamma ran high
100/09-32-079-08 W4/00	09-32-079-08W4							380.0	285.8	390.0	275.8	439.0	226.8	0.0	-5.0	226.8	
100/11-35-079-08 W4/00	11-35-079-08W4							352.0	288.6	364.0	276.6	413.0	227.6	0.0	-5.0	227.6	
100/06-02-079-09W4	06-02-079-09W4							366.0	275.7	374.0	267.7	423.0	218.7	0.0	-5.0	218.7	
100/06-03-079-09W4	06-03-079-09W4							382.5	275.6	391.0	267.1	444.0	214.1	0.0	-5.0	214.1	gamma ran high
1AA/12-04-079-09W4	12-04-079-09W4							384.0	272.3	396.0	260.3	450.0	206.3	0.0	-5.0	206.3	
100/07-05-079-09W4	07-05-079-09W4							387.0	270.2	398.0	259.2	446.0	211.2	0.0	-5.0	211.2	gamma ran high
100/06-07-079-09W4	06-07-079-09W4							384.0	273.2	394.0	263.2	446.0	211.2	0.0	-5.0	211.2	
100/08-08-079-09W4	08-08-079-09W4							387.0	276.8	398.0	265.8	448.0	215.8	0.0	-5.0	215.8	
100/06-10-079-09W4	06-10-079-09W4							387.0	277.0	398.0	266.0	442.0	222.0				
100/06-11-079-09W4	06-11-079-09W4							360.0	280.4	372.0	268.4	416.0	224.4	6.0	6.0	230.4	
100/08-13-079-09W4	08-13-079-09W4							348.0	282.1	359.0	271.1	406.0	224.1	0.0	-5.0	224.1	
100/10-14-079-09W4	10-14-079-09W4							402.0	280.1	412.0	270.1	459.0	223.1	0.0	-5.0	223.1	gamma ran high
100/11-15-079-09W4	11-15-079-09W4							399.0	279.5	410.0	268.5	455.5	223.0	3.0	3.0	226.0	
100/10-16-079-09W4	10-16-079-09W4							404.5	275.5	415.0	265.0	467.0	213.0	0.0	-5.0	213.0	gamma ran high
100/11-16-079-09W4	11-16-079-09W4							405.0	278.3	416.0	267.3	472.0	211.3	6.0	6.0	217.3	
100/12-16-079-09W4	12-16-079-09W4							408.0	276.3	419.0	265.3	474.0	210.3	0.0	-5.0	210.3	

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Northing (m) NAD 27	Easting (m) NAD 27	KB (m asl)	TD (m)	Top Grand Rapids (m bKB)	Top Grand Rapids (m asl)	Grand Rapids Watersand Thickness (m)	Grand Rapids Watersand Top (m bKB)	Grand Rapids Watersand Top (m asl)	Grand Rapids Watersand Base (m bKB)	Grand Rapids Watersand Base (m asl)	Top Clearwater (m bKB)	Top Clearwater (m asl)	Upper Clearwater Watersand Thickness (m)	Middle Clearwater Watersand Thickness (m)	Upper Clearwater Watersand Thickness (Surfer) (m)	Middle Clearwater Watersand Thickness (Surfer) (m)	Upper Clearwater Watersand Top (m bKB)	Upper Clearwater Watersand Top (m asl)
100/05-17-079-09W4	05-17-079-09W4	6188586	475903	666.4	454.0	242.0	424.4	22.0	295.0	371.4	317.0	349.4	328.0	338.4	0.0	0.0	-5.0	-5.0		
100/06-18-079-09W4	06-18-079-09W4	6188593	474677	669.6	460.0	243.5	426.1	23.0	298.0	371.6	321.0	348.6	331.0	338.6	0.0	0.0	-5.0	-5.0		
100/08-19-079-09W4	08-19-079-09W4	6190208	475503	678.7	477.0	253.0	425.7	28.0	304.0	374.7	332.0	346.7	341.0	337.7	0.0	0.0	-5.0	-5.0		
100/09-21-079-09W4	09-21-079-09W4	6190596	478772	677.1	461.0	255.0	422.1	26.0	302.0	375.1	328.0	349.1	341.0	336.1	0.0	0.0	-5.0	-5.0		
100/10-26-079-09W4	10-26-079-09W4	6192202	481637	684.8	480.0	253.0	431.8	24.0	304.0	380.8	328.0	356.8	341.0	343.8	0.0	0.0	-5.0	-5.0		
100/11-27-079-09W4	11-27-079-09W4	6192212	479597	683.5	473.0	252.0	431.5	20.0	309.0	374.5	329.0	354.5	340.0	343.5	0.0	0.0	-5.0	-5.0		
100/10-28-079-09W4	10-28-079-09W4	6192217	478372	681.0	458.0	256.0	425.0	20.0	309.0	372.0	329.0	352.0	339.0	342.0	0.0	0.0	-5.0	-5.0		
100/09-32-079-09W4	09-32-079-09W4	6193844	477156	699.7	496.0	269.0	430.7	38.0	311.0	388.7	349.0	350.7	358.0	341.7	0.0	0.0	-5.0	-5.0		
100/06-34-079-09W4	06-34-079-09W4	6193426	479602	683.1	468.0	252.0	431.1	20.0	308.0	375.1	328.0	355.1	340.0	343.1	0.0	0.0	-5.0	-5.0		
100/10-35-079-09W4	10-35-079-09W4	6193822	481644	681.2	447.0	248.0	433.2	19.0	306.0	375.2	325.0	356.2	338.0	343.2	0.0	0.0	-5.0	-5.0		
100/09-36-079-09W4	09-36-079-09W4	6193814	483684	674.1	440.0	245.0	429.1	18.0	298.0	376.1	316.0	358.1	325.0	349.1	0.0	0.0	-5.0	-5.0		
100/12-02-079-10W4	12-02-079-10W4	6185781	470980	659.2	461.0	243.0	416.2	20.0	294.0	365.2	314.0	345.2	329.0	330.2	0.0	0.0	-5.0	-5.0		
1AA/01-03-079-10W4	01-03-079-10W4	6185004	470566	653.2	456.0	239.0	414.2	23.0	292.0	361.2	315.0	338.2	324.0	329.2	0.0	0.0	-5.0	-5.0		
1AA/02-03-079-10W4	02-03-079-10W4	6185007	470162	654.2	472.0	241.0	413.2	25.0	292.0	362.2	317.0	337.2	326.0	328.2	0.0	0.0	-5.0	-5.0		
100/12-03-079-10W4	12-03-079-10W4	6185792	469344	667.9	475.5	248.0	419.9	39.0	290.0	377.9	329.0	338.9	335.0	332.9	0.0	0.0	-5.0	-5.0		
1AA/09-04-079-10W4	09-04-079-10W4	6185820	468936	663.7	474.5	248.0	415.7	41.0	289.0	374.7	330.0	333.7	336.0	327.7	0.0	0.0	-5.0	-5.0		
100/11-04-079-10W4	11-04-079-10W4	6185801	468118	665.6	475.0	247.0	418.6	36.0	288.0	377.6	324.0	341.6	336.0	329.6	0.0	0.0	-5.0	-5.0		
1AA/16-04-079-10W4	16-04-079-10W4	6186222	468939	669.2	479.5	254.0	415.2	35.0	297.0	372.2	332.0	337.2	343.0	326.2	0.0	0.0	-5.0	-5.0		
100/09-05-079-10W4	09-05-079-10W4	6185807	467301	665.2	483.0	247.0	418.2	39.0	290.0	375.2	329.0	336.2	335.0	330.2	0.0	0.0	-5.0	-5.0		
1AA/12-05-079-10W4	12-05-079-10W4	6185842	466088	674.1	488.0	256.0	418.1	35.0	298.0	376.1	333.0	341.1	346.0	328.1	0.0	0.0	-5.0	-5.0		
1AA/16-05-079-10W4	16-05-079-10W4	6186212	467304	667.9	481.2	251.0	416.9	40.5	293.0	374.9	333.5	334.4	339.0	328.9	0.0	0.0	-5.0	-5.0		
100/07-06-079-10W4	07-06-079-10W4	6185418	465253	677.3	488.0	261.0	416.3	38.0	306.0	371.3	344.0	333.3	351.0	326.3	0.0	0.0	-5.0	-5.0		
1AA/05-08-079-10W4	05-08-079-10W4	6187048	466098	674.9	486.0	258.0	416.9	38.0	305.0	369.9	343.0	331.9	346.0	328.9	0.0	0.0	-5.0	-5.0		
1AA/13-08-079-10W4	13-08-079-10W4	6187852	466104	674.6	492.6	259.0	415.6	32.0	304.0	370.6	336.0	338.6	347.0	327.6	0.0	0.0	-5.0	-5.0		
1AA/15-08-079-10W4	15-08-079-10W4	6187846	466911	688.6	496.0	274.0	414.6	30.0	318.0	370.6	348.0	340.6	363.0	325.6	0.0	0.0	-5.0	-5.0		
100/12-09-079-10W4	12-09-079-10W4	6187424	467721	666.6	485.6	248.0	418.6	20.0	290.0	376.6	310.0	356.6	337.0	329.6	0.0	0.0	-5.0	-5.0		
1AA/13-09-079-10W4	13-09-079-10W4	6187840	467739	685.0	496.0	269.0	416.0	29.0	314.0	371.0	343.0	342.0	356.0	329.0	0.0	0.0	-5.0	-5.0		
100/07-10-079-10W4	07-10-079-10W4	6187001	470170	665.0	467.0	242.0	423.0	40.5	285.0	380.0	325.5	339.5	333.0	332.0	0.0	0.0	-5.0	-5.0		
100/06-11-079-10W4	06-11-079-10W4	6186993	471396	668.4	466.0	242.0	426.4	31.0	294.0	374.4	325.0	343.4	336.0	332.4	0.0	0.0	-5.0	-5.0		
100/10-12-079-10W4	10-12-079-10W4	6187385	473442	658.3	465.0	236.0	422.3	24.0	287.0	371.3	311.0	347.3	321.0	337.3	0.0	0.0	-5.0	-5.0		
100/07-13-079-10W4	07-13-079-10W4	6188600	473450	675.8	460.0	249.0	426.8	25.0	303.0	372.8	328.0	347.8	337.0	338.8	0.0	0.0	-5.0	-5.0		
100/06-14-079-10W4	06-14-079-10W4	6188613	471407	649.2	453.0	224.0	425.2	38.0	266.0	383.2	304.0	345.2	339.0	310.2	0.0	0.0	-5.0	-5.0		
100/07-14-079-10W4	07-14-079-10W4	6188610	471816	648.7	449.0	224.0	424.7	39.0	268.0	380.7	307.0	341.7	316.0	332.7	0.0	0.0	-5.0	-5.0		
100/08-15-079-10W4	08-15-079-10W4	6188618	470590	672.4	477.0	246.0	426.4	38.0	290.0	382.4	328.0	344.4	337.0	335.4	0.0	0.0	-5.0	-5.0		
1AA/16-15-079-10W4	16-15-079-10W4	6189448	470596	675.8	485.0	254.0	421.8	37.0	298.0	377.8	335.0	340.8	344.0	331.8	0.0	0.0	-5.0	-5.0		
100/02-16-079-10W4	02-16-079-10W4	6188228	468545	680.7	500.0	261.0	419.7	30.0	307.0	373.7	337.0	343.7	349.0	331.7	0.0	0.0	-5.0	-5.0		
100/01-17-079-10W4	01-17-079-10W4	6188237	467319	689.2	497.0	272.0	417.2	36.0	317.0	372.2	353.0	336.2	360.0	329.2	0.0	0.0	-5.0	-5.0		
100/04-19-079-10W4	04-19-079-10W4	6189879	464472	685.2	491.0	270.0	415.2	32.5	313.0	372.2	345.5	339.7	361.0	324.2	0.0	0.0	-5.0	-5.0		
100/15-22-079-10W4	15-22-079-10W4	6191051	470198	684.8	484.0	263.0	421.8	36.0	308.0	376.8	344.0	340.8	352.0	332.8	0.0	0.0	-5.0	-5.0		
100/06-23-079-10W4	06-23-079-10W4	6190233	471418	673.1	470.0	249.0	424.1	37.0	291.0	382.1	328.0	345.1	339.0	334.1	0.0	0.0	-5.0	-5.0		
1AA/09-23-079-10W4	09-23-079-10W4	6190644	472238	678.2	484.5	253.0	425.2	31.0	295.0	383.2	326.0	352.2	340.0	338.2	0.0	0.0	-5.0	-5.0		
100/03-24-079-10W4	03-24-079-10W4	6189817	473049	680.5	462.0	255.0	425.5	36.0	299.0	381.5	335.0	345.5	343.0	337.5	0.0	0.0	-5.0	-5.0		
100/12-25-079-10W4	12-25-079-10W4	6192250	472656	699.0	483.0	275.0	424.0	35.0	318.0	381.0	353.0	346.0	363.0	336.0	0.0	0.0	-5.0	-5.0		
100/07-26-079-10W4	07-26-079-10W4	6191850	471837	682.8	487.7	261.0	421.8	35.0	306.0	376.8	341.0	341.8	351.0	331.8	0.0	0.0	-5.0	-5.0		
100/15-26-079-10W4	15-26-079-10W4	6192660	471842	694.5	495.0	274.0	420.5	31.0	321.0	373.5	352.0	342.5	362.0	332.5	0.0	0.0	-5.0	-5.0		
100/13-27-079-10W4	13-27-079-10W4	6192677	469393	675.5	473.0	253.0	422.5	36.0	296.0	379.5	332.0	343.5	341.0	334.5	0.0	0.0	-5.0	-5.0		
100/10-28-079-10W4	10-28-079-10W4	6192278	468574	666.5	466.0	245.0	421.5	38.0	287.0	379.5	325.0	341.5	333.0	333.5	0.0	0.0	-5.0	-5.0		
100/10-29-079-10W4	10-29-079-10W4	6192290	466941	667.8	473.0	242.0	425.8	31.0	291.0	376.8	322.0	345.8	339.0	328.8	0.0	0.0	-5.0	-5.0		
100/02-31-079-10W4	02-31-079-10W4	6193112	465315	679.6	478.0	246.0	433.6	36.0	292.0	387.6	328.0	351.6	342.0	337.6	0.0	0.0	-5.0	-5.0		
1AA/04-31-079-10W4	04-31-079-10W4	6193134	464512	686.7	485.0	260.0	426.7	33.0	316.0	370.7	349.0	337.7	351.0	335.7	0.0	0.0	-5.0	-5.0		
1AA/15-31-079-10W4	15-31-079-10W4	6194334	465328	676.1	483.0	251.0	425.1	30.0	312.0	364.1	342.0	334.1	343.0	333.1	0.0	0.0	-5.0	-5.0		
100/05-32-079-10W4	05-32-079-10W4	6193511	466134	674.6	476.0	252.0	422.6	36.5	298.0	376.6	334.5	340.1	350.0	324.6	0.0	0.0	-5.0	-5.0		
1AA/07-32-079-10W4	07-32-079-10W4	6193516	466955	673.6	482.0	257.0	416.6	35.0	300.0	373.6	335.0	338.6	350.0	323.6	0.0	0.0	-5.0	-5.0		
1AA/02-33-079-10W4	02-33-079-10W4	6193102	468585	671.6	493.5	252.0	419.6	29.0	295.0	376.6	324.0	347.6	343.0	328.6	0.0	0.0	-5.0	-5.0		
100/06-35-079-10W4	06-35-079-10W4	6193473	471439	695.0	491.0	271.0	424.0	38.0	317.0	378.0	355.0	340.0	362.5	332.5	0.0	0.0	-5.0	-5.0		
100/14-03-079-11W4	14-03-079-11W4	6186274	459944	699.7	499.0	279.0	420.7	34.5	325.0	374.7	359.5	340.2	370.0	329.7	0.0	0.0	-5.0	-5.0		

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Upper Clearwater Watersand Base (m bKB)	Upper Clearwater Watersand Base (m asl)	Middle Clearwater Watersand Top (m bKB)	Middle Clearwater Watersand Top (m asl)	Middle Clearwater Watersand Base (m bKB)	Middle Clearwater Watersand Base (m asl)	Top Wabiskaw (m bKB)	Top Wabiskaw (m asl)	Top McMurray (m bKB)	Top McMurray (m asl)	Paleo Surface (m bKB)	Paleo Surface (m asl)	Watersand Thickness (m)	Watersand Thickness (Surfer) (m)	Watersand Surface Elevation (m asl)	Log Analysis Notes:
100/05-17-079-09W4	05-17-079-09W4							387.5	278.9	397.0	269.4	451.5	214.9	0.0	-5.0	214.9	
100/06-18-079-09W4	06-18-079-09W4							392.0	277.6	402.0	267.6						
100/08-19-079-09W4	08-19-079-09W4							401.0	277.7	410.0	268.7	461.0	217.7	0.0	-5.0	217.7	
100/09-21-079-09W4	09-21-079-09W4							402.0	275.1	413.0	264.1						
100/10-26-079-09W4	10-26-079-09W4							401.0	283.8	414.0	270.8	458.0	226.8	3.0	3.0	229.8	
100/11-27-079-09W4	11-27-079-09W4							400.0	283.5	410.0	273.5	456.0	227.5	0.0	-5.0	227.5	
100/10-28-079-09W4	10-28-079-09W4							399.0	282.0	410.0	271.0						
100/09-32-079-09W4	09-32-079-09W4							418.0	281.7	428.0	271.7	478.5	221.2	11.0	11.0	232.2	
100/06-34-079-09W4	06-34-079-09W4							399.0	284.1	410.0	273.1	457.0	226.1	5.0	5.0	231.1	
100/10-35-079-09W4	10-35-079-09W4							396.0	285.2	407.0	274.2						
100/09-36-079-09W4	09-36-079-09W4							389.0	285.1	400.0	274.1						
100/12-02-079-10W4	12-02-079-10W4							394.0	265.2	402.0	257.2	454.0	205.2	6.0	6.0	211.2	
1AA/01-03-079-10W4	01-03-079-10W4							387.0	266.2	398.0	255.2	449.0	204.2	0.0	-5.0	204.2	
1AA/02-03-079-10W4	02-03-079-10W4							390.0	264.2	400.0	254.2	466.0	188.2	2.0	2.0	190.2	
100/12-03-079-10W4	12-03-079-10W4							399.0	268.9	409.0	258.9	469.0	198.9	0.0	-5.0	198.9	
1AA/09-04-079-10W4	09-04-079-10W4							401.0	262.7	410.0	253.7	468.0	195.7	2.0	2.0	197.7	
100/11-04-079-10W4	11-04-079-10W4							402.0	263.6	412.0	253.6	469.0	196.6	0.0	-5.0	196.6	
1AA/16-04-079-10W4	16-04-079-10W4							404.0	265.2	413.0	256.2	473.0	196.2	0.0	-5.0	196.2	
100/09-05-079-10W4	09-05-079-10W4							399.0	266.2	409.0	256.2	475.0	190.2	10.0	10.0	200.2	
1AA/12-05-079-10W4	12-05-079-10W4							409.0	265.1	420.0	254.1	475.0	199.1	0.0	-5.0	199.1	
1AA/16-05-079-10W4	16-05-079-10W4							404.0	263.9	413.0	254.9	477.0	190.9	10.0	10.0	200.9	
100/07-06-079-10W4	07-06-079-10W4							415.5	261.8	425.0	252.3	482.0	195.3	0.0	-5.0	195.3	
1AA/05-08-079-10W4	05-08-079-10W4							412.0	262.9	423.0	251.9	479.0	195.9	1.0	1.0	196.9	
1AA/13-08-079-10W4	13-08-079-10W4							412.0	262.6	422.0	252.6	478.0	196.6	2.0	2.0	198.6	
1AA/15-08-079-10W4	15-08-079-10W4							428.0	260.6	439.0	249.6	489.0	199.6	0.0	-5.0	199.6	
100/12-09-079-10W4	12-09-079-10W4							400.0	266.6	410.0	256.6	476.0	190.6	5.0	5.0	195.6	
1AA/13-09-079-10W4	13-09-079-10W4							419.0	266.0	429.0	256.0	489.0	196.0	7.0	7.0	203.0	
100/07-10-079-10W4	07-10-079-10W4							398.0	267.0	407.0	258.0	459.0	206.0	4.0	4.0	210.0	
100/06-11-079-10W4	06-11-079-10W4							400.0	268.4	410.0	258.4	459.0	209.4	0.0	-5.0	209.4	
100/10-12-079-10W4	10-12-079-10W4							383.0	275.3	394.0	264.3	448.5	209.8	0.0	-5.0	209.8	
100/07-13-079-10W4	07-13-079-10W4							398.5	277.3	409.0	266.8						
100/06-14-079-10W4	06-14-079-10W4							374.0	275.2	384.0	265.2						
100/07-14-079-10W4	07-14-079-10W4							383.0	265.7	392.0	256.7						
100/08-15-079-10W4	08-15-079-10W4							400.0	272.4	409.0	263.4	466.0	206.4	8.0	8.0	214.4	
1AA/16-15-079-10W4	16-15-079-10W4							407.0	268.8	417.0	258.8	468.0	207.8	2.0	2.0	209.8	
100/02-16-079-10W4	02-16-079-10W4							412.0	268.7	421.0	259.7	484.0	196.7	8.0	8.0	204.7	
100/01-17-079-10W4	01-17-079-10W4							423.0	266.2	433.0	256.2	492.0	197.2	4.0	4.0	201.2	
100/04-19-079-10W4	04-19-079-10W4							421.0	264.2	431.0	254.2	485.0	200.2	3.0	3.0	203.2	
100/15-22-079-10W4	15-22-079-10W4							413.0	271.8	423.0	261.8	481.0	203.8	5.0	5.0	208.8	
100/06-23-079-10W4	06-23-079-10W4							399.0	274.1	409.0	264.1	463.5	209.6	2.0	2.0	211.6	
1AA/09-23-079-10W4	09-23-079-10W4							402.0	276.2	412.0	266.2	482.0	196.2	0.0	-5.0	196.2	
100/03-24-079-10W4	03-24-079-10W4							406.0	274.5	416.0	264.5						
100/12-25-079-10W4	12-25-079-10W4							422.0	277.0	432.0	267.0						
100/07-26-079-10W4	07-26-079-10W4							414.0	268.8	424.0	258.8	473.0	209.8	0.0	-5.0	209.8	
100/15-26-079-10W4	15-26-079-10W4							423.0	271.5	432.0	262.5	488.0	206.5	4.5	4.5	211.0	
100/13-27-079-10W4	13-27-079-10W4							400.0	275.5	410.0	265.5	466.0	209.5	3.0	3.0	212.5	
100/10-28-079-10W4	10-28-079-10W4							393.0	273.5	402.0	264.5	458.0	208.5	3.0	3.0	211.5	
100/10-29-079-10W4	10-29-079-10W4							398.0	269.8	407.0	260.8	464.0	203.8	3.0	3.0	206.8	
100/02-31-079-10W4	02-31-079-10W4							404.0	275.6	414.0	265.6	469.0	210.6	0.0	-5.0	210.6	
1AA/04-31-079-10W4	04-31-079-10W4							413.0	273.7	424.0	262.7	477.0	209.7	0.0	-5.0	209.7	
1AA/15-31-079-10W4	15-31-079-10W4							404.0	272.1	415.0	261.1	468.0	208.1	0.0	-5.0	208.1	
100/05-32-079-10W4	05-32-079-10W4							414.0	260.6	423.0	251.6	472.0	202.6	0.0	-5.0	202.6	
1AA/07-32-079-10W4	07-32-079-10W4							414.0	259.6	422.0	251.6	472.0	201.6	0.0	-5.0	201.6	
1AA/02-33-079-10W4	02-33-079-10W4							402.0	269.6	413.0	258.6	478.0	193.6	4.0	4.0	197.6	
100/06-35-079-10W4	06-35-079-10W4							424.0	271.0	433.0	262.0	485.0	210.0	0.0	-5.0	210.0	
100/14-03-079-11W4	14-03-079-11W4							435.0	264.7	445.0	254.7	494.0	205.7	0.0	-5.0	205.7	

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Northing (m) NAD 27	Easting (m) NAD 27	KB (m asl)	TD (m)	Top Grand Rapids (m bKB)	Top Grand Rapids (m asl)	Grand Rapids Watersand Thickness (m)	Grand Rapids Watersand Top (m bKB)	Grand Rapids Watersand Top (m asl)	Grand Rapids Watersand Base (m bKB)	Grand Rapids Watersand Base (m asl)	Top Clearwater (m bKB)	Top Clearwater (m asl)	Upper Clearwater Watersand Thickness (m)	Middle Clearwater Watersand Thickness (m)	Upper Clearwater Watersand Thickness (Surfer) (m)	Middle Clearwater Watersand Thickness (Surfer) (m)	Upper Clearwater Watersand Top (m bKB)	Upper Clearwater Watersand Top (m asl)
100/16-06-079-11W4	16-06-079-11W4	6186313	455857	693.4	485.0	271.0	422.4	35.0	320.0	373.4	355.0	338.4	357.0	336.4	0.0	0.0	-5.0	-5.0		
100/10-07-079-11W4	10-07-079-11W4	6187533	455461	707.6	505.0	283.0	424.6	44.0	326.0	381.6	370.0	337.6	375.0	332.6	0.0	0.0	-5.0	-5.0		
100/11-08-079-11W4	11-08-079-11W4	6187520	456687	708.4	540.0	283.0	425.4	40.0	331.0	377.4	371.0	337.4	378.0	330.4	0.0	0.0	-5.0	-5.0		
100/11-09-079-11W4	11-09-079-11W4	6187504	458321	695.8	496.0			38.0	319.0	376.8	357.0	338.8	363.0	332.8	0.0	0.0	-5.0	-5.0		
100/09-10-079-11W4	09-10-079-11W4	6187481	460773	686.0	490.0	275.0	411.0	25.0	329.0	357.0	354.0	332.0	365.0	321.0	0.0	0.0	-5.0	-5.0		
100/12-14-079-11W4	12-14-079-11W4	6189097	461196	688.2	493.0	265.0	423.2	42.0	308.0	380.2	350.0	338.2	358.0	330.2	0.0	0.0	-5.0	-5.0		
100/13-15-079-11W4	13-15-079-11W4	6189517	459566	690.9	493.0	263.0	427.9	40.0	308.0	382.9	348.0	342.9	356.0	334.9	0.0	0.0	-5.0	-5.0		
100/15-16-079-11W4	15-16-079-11W4	6189525	458749	690.0	494.0	265.0	425.0	42.0	309.0	381.0	351.0	339.0	357.0	333.0	0.0	0.0	-5.0	-5.0		
100/10-17-079-11W4	10-17-079-11W4	6189136	457111	686.3	488.0	260.0	426.3	43.0	303.0	383.3	346.0	340.3	351.0	335.3	0.0	0.0	-5.0	-5.0		
100/14-18-079-11W4	14-18-079-11W4	6189562	455073	681.9	310.5	256.0	425.9													
100/09-20-079-11W4	09-20-079-11W4	6190752	457536	685.6	489.0	260.0	425.6	42.0	304.0	381.6	346.0	339.6	351.0	334.6	0.0	0.0	-5.0	-5.0		
100/12-21-079-11W4	12-21-079-11W4	6190748	457944	685.5	484.0	256.0	429.5	46.0	301.0	384.5	347.0	338.5	352.0	333.5	0.0	0.0	-5.0	-5.0		
100/11-22-079-11W4	11-22-079-11W4	6190728	459985	689.3	491.0	261.0	428.3	41.0	306.0	383.3	347.0	342.3	355.0	334.3	0.0	0.0	-5.0	-5.0		
100/06-24-079-11W4	06-24-079-11W4	6190294	463249	687.4	493.0	265.0	422.4	35.0	310.0	377.4	345.0	342.4	358.0	329.4	0.0	0.0	-5.0	-5.0		
100/01-25-079-11W4	01-25-079-11W4	6191503	464075	684.2	485.0	260.0	424.2	32.0	306.0	378.2	338.0	346.2	351.0	333.2	0.0	0.0	-5.0	-5.0		
100/09-26-079-11W4	09-26-079-11W4	6192326	462449	687.2	485.0	257.0	430.2	35.0	300.0	387.2	335.0	352.2	352.0	335.2	0.0	0.0	-5.0	-5.0		
1AA/15-26-079-11W4	15-26-079-11W4	6192735	462045	691.0	485.9	266.0	425.0	39.5	308.5	382.5	348.0	343.0	360.0	331.0	0.0	0.0	-5.0	-5.0		
100/11-27-079-11W4	11-27-079-11W4	6192348	460000	689.4	490.0	260.0	429.4	43.0	305.5	383.9	348.5	340.9	356.0	333.4	0.0	0.0	-5.0	-5.0		
100/09-28-079-11W4	09-28-079-11W4	6192356	459184	688.6	486.0	259.0	429.6	43.0	304.0	384.6	347.0	341.6	355.0	333.6	0.0	0.0	-5.0	-5.0		
100/10-29-079-11W4	10-29-079-11W4	6192376	457143	688.8	490.0	261.0	427.8	44.0	305.0	383.8	349.0	339.8	353.0	335.8	0.0	0.0	-5.0	-5.0		
100/11-29-079-11W4	11-29-079-11W4	6192380	456735	693.6	500.0	262.0	431.6	45.0	307.0	386.6	352.0	341.6	356.0	337.6	0.0	0.0	-5.0	-5.0		
1AA/15-30-079-11W4	15-30-079-11W4	6192797	455515	693.1	490.4	264.0	429.1	46.0	310.0	383.1	356.0	337.1	356.0	337.1	0.0	0.0	-5.0	-5.0		
102/16-30-079-11W4	16-30-079-11W4	6192793	455923	693.5	475.0	263.0	430.5	45.0	307.0	386.5	352.0	341.5	355.0	338.5	0.0	0.0	-5.0	-5.0		
100/11-31-079-11W4	11-31-079-11W4	6194016	455119	691.7	509.5	263.5	428.2	36.0	314.0	377.7	350.0	341.7	356.0	335.7	0.0	0.0	-5.0	-5.0		
100/13-32-079-11W4	13-32-079-11W4	6194409	456347	689.5	491.0	259.0	430.5	46.0	303.0	386.5	349.0	340.5	353.0	336.5	0.0	0.0	-5.0	-5.0		
100/13-33-079-11W4	13-33-079-11W4	6194392	457979	687.2	490.0	257.0	430.2	41.5	303.5	383.7	345.0	342.2	351.0	336.2	0.0	0.0	-5.0	-5.0		
100/12-36-079-11W4	12-36-079-11W4	6193943	462872	686.0	502.0	258.0	428.0	40.0	301.0	385.0	341.0	345.0	352.0	334.0	0.0	0.0	-5.0	-5.0		
100/14-05-079-12W400	14-05-079-12W4	6186522	446845	684.3	474.9	271.0	413.3	35.0	317.0	367.3	352.0	332.3	355.0	329.3	0.0	0.0	-5.0	-5.0		
100/16-06-079-12W400	16-06-079-12W4	6186491	445822	691.5	511.0	276.0	415.5	39.0	322.0	369.5	361.0	330.5	364.1	327.5	0.0	1.0	-5.0	1.0		
100/10-07-079-12W400	10-07-079-12W4	6187690	445722	708.0	518.0	291.7	416.3	40.0	339.0	369.0	379.0	329.0	381.7	326.3	0.0	0.0	-5.0	-5.0		
100/04-08-079-12W400	04-08-079-12W4	6187228	446598	693.4	508.0	278.1	415.3	38.0	325.0	368.4	363.0	330.4	365.9	327.5	0.0	0.0	-5.0	-5.0		
100/10-14-079-12W400	10-14-079-12W4	6189352	452161	681.6	475.0	256.0	425.6	31.0	307.0	374.6	338.0	343.6	348.9	332.7	0.0	0.0	-5.0	-5.0		
100/11-16-079-12W400	11-16-079-12W4	6189373	448513	688.4	480.0	270.1	418.3	27.0	317.0	371.4	344.0	344.4	354.5	333.9	0.0	0.0	-5.0	-5.0		
100/13-16-079-12W400	13-16-079-12W4	6189913	448237	685.0	463.0	266.6	418.4	33.0	317.0	368.0	350.0	335.0	353.5	331.5	0.0	0.0	-5.0	-5.0		
100/04-17-079-12W400	04-17-079-12W4	6188838	446625	691.0	494.0	274.9	416.1	29.0	324.0	367.0	353.0	338.0	364.2	326.8	0.0	0.0	-5.0	-5.0		
100/11-18-079-12W400	11-18-079-12W4	6189691	445031	711.3	526.0	295.0	416.3	38.0	345.0	366.3	383.0	328.3	387.2	324.1	0.0	0.0	-5.0	-5.0		
100/13-20-079-12W400	13-20-079-12W4	6191367	446540	687.3	497.0	266.8	420.5	28.0	318.0	369.3	346.0	341.3	359.4	327.9	0.0	0.0	-5.0	-5.0		
100/15-21-079-12W400	15-21-079-12W4	6191381	448883	685.7	472.0	263.8	421.9	45.0	306.0	379.7	351.0	334.7	354.0	331.7	0.0	0.0	-5.0	-5.0		
100/07-22-079-12W400	07-22-079-12W4	6190516	450390	692.3	475.0	269.9	422.4						357.4	334.9						
100/12-23-079-12W400	12-23-079-12W4	6190967	451545	686.5	452.0	263.5	423.0	40.0	310.0	376.5	350.0	336.5	352.4	334.1	0.0	0.0	-5.0	-5.0		
100/11-24-079-12W400	11-24-079-12W4	6191030	453406	695.8	496.0	270.3	425.5	32.0	319.0	376.8	351.0	344.8	361.9	333.9	0.0	0.0	-5.0	-5.0		
100/07-25-079-12W400	07-25-079-12W4	6192071	453881	688.7	488.0	257.7	431.0	43.0	304.0	384.7	347.0	341.7	351.2	337.5	0.0	0.0	-5.0	-5.0		
100/04-26-079-12W400	04-26-079-12W4	6191993	451495	687.2	453.0	259.2	428.0	39.0	309.0	378.2	348.0	339.2	351.0	336.2	0.0	0.0	-5.0	-5.0		
100/05-27-079-12W400	05-27-079-12W4	6192209	449802	685.9	462.0	258.8	427.2	31.0	309.0	376.9	340.0	345.9	351.9	334.1	0.0	0.0	-5.0	-5.0		
100/07-28-079-12W400	07-28-079-12W4	6192198	449096	687.8	496.0	262.6	425.2	45.0	308.0	379.8	353.0	334.8	356.5	331.3	0.0	0.0	-5.0	-5.0		
100/07-29-079-12W400	07-29-079-12W4	6192224	447161	686.7	487.0	270.0	416.7	17.0	330.0	356.7	347.0	339.7	358.2	328.5	0.0	0.0	-5.0	-5.0		
100/07-30-079-12W400	07-30-079-12W4	6192264	445852	686.7	495.5	265.9	420.8	28.0	319.0	367.7	347.0	339.7	360.6	326.1	0.0	0.0	-5.0	-5.0		
100/06-31-079-12W400	06-31-079-12W4	6194140	445427	685.3	500.0	264.2	421.1	37.0	319.0	366.3	356.0	329.3	358.4	326.9	0.0	0.0	-5.0	-5.0		
100/11-32-079-12W400	11-32-079-12W4	6194277	446706	687.9	502.0	266.2	421.7	27.0	321.0	366.9	348.0	339.9	360.4	327.5	0.0	0.0	-5.0	-5.0		
100/15-32-079-12W400	15-32-079-12W4	6194576	447281	689.0	513.0	267.4	421.6	34.0	326.0	363.0	360.0	329.0	361.9	327.1	0.0	0.0	-5.0	-5.0		
100/11-35-079-12W400	11-35-079-12W4	6194267	451804	685.4	513.0	256.2	429.2	33.0	307.0	378.4	340.0	345.4	351.3	334.1	0.0	0.0	-5.0	-5.0		
100/10-36-079-12W400	10-36-079-12W4	6194458	453949	684.8	496.0	259.2	425.6	37.0	305.0	379.8	342.0	342.8	353.9	330.9	0.0	0.0	-5.0	-5.0		
100/15-36-079-12W400	15-36-079-12W4	6194487	453973	688.0	484.0	259.3	428.7	47.0	304.0	384.0	351.0	337.0	353.8	334.2	0.0	0.0	-5.0	-5.0		
100/07-01-079-13W400	07-01-079-13W4	6186035	444040	682.8	499.9	273.1	409.7	37.0	317.0	365.8	354.0	328.8	358.7	324.1	0.0	0.0	-5.0	-5.0		
100/07-02-079-13W400	07-02-079-13W4	6186110	442118	681.5	496.0	270.6	410.9	39.0	319.0	362.5	358.0	323.5	360.7	320.8	0.0	0.0	-5.0	-5.0		
100/07-03-079-13W400	07-03-079-13W4	6186130	440660	680.4	494.0	273.5	406.9	38.0	321.0	359.4	359.0	321.4	362.4	318.0	0.0	0.0	-5.0	-5.0		

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Upper Clearwater Watersand Base (m bKB)	Upper Clearwater Watersand Base (m asl)	Middle Clearwater Watersand Top (m bKB)	Middle Clearwater Watersand Top (m asl)	Middle Clearwater Watersand Base (m bKB)	Middle Clearwater Watersand Base (m asl)	Top Wabiskaw (m bKB)	Top Wabiskaw (m asl)	Top McMurray (m bKB)	Top McMurray (m asl)	Paleo Surface (m bKB)	Paleo Surface (m asl)	Watersand Thickness (m)	Watersand Thickness (Surfer) (m)	Watersand Surface Elevation (m asl)	Log Analysis Notes:
100/16-06-079-11W4	16-06-079-11W4							424.0	269.4	434.0	259.4						
100/10-07-079-11W4	10-07-079-11W4							443.0	264.6	453.0	254.6						
100/11-08-079-11W4	11-08-079-11W4							445.0	263.4	458.0	250.4						
100/11-09-079-11W4	11-09-079-11W4							430.0	265.8	443.0	252.8						
100/09-10-079-11W4	09-10-079-11W4							431.0	255.0	441.0	245.0						
100/12-14-079-11W4	12-14-079-11W4							422.0	266.2	434.0	254.2	485.0	203.2	3.0	3.0	206.2	
100/13-15-079-11W4	13-15-079-11W4							420.0	270.9	433.0	257.9	487.0	203.9	0.0	-5.0	203.9	
100/15-16-079-11W4	15-16-079-11W4							422.0	268.0	434.0	256.0						
100/10-17-079-11W4	10-17-079-11W4							418.0	268.3	432.0	254.3	481.0	205.3	0.0	-5.0	205.3	
100/14-18-079-11W4	14-18-079-11W4																
100/09-20-079-11W4	09-20-079-11W4							416.0	269.6	426.0	259.6						
100/12-21-079-11W4	12-21-079-11W4							418.0	267.5	432.0	253.5						
100/11-22-079-11W4	11-22-079-11W4							418.5	270.8	432.0	257.3	484.0	205.3	0.0	-5.0	205.3	
100/06-24-079-11W4	06-24-079-11W4							422.0	265.4	434.0	253.4	484.0	203.4	3.0	3.0	206.4	
100/01-25-079-11W4	01-25-079-11W4							412.5	271.7	424.0	260.2	477.0	207.2	4.0	4.0	211.2	
100/09-26-079-11W4	09-26-079-11W4							412.0	275.2	424.0	263.2	478.0	209.2	0.0	-5.0	209.2	
1AA/15-26-079-11W4	15-26-079-11W4							423.0	268.0	434.0	257.0						
100/11-27-079-11W4	11-27-079-11W4							418.0	271.4	432.0	257.4						
100/09-28-079-11W4	09-28-079-11W4							418.0	270.6	432.0	256.6	481.0	207.6	0.0	-5.0	207.6	
100/10-29-079-11W4	10-29-079-11W4							416.0	272.8	430.0	258.8						
100/11-29-079-11W4	11-29-079-11W4							419.0	274.6	433.0	260.6	487.0	206.6	0.0	-5.0	206.6	
1AA/15-30-079-11W4	15-30-079-11W4							424.0	269.1	438.0	255.1						
102/16-30-079-11W4	16-30-079-11W4							419.0	274.5	432.0	261.5						
100/11-31-079-11W4	11-31-079-11W4							420.5	271.2	432.0	259.7	488.0	203.7	0.0	-5.0	203.7	
100/13-32-079-11W4	13-32-079-11W4							417.0	272.5	426.0	263.5						
100/13-33-079-11W4	13-33-079-11W4							414.0	273.2	424.0	263.2	479.0	208.2	0.0	-5.0	208.2	
100/12-36-079-11W4	12-36-079-11W4							416.0	270.0	430.0	256.0	477.0	209.0	0.0	-5.0	209.0	
100/14-05-079-12W400	14-05-079-12W4							428.0	256.3	437.0	247.3	469.0	215.3	0.0	-5.0	215.3	
100/16-06-079-12W400	16-06-079-12W4			409.0	282.5	410.0	281.5	436.3	255.2	445.8	245.7	490.7	200.8	6.0	6.0	206.8	
100/10-07-079-12W400	10-07-079-12W4							452.7	255.3	466.8	241.2	507.2	200.8	4.9	4.9	205.7	
100/04-08-079-12W400	04-08-079-12W4							436.6	256.8	446.3	247.1	491.5	201.9	3.9	3.9	205.9	
100/10-14-079-12W400	10-14-079-12W4							418.4	263.2	430.5	251.1	453.7	227.9	0.0	-5.0	227.9	
100/11-16-079-12W400	11-16-079-12W4							423.2	265.2	433.0	255.5	454.6	233.8	0.0	-5.0	233.8	
100/13-16-079-12W400	13-16-079-12W4							421.9	263.1	434.8	250.2						
100/04-17-079-12W400	04-17-079-12W4							434.0	257.0	447.4	243.6	488.8	202.2	5.0	5.0	207.2	
100/11-18-079-12W400	11-18-079-12W4							456.7	254.6	467.4	244.0	514.2	197.1	3.0	3.0	200.1	
100/13-20-079-12W400	13-20-079-12W4							426.4	260.9	440.5	246.9	486.4	200.9	13.4	13.4	214.3	
100/15-21-079-12W400	15-21-079-12W4							421.5	264.2	434.7	251.0	462.5	223.2	0.0	-5.0	223.2	
100/07-22-079-12W400	07-22-079-12W4							423.6	268.7	435.4	256.9	455.7	236.6	0.0	-5.0	236.6	gamma ran high
100/12-23-079-12W400	12-23-079-12W4							418.0	268.5	429.8	256.7	450.7	235.8	0.0	-5.0	235.8	
100/11-24-079-12W400	11-24-079-12W4							428.9	266.9	443.1	252.7	484.0	211.8	0.0	-5.0	211.8	
100/07-25-079-12W400	07-25-079-12W4							419.1	269.6	430.7	258.0	479.2	209.6	2.0	2.0	211.6	
100/04-26-079-12W400	04-26-079-12W4							417.2	270.0	430.8	256.4						
100/05-27-079-12W400	05-27-079-12W4							418.6	267.3	433.0	252.9	456.3	229.6	0.0	-5.0	229.6	
100/07-28-079-12W400	07-28-079-12W4							423.9	263.9	433.6	254.2	470.5	217.3	0.0	-5.0	217.3	
100/07-29-079-12W400	07-29-079-12W4							423.9	262.8	433.9	252.8	481.3	205.4	2.3	2.3	207.7	
100/07-30-079-12W400	07-30-079-12W4							427.6	259.1	437.2	249.6	484.2	202.5	7.4	7.4	209.9	
100/06-31-079-12W400	06-31-079-12W4							423.9	261.4	436.1	249.2	484.0	201.3	8.0	8.0	209.3	
100/11-32-079-12W400	11-32-079-12W4							425.4	262.5	438.2	249.7	485.9	202.0	15.4	15.4	217.4	
100/15-32-079-12W400	15-32-079-12W4							426.2	262.9	439.6	249.4	486.2	202.8	15.0	15.0	217.8	
100/11-35-079-12W400	11-35-079-12W4							416.8	268.6	430.8	254.6	475.0	210.4	0.0	-5.0	210.4	
100/10-36-079-12W400	10-36-079-12W4							417.4	267.4	429.9	254.9	480.0	204.8	1.0	1.0	205.8	
100/15-36-079-12W400	15-36-079-12W4							418.0	270.0	432.4	255.6	480.8	207.2	0.0	-5.0	207.2	
100/07-01-079-13W400	07-01-079-13W4							432.1	250.7	442.0	240.8	488.0	194.8	3.7	3.7	198.5	
100/07-02-079-13W400	07-02-079-13W4							434.9	246.6	449.0	232.5						
100/07-03-079-13W400	07-03-079-13W4							435.5	244.9	449.3	231.2						

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Northing (m) NAD 27	Easting (m) NAD 27	KB (m asl)	TD (m)	Top Grand Rapids (m bKB)	Top Grand Rapids (m asl)	Grand Rapids Watersand Thickness (m)	Grand Rapids Watersand Top (m bKB)	Grand Rapids Watersand Top (m asl)	Grand Rapids Watersand Base (m bKB)	Grand Rapids Watersand Base (m asl)	Top Clearwater (m bKB)	Top Clearwater (m asl)	Upper Clearwater Watersand Thickness (m)	Middle Clearwater Watersand Thickness (m)	Upper Clearwater Watersand Thickness (Surfer) (m)	Middle Clearwater Watersand Thickness (Surfer) (m)	Upper Clearwater Watersand Top (m bKB)	Upper Clearwater Watersand Top (m asl)
100/08-04-079-13W400	08-04-079-13W4	6186149	439257	681.5	520.0	271.9	409.6	38.0	322.0	359.5	360.0	321.5	362.4	319.1	0.0	0.0	-5.0	-5.0		
100/07-05-079-13W400	07-05-079-13W4	6186177	437408	685.0	510.6	276.2	408.8	32.0	327.0	358.0	359.0	326.0	366.9	318.1	0.0	0.0	-5.0	-5.0		
100/06-06-079-13W400	06-06-079-13W4	6186200	435369	693.6	520.0	284.6	409.0	36.0	337.0	356.6	373.0	320.6	375.7	318.0	0.0	0.0	-5.0	-5.0		
100/05-07-079-13W400	05-07-079-13W4	6187564	435107	691.1	524.0	281.4	409.8	34.0	335.0	356.1	369.0	322.1	370.5	320.6	0.0	0.0	-5.0	-5.0		
100/06-09-079-13W400	06-09-079-13W4	6187675	438497	683.0	511.0	273.0	410.0	36.0	321.0	362.0	357.0	326.0	358.0	325.0	0.0	0.0	-5.0	-5.0		
100/08-10-079-13W400	08-10-079-13W4	6187694	441283	684.8	516.0	272.6	412.2	37.0	324.0	360.8	361.0	323.8	363.6	321.3	0.0	13.0	-5.0	13.0		
100/01-11-079-13W400	01-11-079-13W4	6187258	442590	694.5	505.5	282.6	411.9	37.0	333.0	361.5	370.0	324.5	373.5	321.0	0.0	0.0	-5.0	-5.0		
100/14-12-079-13W400	14-12-079-13W4	6188244	443598	710.7	526.0	303.2	407.6	37.0	348.0	362.7	385.0	325.7	388.5	322.3	0.0	0.0	-5.0	-5.0		
100/10-13-079-13W400	10-13-079-13W4	6189658	444140	712.0	520.0	296.3	415.7	39.0	345.0	367.0	384.0	328.0	387.1	325.0	0.0	0.0	-5.0	-5.0		
102/10-13-079-13W400	10-13-079-13W4	6189687	444157	712.3	524.0	297.4	414.9	40.0	346.0	366.3	386.0	326.3	388.1	324.2	0.0	0.0	-5.0	-5.0		
100/05-14-079-13W400	05-14-079-13W4	6189072	441465	691.2	511.0	277.4	413.8	28.0	330.0	361.2	358.0	333.2	368.2	323.0	0.0	0.0	-5.0	-5.0		
100/11-15-079-13W400	11-15-079-13W4	6189632	440252	683.4	492.0	270.1	413.3	37.0	320.0	363.4	357.0	326.4	360.1	323.3	0.0	0.0	-5.0	-5.0		
100/01-17-079-13W400	01-17-079-13W4	6188804	437864	696.2	514.0	282.9	413.3	29.0	341.0	355.2	370.0	326.2	372.4	323.8	0.0	0.0	-5.0	-5.0		
100/16-18-079-13W400	16-18-079-13W4	6189973	436419	685.0	523.0	274.0	411.0	36.0	324.0	361.0	360.0	325.0	362.9	322.1	0.0	0.0	-5.0	-5.0		
100/12-20-079-13W400	12-20-079-13W4	6191088	436828	688.6	510.0	284.2	404.5	35.0	326.0	362.6	361.0	327.6	363.3	325.3	0.0	0.0	-5.0	-5.0		
100/10-21-079-13W400	10-21-079-13W4	6191047	439255	694.4	514.0	279.4	415.0	34.0	331.0	363.4	365.0	329.4	369.0	325.4	0.0	0.0	-5.0	-5.0		
100/05-22-079-13W400	05-22-079-13W4	6190700	440055	685.3	501.0	270.8	414.5	37.0	324.0	361.3	361.0	324.3	362.9	322.4	0.0	0.0	-5.0	-5.0		
100/14-25-079-13W400	14-25-079-13W4	6193062	443649	685.6	495.0	264.9	420.7	38.0	319.0	366.6	357.0	328.6	358.9	326.7	0.0	0.0	-5.0	-5.0		
100/04-26-079-13W400	04-26-079-13W4	6192118	441712	684.5	497.2	268.6	415.9	30.0	320.0	364.5	350.0	334.5	359.0	325.6	0.0	0.0	-5.0	-5.0		
100/09-27-079-13W400	09-27-079-13W4	6192748	441069	683.1	500.0	266.1	417.0	36.0	319.0	364.1	355.0	328.1	357.0	326.1	0.0	0.0	-5.0	-5.0		
100/07-28-079-13W400	07-28-079-13W4	6192273	438946	689.9	487.0	277.1	412.8	36.0	326.0	363.9	362.0	327.9	363.0	326.9	0.0	0.0	-5.0	-5.0		
100/02-29-079-13W400	02-29-079-13W4	6191988	437475	699.0	503.5	290.4	408.6	34.0	336.0	363.0	370.0	329.0	371.4	327.6	0.0	0.0	-5.0	-5.0		
100/07-30-079-13W400	07-30-079-13W4	6192585	436017	694.7	506.0	280.1	414.7	14.0	332.0	362.7	346.0	348.7	368.0	326.7	0.0	0.0	-5.0	-5.0		
100/05-31-079-13W400	05-31-079-13W4	6193959	435062	697.3	510.0	282.9	414.5	17.0	335.0	362.3	352.0	345.3	372.3	325.0	0.0	0.0	-5.0	-5.0		
100/01-34-079-13W400	01-34-079-13W4	6193626	441056	685.9	505.0	268.6	417.3	37.0	320.0	365.9	357.0	328.9	360.2	325.7	0.0	0.0	-5.0	-5.0		
100/02-34-079-13W400	02-34-079-13W4	6193643	440723	685.0	495.0	268.9	416.1	37.0	320.0	365.0	357.0	328.0	359.4	325.6	0.0	0.0	-5.0	-5.0		
100/13-35-079-13W400	13-35-079-13W4	6194614	441764	687.3	485.0	267.4	420.0	20.0	320.0	367.3	340.0	347.3	361.6	325.7	0.0	0.0	-5.0	-5.0		
100/12-36-079-13W400	12-36-079-13W4	6194465	443439	686.6	480.0	267.7	418.9	37.0	322.0	364.6	359.0	327.6	360.6	326.0	0.0	0.0	-5.0	-5.0		
100/10-04-079-14 W4/00	10-04-079-14 W4	6186283	429278	698.4	510.3	295.0	403.4	36.0	347.0	351.4	383.0	315.4	385.0	313.4	0.0	0.0	-5.0	-5.0		
100/14-07-079-14 W4/00	14-07-079-14 W4	6188355	425637	687.7	505.0	286.0	401.7	12.0	340.0	347.7	352.0	335.7	373.0	314.7	1.0	0.0	1.0	-5.0	394.0	293.7
100/16-11-079-14 W4/00	16-11-079-14 W4	6188236	432984	689.5	509.0	284.0	405.5	39.0	331.0	358.5	370.0	319.5	371.0	318.5	0.0	0.0	-5.0	-5.0		
1AA/10-29-079-14 W4/00	10-29-079-14 W4	6192785	427750	684.4	506.8	276.0	408.4						370.0	314.4						
100/04-34-079-14 W4/00	04-34-079-14 W4	6193548	430223	705.5	554.0	295.0	410.5	23.0	346.0	359.5	369.0	336.5	388.0	317.5	0.0	0.0	-5.0	-5.0		
100/01-12-079-14W400	01-12-079-14W4	6187352	434438	692.0	521.0	281.8	410.2	35.0	333.0	359.0	368.0	324.0	370.7	321.3	0.0	0.0	-5.0	-5.0		
100/07-13-079-14W400	07-13-079-14W4	6189099	434337	691.1	499.0	281.1	410.0	31.0	333.0	358.1	364.0	327.1	369.1	322.1	0.0	0.0	-5.0	-5.0		
100/15-13-079-14W400	15-13-079-14W4	6190038	434292	690.4	504.0	283.6	406.8	40.0	331.0	359.4	371.0	319.4	373.0	317.4	0.0	0.0	-5.0	-5.0		
100/07-24-079-14W400	07-24-079-14W4	6190804	434241	690.6	496.0	280.9	409.8	20.0	331.0	359.6	351.0	339.6	368.2	322.4	0.0	0.0	-5.0	-5.0		
100/12-25-079-14W400	12-25-079-14W4	6192951	433239	698.6	507.0	287.5	411.1	19.0	338.0	360.6	357.0	341.6	377.4	321.2	0.0	0.0	-5.0	-5.0		
100/08-36-079-14W400	08-36-079-14W4	6193948	434488	700.5	448.0	288.2	412.3	19.0	337.0	363.5	356.0	344.5	378.8	321.7	0.0	0.0	-5.0	-5.0		
100/07-01-080-06 W4/00	07-01-080-06 W4	6195038	512664	466.7	293.0								124.0	342.7	0.0	0.0	-5.0	-5.0		
100/03-02-080-06 W4/00	03-02-080-06 W4	6194631	510629	500.4	326.0			25.0	131.0	369.4	156.0	344.4	160.0	340.4	0.0	0.0	-5.0	-5.0		
100/10-02-080-06 W4/00	10-02-080-06 W4	6195436	511030	493.1	317.0	67.0	426.1	22.0	128.0	365.1	150.0	343.1	156.0	337.1	0.0	0.0	-5.0	-5.0		
100/07-04-080-06 W4/00	07-04-080-06 W4	6195027	507767	560.4	377.0	133.0	427.4	24.0	192.0	368.4	216.0	344.4	216.0	344.4	0.0	0.0	-5.0	-5.0		
100/07-06-080-06 W4/00	07-06-080-06 W4	6195022	504502	556.0	380.0	131.0	425.0	23.0	188.0	368.0	211.0	345.0	211.0	345.0	0.0	0.0	-5.0	-5.0		
100/10-07-080-06 W4/00	10-07-080-06 W4	6197033	504500	560.5	368.8	132.0	428.5	21.0	195.0	365.5	216.0	344.5	216.0	344.5	0.0	0.0	-5.0	-5.0		
100/11-09-080-06 W4/00	11-09-080-06 W4	6197037	507360	571.8	381.0	143.0	428.8	23.0	206.0	365.8	229.0	342.8	232.0	339.8	0.0	0.0	-5.0	-5.0		
100/07-14-080-06 W4/00	07-14-080-06 W4	6198271	511023	506.4	324.5	76.0	430.4	18.0	141.0	365.4	159.0	347.4	163.0	343.4	0.0	0.0	-5.0	-5.0		
100/11-16-080-06 W4/00	11-16-080-06 W4	6198666	507358	584.2	399.0	158.0	426.2	22.0	224.0	360.2	246.0	338.2	246.0	338.2	0.0	0.0	-5.0	-5.0		
100/11-18-080-06 W4/00	11-18-080-06 W4	6198661	504096	573.2	381.0	142.0	431.2	23.0	204.0	369.2	227.0	346.2	227.0	346.2	0.0	0.0	-5.0	-5.0		
100/11-19-080-06 W4/00	11-19-080-06 W4	6200270	504094	570.5	381.0	138.0	432.5	28.0	198.0	372.5	226.0	344.5	227.0	343.5	0.0	0.0	-5.0	-5.0		
100/06-22-080-06 W4/00	06-22-080-06 W4	6199875	508986	574.8	395.0	150.0	424.8	24.0	209.0	365.8	233.0	341.8	233.0	341.8	0.0	0.0	-5.0	-5.0		
100/13-24-080-06 W4/00	13-24-080-06 W4	6200687	511842	483.1	295.0			21.0	120.0	363.1	141.0	342.1	144.0	339.1	0.0	0.0	-5.0	-5.0		
100/07-25-080-06 W4/00	07-25-080-06 W4	6201513	512645	488.9	306.0								142.0	346.9						
100/13-25-080-06 W4/00	13-25-080-06 W4	6202315	511838	479.4	292.0			19.0	114.0	365.4	133.0	346.4	136.0	343.4	0.0	0.0	-5.0	-5.0		
100/15-26-080-06 W4/00	15-26-080-06 W4	6202313	511013	479.1	296.0								132.0	347.1						

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Upper Clearwater Watersand Base (m bKB)	Upper Clearwater Watersand Base (m asl)	Middle Clearwater Watersand Top (m bKB)	Middle Clearwater Watersand Top (m asl)	Middle Clearwater Watersand Base (m bKB)	Middle Clearwater Watersand Base (m asl)	Top Wabiskaw (m bKB)	Top Wabiskaw (m asl)	Top McMurray (m bKB)	Top McMurray (m asl)	Paleo Surface (m bKB)	Paleo Surface (m asl)	Watersand Thickness (m)	Watersand Thickness (Surfer) (m)	Watersand Surface Elevation (m asl)	Log Analysis Notes:
100/08-04-079-13W400	08-04-079-13W4							436.5	245.0	445.8	235.7	500.2	181.4	0.0	-5.0	181.4	
100/07-05-079-13W400	07-05-079-13W4							439.7	245.3	449.5	235.5	505.2	179.8	0.0	-5.0	179.8	
100/06-06-079-13W400	06-06-079-13W4							448.4	245.2	458.4	235.2	506.6	187.0	0.0	-5.0	187.0	
100/05-07-079-13W400	05-07-079-13W4							442.1	249.0	453.3	237.8	505.1	186.0	0.0	-5.0	186.0	
100/06-09-079-13W400	06-09-079-13W4							432.0	251.0	442.0	241.0	498.0	185.0	8.1	8.1	193.1	
100/08-10-079-13W400	08-10-079-13W4			405.0	279.8	418.0	266.8	434.5	250.3	443.8	241.1	496.2	188.6	7.1	7.1	195.8	
100/01-11-079-13W400	01-11-079-13W4							446.7	247.9	456.3	238.2						
100/14-12-079-13W400	14-12-079-13W4							460.6	250.1	470.2	240.5	518.1	192.6	0.0	-5.0	192.6	
100/10-13-079-13W400	10-13-079-13W4							457.7	254.3	467.6	244.4	515.7	196.4	0.0	-5.0	196.4	
102/10-13-079-13W400	10-13-079-13W4							458.6	253.7	469.7	242.6	516.7	195.6	0.0	-5.0	195.6	
100/05-14-079-13W400	05-14-079-13W4							439.5	251.7	452.2	239.0	500.5	190.7	1.0	1.0	191.7	
100/11-15-079-13W400	11-15-079-13W4							432.2	251.2	442.9	240.5						
100/01-17-079-13W400	01-17-079-13W4							443.6	252.7	456.3	239.9	507.0	189.2	0.0	-5.0	189.2	
100/16-18-079-13W400	16-18-079-13W4							434.0	251.0	446.0	239.0	502.0	183.0	0.0	-5.0	183.0	
100/12-20-079-13W400	12-20-079-13W4							434.8	253.8	449.4	239.2						
100/10-21-079-13W400	10-21-079-13W4							438.0	256.4	451.6	242.8	503.0	191.5	0.0	-5.0	191.5	
100/05-22-079-13W400	05-22-079-13W4							434.6	250.7	447.7	237.6						
100/14-25-079-13W400	14-25-079-13W4							424.2	261.4	434.0	251.6	484.3	201.3	8.5	8.5	209.8	
100/04-26-079-13W400	04-26-079-13W4							426.5	258.0	435.6	249.0	487.9	196.6	8.3	8.3	205.0	
100/09-27-079-13W400	09-27-079-13W4							423.1	260.0	432.0	251.1	487.3	195.8	0.0	-5.0	195.8	
100/07-28-079-13W400	07-28-079-13W4							434.2	255.7	445.6	244.3						
100/02-29-079-13W400	02-29-079-13W4							442.7	256.3	455.4	243.6	501.0	198.0	5.0	5.0	203.0	
100/07-30-079-13W400	07-30-079-13W4							438.7	256.0	451.7	243.1	504.7	190.0	0.0	-5.0	190.0	
100/05-31-079-13W400	05-31-079-13W4							441.1	256.2	453.0	244.3	504.3	193.0	0.0	-5.0	193.0	
100/01-34-079-13W400	01-34-079-13W4							426.3	259.6	438.1	247.8	485.0	201.0	0.0	-5.0	201.0	
100/02-34-079-13W400	02-34-079-13W4							425.6	259.4	437.8	247.2	486.3	198.7	1.0	1.0	199.7	
100/13-35-079-13W400	13-35-079-13W4							426.2	261.1	438.3	249.0						
100/12-36-079-13W400	12-36-079-13W4							425.6	261.0	439.1	247.5						
100/10-04-079-14 W4/00	10-04-079-14 W4							460.0	238.4	470.0	228.4	506.0	192.4	0.0	-5.0	192.4	
100/14-07-079-14 W4/00	14-07-079-14 W4	395.0	292.7					448.0	239.7	457.0	230.7	501.0	186.7	0.0	-5.0	186.7	
100/16-11-079-14 W4/00	16-11-079-14 W4							445.0	244.5	454.0	235.5	501.0	188.5	4.0	4.0	192.5	
1AA/10-29-079-14 W4/00	10-29-079-14 W4							440.0	244.4	450.0	234.4	493.0	191.4	0.0	-5.0	191.4	no gamma or porosity through GDRD and CLWT
100/04-34-079-14 W4/00	04-34-079-14 W4							457.0	248.5	465.0	240.5	512.0	193.5	0.0	-5.0	193.5	
100/01-12-079-14W400	01-12-079-14W4							442.3	249.7	453.2	238.8	505.9	186.1	7.9	7.9	194.0	
100/07-13-079-14W400	07-13-079-14W4							442.2	248.9	454.2	236.9						
100/15-13-079-14W400	15-13-079-14W4							444.6	245.8	457.4	233.0						
100/07-24-079-14W400	07-24-079-14W4							439.4	251.2	452.5	238.1						
100/12-25-079-14W400	12-25-079-14W4							447.9	250.8	461.0	237.6						
100/08-36-079-14W400	08-36-079-14W4																
100/07-01-080-06 W4/00	07-01-080-06 W4							192.0	274.7	205.0	261.7	277.0	189.7	8.0	8.0	197.7	
100/03-02-080-06 W4/00	03-02-080-06 W4							224.0	276.4	237.0	263.4	311.0	189.4	21.0	21.0	210.4	
100/10-02-080-06 W4/00	10-02-080-06 W4							221.0	272.1	234.0	259.1	307.0	186.1	10.0	10.0	196.1	
100/07-04-080-06 W4/00	07-04-080-06 W4							281.0	279.4	295.0	265.4	361.0	199.4	20.0	20.0	219.4	
100/07-06-080-06 W4/00	07-06-080-06 W4							280.0	276.0	291.0	265.0	356.0	200.0	13.0	13.0	213.0	
100/10-07-080-06 W4/00	10-07-080-06 W4							283.0	277.5	295.0	265.5	361.0	199.5	0.0	-5.0	199.5	
100/11-09-080-06 W4/00	11-09-080-06 W4							294.0	277.8	307.0	264.8	370.0	201.8	21.0	21.0	222.8	
100/07-14-080-06 W4/00	07-14-080-06 W4							227.0	279.4	240.0	266.4	314.0	192.4	34.0	34.0	226.4	
100/11-16-080-06 W4/00	11-16-080-06 W4									324.0	260.2	387.0	197.2	0.0	-5.0	197.2	
100/11-18-080-06 W4/00	11-18-080-06 W4							296.0	277.2	311.0	262.2	368.0	205.2	6.0	6.0	211.2	
100/11-19-080-06 W4/00	11-19-080-06 W4							291.0	279.5	304.0	266.5	375.0	195.5	5.0	5.0	200.5	
100/06-22-080-06 W4/00	06-22-080-06 W4							296.0	278.8	310.0	264.8	381.0	193.8	24.0	24.0	217.8	
100/13-24-080-06 W4/00	13-24-080-06 W4							210.0	273.1	218.0	265.1	291.0	192.1	10.0	10.0	202.1	
100/07-25-080-06 W4/00	07-25-080-06 W4							210.0	278.9	224.0	264.9	290.0	198.9	28.0	28.0	226.9	gamma runs high
100/13-25-080-06 W4/00	13-25-080-06 W4							202.0	277.4	215.0	264.4	286.0	193.4	16.0	16.0	209.4	
100/15-26-080-06 W4/00	15-26-080-06 W4							195.0	284.1	209.0	270.1	290.0	189.1	16.0	16.0	205.1	gamma runs high

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Northing (m) NAD 27	Easting (m) NAD 27	KB (m asl)	TD (m)	Top Grand Rapids (m bKB)	Top Grand Rapids (m asl)	Grand Rapids Watersand Thickness (m)	Grand Rapids Watersand Top (m bKB)	Grand Rapids Watersand Top (m asl)	Grand Rapids Watersand Base (m bKB)	Grand Rapids Watersand Base (m asl)	Top Clearwater (m bKB)	Top Clearwater (m asl)	Upper Clearwater Watersand Thickness (m)	Middle Clearwater Watersand Thickness (m)	Upper Clearwater Watersand Thickness (Surfer) (m)	Middle Clearwater Watersand Thickness (Surfer) (m)	Upper Clearwater Watersand Top (m bKB)	Upper Clearwater Watersand Top (m asl)
100/10-27-080-06 W4/00	10-27-080-06 W4	6201907	509384	512.1	318.5			23.0	144.0	368.1	167.0	345.1	167.0	345.1	0.0	0.0	-5.0	-5.0		
100/11-28-080-06 W4/00	11-28-080-06 W4	6201903	507352	551.1	365.0	120.0	431.1	26.0	179.0	372.1	205.0	346.1	205.0	346.1	0.0	0.0	-5.0	-5.0		
100/10-30-080-06 W4/00	10-30-080-06 W4	6201899	504495	520.1	334.0			29.0	145.0	375.1	174.0	346.1	174.0	346.1	0.0	0.0	-5.0	-5.0		
100/11-30-080-06 W4/00	11-30-080-06 W4	6201899	504093	523.4	326.0	92.0	431.4	26.0	147.0	376.4	173.0	350.4	173.0	350.4	0.0	0.0	-5.0	-5.0		
100/14-31-080-06 W4/00	14-31-080-06 W4	6203910	504091	522.8	325.0			27.0	148.0	374.8	175.0	347.8	175.0	347.8	0.0	0.0	-5.0	-5.0		
100/02-32-080-06 W4/00	02-32-080-06 W4	6202706	506124	516.8	330.0			23.0	143.0	373.8	166.0	350.8	166.0	350.8	0.0	0.0	-5.0	-5.0		
100/07-32-080-06 W4/00	07-32-080-06 W4	6203108	506123	525.6	331.0	89.0	436.6	24.0	149.0	376.6	173.0	352.6	173.0	352.6	0.0	0.0	-5.0	-5.0		
100/11-34-080-06 W4/00	11-34-080-06 W4	6203515	508978	513.5	330.0			18.0	143.0	370.5	161.0	352.5	161.0	352.5	0.0	0.0	-5.0	-5.0		
100/07-36-080-06 W4/00	07-36-080-06 W4	6203122	512640	477.6	288.0			21.0	105.0	372.6	126.0	351.6	128.0	349.6	0.0	0.0	-5.0	-5.0		
1AA/10-03-080-07 W4/00	10-03-080-07 W4	6195421	499607	587.5	388.1			29.0	211.0	376.5	240.0	347.5	240.0	347.5	0.0	0.0	-5.0	-5.0		
100/11-06-080-07 W4/00	11-06-080-07 W4	6195425	494307	616.5	398.0	178.0	438.5	22.0	235.0	381.5	257.0	359.5	257.0	359.5	0.0	0.0	-5.0	-5.0		
1AA/10-10-080-07 W4/00	10-10-080-07 W4	6197030	499607	592.5	374.0	160.0	432.5	32.0	218.0	374.5	250.0	342.5	250.0	342.5	0.0	0.0	-5.0	-5.0		
100/10-11-080-07 W4/00	10-11-080-07 W4	6197030	501238	583.2	382.0	153.0	430.2						238.0	345.2						
100/07-13-080-07 W4/00	07-13-080-07 W4	6198258	502869	578.6	379.0	147.0	431.6	25.0	207.0	371.6	232.0	346.6	232.0	346.6	0.0	0.0	-5.0	-5.0		
100/07-14-080-07 W4/00	07-14-080-07 W4	6198257	501238	590.8	389.5	156.0	434.8	29.0	215.0	375.8	244.0	346.8	244.0	346.8	0.0	0.0	-5.0	-5.0		
1AA/10-22-080-07 W4/00	10-22-080-07 W4	6200268	499607	598.7	405.0	166.0	432.7	26.0	226.0	372.7	252.0	346.7	252.0	346.7	0.0	0.0	-5.0	-5.0		
100/09-24-080-07 W4/00	09-24-080-07 W4	6200269	503270	558.0	372.0	124.0	434.0	29.0	181.0	377.0	210.0	348.0	210.0	348.0	0.0	0.0	-5.0	-5.0		
100/11-25-080-07 W4/00	11-25-080-07 W4	6201897	502464	537.5	350.0			29.0	161.0	376.5	190.0	347.5	190.0	347.5	0.0	0.0	-5.0	-5.0		
100/06-26-080-07 W4/00	06-26-080-07 W4	6201494	500835	588.8	397.0	158.0	430.8	24.0	219.0	369.8	243.0	345.8	243.0	345.8	0.0	0.0	-5.0	-5.0		
1AA/10-26-080-07 W4/00	10-26-080-07 W4	6201897	501237	584.8	403.0	155.0	429.8						240.0	344.8						
1AA/10-29-080-07 W4/00	10-29-080-07 W4	6201898	496348	629.1	456.7	196.0	433.1						280.0	349.1						
100/08-30-080-07 W4/00	08-30-080-07 W4	6201497	495120	635.6	425.0	199.0	436.6	27.0	253.0	382.6	280.0	355.6	285.0	350.6	0.0	0.0	-5.0	-5.0		
100/16-31-080-07 W4/00	16-31-080-07 W4	6203910	495123	640.3	437.0	205.0	435.3	19.0	263.0	377.3	282.0	358.3	282.0	358.3	0.0	0.0	-5.0	-5.0		
100/03-32-080-07 W4/00	03-32-080-07 W4	6202703	495946	637.1	433.0	200.0	437.1	24.0	257.0	380.1	281.0	356.1	281.0	356.1	0.0	0.0	-5.0	-5.0		
100/03-34-080-07 W4/00	03-34-080-07 W4	6202701	499205	606.4	421.0	171.0	435.4	30.0	229.0	377.4	259.0	347.4	259.0	347.4	0.0	0.0	-5.0	-5.0		
100/04-35-080-07 W4/00	04-35-080-07 W4	6202701	500432	591.2	400.0	156.0	435.2	21.0	216.0	375.2	237.0	354.2	237.0	354.2	0.0	0.0	-5.0	-5.0		
100/02-36-080-07 W4/00	02-36-080-07 W4	6202702	502866	525.9	330.0			27.0	148.0	377.9	175.0	350.9	175.0	350.9	0.0	0.0	-5.0	-5.0		
100/16-03-080-08 W4/00	16-03-080-08W4	6195834	490220	640.4	414.0	204.0	436.4	21.0	258.0	382.4	279.0	361.4	286.0	354.4	0.0	0.0	-5.0	-5.0		
100/16-04-080-08 W4/00	16-04-080-08W4	6195838	488588	660.3	435.0	226.0	434.3	22.0	280.0	380.3	302.0	358.3	313.0	347.3	0.0	0.0	-5.0	-5.0		
100/03-11-080-08 W4/00	03-11-080-08W4	6196235	491047	634.5	411.0	198.0	436.5	29.0	249.0	385.5	278.0	356.5	286.0	348.5	0.0	0.0	-5.0	-5.0		
100/14-12-080-08 W4/00	14-12-080-08W4	6197438	492681	636.7	414.7	198.0	438.7	32.0	250.0	386.7	282.0	354.7	290.0	346.7	0.0	0.0	-5.0	-5.0		
100/11-13-080-08 W4/00	11-13-080-08W4	6198665	492683	638.0	427.0	199.0	439.0	29.0	253.0	385.0	282.0	356.0	289.0	349.0	0.0	0.0	-5.0	-5.0		
100/01-15-080-08 W4/00	01-15-080-08W4	6197865	490225	655.9	435.0	224.0	431.9	19.0	275.0	380.9	294.0	361.9	306.0	349.9	0.0	0.0	-5.0	-5.0		
100/01-18-080-08 W4/00	01-18-080-08W4	6197879	485331	685.1	460.0	252.0	433.1	15.0	309.0	376.1	324.0	361.1	340.0	345.1	0.0	0.0	-5.0	-5.0		
100/14-20-080-08 W4/00	14-20-080-08W4	6200692	486166	707.7	470.0	271.0	436.7	18.0	326.0	381.7	344.0	363.7	359.0	348.7	0.0	0.0	-5.0	-5.0		
100/05-23-080-08 W4/00	05-23-080-08W4	6199875	490652	655.4	429.0	222.0	433.4	11.0	279.0	376.4	290.0	365.4	310.0	345.4	0.0	0.0	-5.0	-5.0		
100/14-25-080-08 W4/00	14-25-080-08W4	6202304	492689	664.7	456.0	231.0	433.7	16.0	289.0	375.7	305.0	359.7	318.0	346.7	0.0	0.0	-5.0	-5.0		
100/12-27-080-08 W4/00	12-27-080-08W4	6201910	489027	677.5	457.0	238.0	439.5	17.0	295.0	382.5	312.0	365.5	319.0	358.5	0.0	0.0	-5.0	-5.0		
100/02-28-080-08 W4/00	02-28-080-08W4	6201108	488200	687.4	443.0	250.0	437.4	15.0	308.0	379.4	323.0	364.4	332.0	355.4	0.0	0.0	-5.0	-5.0		
100/05-31-080-08 W4/00	05-31-080-08W4	6203132	484142	732.6	496.0	296.0	436.6	35.0	339.0	393.6	374.0	358.6	386.0	346.6	0.0	0.0	-5.0	-5.0		
100/03-34-080-08 W4/00	03-34-080-08W4	6202713	489431	691.3	455.0	255.0	436.3	15.0	311.0	380.3	326.0	365.3	337.0	354.3	0.0	0.0	-5.0	-5.0		
100/15-34-080-08 W4/00	15-34-080-08W4	6203919	489837	701.4	479.0	266.0	435.4	17.0	325.0	376.4	342.0	359.4	342.0	359.4	0.0	0.0	-5.0	-5.0		
100/03-36-080-08 W4/00	03-36-080-08W4	6202707	492690	667.0	450.0	235.0	432.0	16.0	292.0	375.0	308.0	359.0	308.0	359.0	0.0	0.0	-5.0	-5.0		
1AA/06-13-080-08W400	06-13-080-08W4	6198491	492683	637.0	425.0	204.4	432.7	28.0	255.0	382.0	283.0	354.0	288.1	348.9	0.0	0.0	-5.0	-5.0		
100/10-14-080-08W400	10-14-080-08W4	6198915	491413	655.6	425.5	217.8	437.9	23.0	270.0	385.6	293.0	362.6	302.2	353.4	0.0	0.0	-5.0	-5.0		
102/10-14-080-08W400	10-14-080-08W4	6198920	491484	648.2	430.0	216.6	431.6	23.0	268.0	380.2	291.0	357.2	295.8	352.4	0.0	0.0	-5.0	-5.0		
100/11-17-080-08W400	11-17-080-08W4	6199102	486272	685.8	451.0	254.5	431.3	15.0	309.0	376.8	324.0	361.8	338.8	347.1	0.0	0.0	-5.0	-5.0		
100/03-24-080-08W400	03-24-080-08W4	6199605	492720	633.4	412.0	201.5	431.9	24.0	254.0	379.4	278.0	355.4	285.1	348.3	0.0	0.0	-5.0	-5.0		
100/12-26-080-08W400	12-26-080-08W4	6202238	490580	675.1	439.0	240.0	435.1	19.0	295.0	380.1	314.0	361.1	322.7	352.4	0.0	0.0	-5.0	-5.0		
100/12-30-080-08W400	12-30-080-08W4	6202096	484125	727.3	476.0	289.6	437.7	32.0	336.0	391.3	368.0	359.3	380.2	347.1	0.0	0.0	-5.0	-5.0		
100/07-01-080-09 W4/00	07-01-080-09W4	6195051	483288	678.8	454.0	242.0	436.8	13.0	302.0	376.8	315.0	363.8	334.0	344.8	0.0	0.0	-5.0	-5.0		
100/10-02-080-09 W4/00	10-02-080-09W4	6195459	481658	687.8	472.0	254.0	433.8	19.0	311.0	376.8	330.0	357.8	342.0	345.8	0.0	0.0	-5.0	-5.0		
100/11-07-080-09 W4/00	11-07-080-09W4	6197103	474736	704.5	512.0	277.0	427.5	37.0	320.0	384.5	357.0	347.5	364.0	340.5	0.0	0.0	-5.0	-5.0		
100/06-08-080-09 W4/00	06-08-080-09W4	6196692	476365	704.1	502.9	275.0	429.1	35.0	321.0	383.1	356.0	348.1	364.0	340.1	0.0	0.0	-5.0	-5.0		
100/10-11-080-09 W4/00	10-11-080-09W4	6197068	481665	715.2	489.0	281.0	434.2	22.0	329.0	386.2	351.0	364.2	366.0	349.2	0.0	0.0	-5.0	-5.0		
100/10-13-080-09 W4/00	10-13-080-09W4	6198690	483302	702.1	472.0	267.0	435.1	23.0	321.0	381.1	344.0	358.1	353.0	349.1	0.0	0.0	-5.0	-5.0		

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Upper Clearwater Watersand Base (m bKB)	Upper Clearwater Watersand Base (m asl)	Middle Clearwater Watersand Top (m bKB)	Middle Clearwater Watersand Top (m asl)	Middle Clearwater Watersand Base (m bKB)	Middle Clearwater Watersand Base (m asl)	Top Wabiskaw (m bKB)	Top Wabiskaw (m asl)	Top McMurray (m bKB)	Top McMurray (m asl)	Paleo Surface (m bKB)	Paleo Surface (m asl)	Watersand Thickness (m)	Watersand Thickness (Surfer) (m)	Watersand Surface Elevation (m asl)	Log Analysis Notes:
100/10-27-080-06 W4/00	10-27-080-06 W4							231.0	281.1	244.0	268.1	311.0	201.1	10.0	10.0	211.1	
100/11-28-080-06 W4/00	11-28-080-06 W4							271.0	280.1	284.0	267.1	357.0	194.1	0.0	-5.0	194.1	
100/10-30-080-06 W4/00	10-30-080-06 W4							240.0	280.1	253.0	267.1	320.0	200.1	0.0	-5.0	200.1	
100/11-30-080-06 W4/00	11-30-080-06 W4							237.0	286.4	251.0	272.4	315.0	208.4	0.0	-5.0	208.4	
100/14-31-080-06 W4/00	14-31-080-06 W4							242.0	280.8	255.0	267.8	312.0	210.8	0.0	-5.0	210.8	
100/02-32-080-06 W4/00	02-32-080-06 W4							233.0	283.8	246.0	270.8	312.0	204.8	0.0	-5.0	204.8	
100/07-32-080-06 W4/00	07-32-080-06 W4							238.0	287.6	251.0	274.6	320.0	205.6	0.0	-5.0	205.6	
100/11-34-080-06 W4/00	11-34-080-06 W4							229.0	284.5	242.0	271.5	315.0	198.5	20.0	20.0	218.5	
100/07-36-080-06 W4/00	07-36-080-06 W4							192.0	285.6	207.0	270.6	286.0	191.6	18.0	18.0	209.6	
1AA/10-03-080-07 W4/00	10-03-080-07 W4							306.0	281.5	317.0	270.5	373.0	214.5	0.0	-5.0	214.5	
100/11-06-080-07 W4/00	11-06-080-07 W4							329.0	287.5	340.0	276.5	396.0	220.5				
1AA/10-10-080-07 W4/00	10-10-080-07 W4							315.0	277.5	328.0	264.5	378.0	214.5	0.0	-5.0	214.5	
100/10-11-080-07 W4/00	10-11-080-07 W4							304.0	279.2	316.0	267.2	371.0	212.2	0.0	-5.0	212.2	gamma runs high
100/07-13-080-07 W4/00	07-13-080-07 W4							297.0	281.6	310.0	268.6	350.0	228.6	0.0	-5.0	228.6	
100/07-14-080-07 W4/00	07-14-080-07 W4							309.0	281.8	320.0	270.8	380.0	210.8	2.0	2.0	212.8	
1AA/10-22-080-07 W4/00	10-22-080-07 W4							319.0	279.7	331.0	267.7	390.0	208.7	0.0	-5.0	208.7	
100/09-24-080-07 W4/00	09-24-080-07 W4							274.0	284.0	287.0	271.0	360.0	198.0	9.0	9.0	207.0	
100/11-25-080-07 W4/00	11-25-080-07 W4							256.0	281.5	269.0	268.5	332.0	205.5	3.0	3.0	208.5	
100/06-26-080-07 W4/00	06-26-080-07 W4							313.0	275.8	324.0	264.8	394.0	194.8	1.0	1.0	195.8	
1AA/10-26-080-07 W4/00	10-26-080-07 W4							311.0	273.8	322.0	262.8	389.0	195.8	0.0	-5.0	195.8	gamma runs high
1AA/10-29-080-07 W4/00	10-29-080-07 W4							343.0	286.1	355.0	274.1	412.0	217.1	0.0	-5.0	217.1	gamma runs high
100/08-30-080-07 W4/00	08-30-080-07 W4							347.0	288.6	361.0	274.6	411.0	224.6	0.0	-5.0	224.6	
100/16-31-080-07 W4/00	16-31-080-07 W4							351.0	289.3	363.0	277.3	422.0	218.3	0.0	-5.0	218.3	
100/03-32-080-07 W4/00	03-32-080-07 W4							350.0	287.1	361.0	276.1	422.0	215.1	0.0	-5.0	215.1	
100/03-34-080-07 W4/00	03-34-080-07 W4							323.0	283.4	335.0	271.4	407.0	199.4	0.0	-5.0	199.4	
100/04-35-080-07 W4/00	04-35-080-07 W4							307.0	284.2	319.0	272.2	383.0	208.2	0.0	-5.0	208.2	
100/02-36-080-07 W4/00	02-36-080-07 W4							239.0	286.9	253.0	272.9	315.0	210.9	9.0	9.0	219.9	
100/16-03-080-08 W4/00	16-03-080-08W4							350.0	290.4	361.0	279.4	409.0	231.4	0.0	-5.0	231.4	
100/16-04-080-08 W4/00	16-04-080-08W4							372.0	288.3	383.0	277.3	430.0	230.3	0.0	-5.0	230.3	
100/03-11-080-08 W4/00	03-11-080-08W4							344.0	290.5	355.0	279.5	404.0	230.5	0.0	-5.0	230.5	
100/14-12-080-08 W4/00	14-12-080-08W4							348.0	288.7	360.0	276.7	409.0	227.7	0.0	-5.0	227.7	
100/11-13-080-08 W4/00	11-13-080-08W4							347.0	291.0	358.0	280.0	412.0	226.0	0.0	-5.0	226.0	
100/01-15-080-08 W4/00	01-15-080-08W4							363.0	292.9	375.0	280.9	425.0	230.9	0.0	-5.0	230.9	
100/01-18-080-08 W4/00	01-18-080-08W4							398.0	287.1	407.0	278.1	452.0	233.1	0.0	-5.0	233.1	
100/14-20-080-08 W4/00	14-20-080-08W4							415.0	292.7	425.0	282.7	455.0	252.7	0.0	-5.0	252.7	
100/05-23-080-08 W4/00	05-23-080-08W4							368.0	287.4	379.0	276.4	425.0	230.4	0.0	-5.0	230.4	
100/14-25-080-08 W4/00	14-25-080-08W4							376.0	288.7	386.0	278.7	449.0	215.7	0.0	-5.0	215.7	
100/12-27-080-08 W4/00	12-27-080-08W4							380.0	297.5	392.0	285.5	415.0	262.5	0.0	-5.0	262.5	
100/02-28-080-08 W4/00	02-28-080-08W4							394.0	293.4	405.0	282.4	437.0	250.4	0.0	-5.0	250.4	
100/05-31-080-08 W4/00	05-31-080-08W4							442.0	290.6	452.0	280.6	485.0	247.6	0.0	-5.0	247.6	
100/03-34-080-08 W4/00	03-34-080-08W4							398.0	293.3	408.0	283.3	445.0	246.3			246.3	
100/15-34-080-08 W4/00	15-34-080-08W4							411.0	290.4	422.0	279.4	476.0	225.4	0.0	-5.0	225.4	
100/03-36-080-08 W4/00	03-36-080-08W4							378.0	289.0	390.0	277.0	444.0	223.0	0.0	-5.0	223.0	
1AA/06-13-080-08W400	06-13-080-08W4							350.0	287.0	360.8	276.2	410.0	227.0	0.0	-5.0	227.0	
100/10-14-080-08W400	10-14-080-08W4							360.0	295.6	370.0	285.6	417.7	237.9	2.0	2.0	239.9	
102/10-14-080-08W400	10-14-080-08W4							358.0	290.2	368.5	279.7	416.5	231.8	2.0	2.0	233.8	
100/11-17-080-08W400	11-17-080-08W4							395.0	290.8	408.0	277.8						
100/03-24-080-08W400	03-24-080-08W4							344.0	289.4								
100/12-26-080-08W400	12-26-080-08W4							384.0	291.1	395.1	280.0	432.9	242.2	0.0	-5.0	242.2	
100/12-30-080-08W400	12-30-080-08W4							436.0	291.3	446.7	280.6						
100/07-01-080-09 W4/00	07-01-080-09W4							392.0	286.8	403.0	275.8	450.0	228.8	0.0	-5.0	228.8	
100/10-02-080-09 W4/00	10-02-080-09W4							401.0	286.8	412.0	275.8	461.0	226.8	0.0	-5.0	226.8	
100/11-07-080-09 W4/00	11-07-080-09W4							424.0	280.5	434.0	270.5	490.0	214.5	2.0	2.0	216.5	
100/06-08-080-09 W4/00	06-08-080-09W4							427.0	277.1	437.0	267.1	489.0	215.1	4.0	4.0	219.1	
100/10-11-080-09 W4/00	10-11-080-09W4							425.0	290.2	435.0	280.2	473.0	242.2	0.0	-5.0	242.2	
100/10-13-080-09 W4/00	10-13-080-09W4							411.0	291.1	421.0	281.1	461.0	241.1	0.0	-5.0	241.1	

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Northing (m) NAD 27	Easting (m) NAD 27	KB (m asl)	TD (m)	Top Grand Rapids (m bKB)	Top Grand Rapids (m asl)	Grand Rapids Watersand Thickness (m)	Grand Rapids Watersand Top (m bKB)	Grand Rapids Watersand Top (m asl)	Grand Rapids Watersand Base (m bKB)	Grand Rapids Watersand Base (m asl)	Top Clearwater (m bKB)	Top Clearwater (m asl)	Upper Clearwater Watersand Thickness (m)	Middle Clearwater Watersand Thickness (m)	Upper Clearwater Watersand Thickness (Surfer) (m)	Middle Clearwater Watersand Thickness (Surfer) (m)	Upper Clearwater Watersand Top (m bKB)	Upper Clearwater Watersand Top (m asl)
100/10-15-080-09 W4/00	10-15-080-09W4	6198704	480041	724.5	516.0	295.0	429.5	35.0	335.0	389.5	370.0	354.5	378.0	346.5	0.0	0.0	-5.0	-5.0		
100/12-17-080-09 W4/00	12-17-080-09W4	6198725	475973	701.3	503.0	273.0	428.3	19.0	322.0	379.3	341.0	360.3	359.0	342.3	0.0	0.0	-5.0	-5.0		
1AA/04-19-080-09 W4/00	04-19-080-09W4	6199539	474347	696.3	499.0	271.0	425.3	28.0	318.0	378.3	346.0	350.3	357.0	339.3	0.0	0.0	-5.0	-5.0		
1AA/09-19-080-09 W4/00	09-19-080-09W4	6200336	475560	700.3	495.0	275.0	425.3	28.0	320.0	380.3	348.0	352.3	360.0	340.3	0.0	0.0	-5.0	-5.0		
1AA/14-19-080-09 W4/00	14-19-080-09W4	6200743	474757	701.5	495.0	275.0	426.5	30.0	321.0	380.5	351.0	350.5	362.0	339.5	0.0	0.0	-5.0	-5.0		
100/08-20-080-09 W4/00	08-20-080-09W4	6199925	477188	700.7	485.0	270.0	430.7	33.0	323.0	377.7	356.0	344.7	361.0	339.7	0.0	0.0	-5.0	-5.0		
100/08-29-080-09 W4/00	08-29-080-09W4	6201554	477196	699.9	475.0	268.0	431.9	29.0	316.0	383.9	345.0	354.9	357.0	342.9	0.0	0.0	-5.0	-5.0		
100/10-29-080-09 W4/00	10-29-080-09W4	6201958	476796	702.6	496.8	274.0	428.6	26.0	323.0	379.6	349.0	353.6	358.0	344.6	0.0	0.0	-5.0	-5.0		
1AA/07-30-080-09 W4/00	07-30-080-09W4	6201565	475164	698.6	490.0	270.0	428.6	32.0	314.0	384.6	346.0	352.6	355.0	343.6	0.0	0.0	-5.0	-5.0		
1AA/13-30-080-09 W4/00	13-30-080-09W4	6202374	474364	697.3	490.0	262.0	435.3	36.0	306.0	391.3	342.0	355.3	349.0	348.3	0.0	0.0	-5.0	-5.0		
1AA/15-30-080-09 W4/00	15-30-080-09W4	6202369	475169	697.5	495.0	266.0	431.5	37.0	308.0	389.5	345.0	352.5	350.0	347.5	0.0	0.0	-5.0	-5.0		
100/05-31-080-09 W4/00	05-31-080-09W4	6203178	474369	698.7	482.0	259.0	439.7	34.0	304.0	394.7	338.0	360.7	345.0	353.7	0.0	0.0	-5.0	-5.0		
1AA/15-31-080-09 W4/00	15-31-080-09W4	6203978	475178	698.9	490.0	262.0	436.9	36.0	307.0	391.9	343.0	355.9	349.0	349.9	0.0	0.0	-5.0	-5.0		
100/12-32-080-09 W4/00	12-32-080-09W4	6203571	476000	697.6	480.0	262.0	435.6	37.0	305.0	392.6	342.0	355.6	351.0	346.6	0.0	0.0	-5.0	-5.0		
100/10-36-080-09 W4/00	10-36-080-09W4	6203536	483321	727.1	502.0	297.0	430.1	32.0	337.0	390.1	369.0	358.1	379.0	348.1	0.0	0.0	-5.0	-5.0		
100/11-04-080-09W400	11-04-080-09W4	6195532	478056	699.5	477.0	264.4	435.1	41.0	305.0	394.5	346.0	353.5	357.4	342.1	0.0	0.0	-5.0	-5.0		
100/07-05-080-09W400	07-05-080-09W4	6195471	476702	702.9	474.0	272.3	430.6	38.0	316.0	386.9	354.0	348.9	362.4	340.5	0.0	0.0	-5.0	-5.0		
100/06-06-080-09W400	06-06-080-09W4	6195432	474835	705.5	483.6	276.9	428.7	33.0	323.0	382.5	356.0	349.5	363.0	342.5	0.0	0.0	-5.0	-5.0		
100/10-14-080-09W400	10-14-080-09W4	6198890	481485	714.5	465.0	275.9	438.7	35.0	320.0	394.5	355.0	359.5	365.9	348.6	0.0	0.0	-5.0	-5.0		
100/12-16-080-09W400	12-16-080-09W4	6199032	477498	704.6	487.9	276.4	428.2	32.0	325.0	379.6	357.0	347.6	362.5	342.1	0.0	0.0	-5.0	-5.0		
1AA/11-18-080-09W400	11-18-080-09W4	6198767	474770	701.8	500.0	276.6	425.2	20.0	327.0	374.8	347.0	354.8	363.3	338.5	0.0	0.0	-5.0	-5.0		
1AA/07-20-080-09W400	07-20-080-09W4	6200309	476773	702.1	500.0	275.4	426.7	20.0	325.0	377.1	345.0	357.1	360.8	341.3	0.0	0.0	-5.0	-5.0		
100/05-24-080-09W400	05-24-080-09W4	6200258	482480	710.6	465.0	270.6	440.0	35.0	311.0	399.6	346.0	364.6	363.9	346.7	0.0	0.0	-5.0	-5.0		
1AA/09-32-080-09W400	09-32-080-09W4	6203600	476976	707.5	498.0	276.5	431.0	31.0	323.0	384.5	354.0	353.5	360.5	347.0	0.0	0.0	-5.0	-5.0		
100/11-34-080-09W400	11-34-080-09W4	6203634	479650	714.4	485.0	284.2	430.2	25.0	332.0	382.4	357.0	357.4	371.6	342.8	0.0	0.0	-5.0	-5.0		
100/11-35-080-09W400	11-35-080-09W4	6203738	481169	718.0	489.0	286.0	432.1	30.0	337.0	381.0	367.0	351.0	372.0	346.0	0.0	0.0	-5.0	-5.0		
100/08-01-080-10 W4/00	08-01-080-10W4	6195097	473899	701.5	507.0	278.0	423.5	26.0	327.0	374.5	353.0	348.5	367.0	334.5	0.0	0.0	-5.0	-5.0		
100/06-02-080-10 W4/00	06-02-080-10W4	6195112	471461	701.3	500.0	275.0	426.3	33.0	324.0	377.3	357.0	344.3	366.0	335.3	0.0	0.0	-5.0	-5.0		
1AA/15-02-080-10 W4/00	15-02-080-10W4	6195914	471869	701.6	510.0	278.0	423.6	37.0	323.0	378.6	360.0	341.6	367.0	334.6	0.0	0.0	-5.0	-5.0		
1AA/10-04-080-10 W4/00	10-04-080-10W4	6195534	468602	685.2	507.0	268.0	417.2	33.0	314.0	371.2	347.0	338.2	362.0	323.2	0.0	0.0	-5.0	-5.0		
1AA/10-09-080-10 W4/00	10-09-080-10W4	6197143	468614	689.1	510.0	260.0	429.1	33.0	305.0	384.1	338.0	351.1	352.0	337.1	0.0	0.0	-5.0	-5.0		
100/12-10-080-10 W4/00	12-10-080-10W4	6197137	469440	686.5	497.0	265.0	421.5	33.0	309.0	377.5	342.0	344.5	356.0	330.5	0.0	0.0	-5.0	-5.0		
100/15-10-080-10 W4/00	15-10-080-10W4	6197533	470248	699.2	504.0	273.0	426.2	35.0	316.0	383.2	351.0	348.2	365.0	334.2	0.0	0.0	-5.0	-5.0		
1AA/12-11-080-10 W4/00	12-11-080-10W4	6197125	471071	704.4	515.0	283.0	421.4	32.0	327.0	377.4	359.0	345.4	370.0	334.4	0.0	0.0	-5.0	-5.0		
1AA/05-13-080-10 W4/00	05-13-080-10W4	6198341	472711	695.6	496.0	272.0	423.6	28.0	319.0	376.6	347.0	348.6	362.0	333.6	0.0	0.0	-5.0	-5.0		
100/10-13-080-10 W4/00	10-13-080-10W4	6198739	473519	700.6	493.0	274.0	426.6	30.0	319.0	381.6	349.0	351.6	361.0	339.6	0.0	0.0	-5.0	-5.0		
100/05-14-080-10 W4/00	05-14-080-10W4	6198352	471080	698.6	510.0	272.0	426.6	33.0	315.0	383.6	348.0	350.6	360.0	338.6	0.0	0.0	-5.0	-5.0		
100/07-14-080-10 W4/00	07-14-080-10W4	6198347	471885	692.3	488.0	264.0	428.3	33.0	307.0	385.3	340.0	352.3	351.0	341.3	0.0	0.0	-5.0	-5.0		
1AA/06-15-080-10 W4/00	06-15-080-10W4	6198360	469851	697.8	490.0	266.0	431.8	34.0	311.0	386.8	345.0	352.8	355.0	342.8	0.0	0.0	-5.0	-5.0		
100/08-15-080-10 W4/00	08-15-080-10W4	6198355	470657	698.2	502.0	266.0	432.2	34.0	307.0	391.2	341.0	357.2	350.0	348.2	0.0	0.0	-5.0	-5.0		
1AA/15-15-080-10 W4/00	15-15-080-10W4	6199162	470260	694.0	498.0	260.0	434.0	31.0	307.0	387.0	338.0	356.0	348.0	346.0	0.0	0.0	-5.0	-5.0		
1AA/11-19-080-10 W4/00	11-19-080-10W4	6200408	464975	689.9	498.0	260.0	429.9	38.0	305.0	384.9	343.0	346.9	351.0	338.9	0.0	0.0	-5.0	-5.0		
1AA/08-20-080-10 W4/00	08-20-080-10W4	6199987	467407	690.7	500.0	260.0	430.7	40.0	303.0	387.7	343.0	347.7	351.0	339.7	0.0	0.0	-5.0	-5.0		
100/01-22-080-10 W4/00	01-22-080-10W4	6199561	470665	689.3	487.0	261.0	428.3	37.0	304.0	385.3	341.0	348.3	352.0	337.3	0.0	0.0	-5.0	-5.0		
1AA/06-23-080-10 W4/00	06-23-080-10W4	6199958	471493	692.5	485.0	257.0	435.5	37.0	300.0	392.5	337.0	355.5	346.0	346.5	0.0	0.0	-5.0	-5.0		
100/08-23-080-10 W4/00	08-23-080-10W4	6199953	472298	695.0	480.0	257.0	438.0	35.0	301.0	394.0	336.0	359.0	345.0	350.0	0.0	0.0	-5.0	-5.0		
1AA/04-24-080-10 W4/00	04-24-080-10W4	6199548	472718	691.3	492.0	259.0	432.3	37.0	302.0	389.3	339.0	352.3	348.0	343.3	0.0	0.0	-5.0	-5.0		
100/08-25-080-10 W4/00	08-25-080-10W4	6201571	473938	700.5	481.0	264.0	436.5	37.0	306.0	394.5	343.0	357.5	349.0	351.5	0.0	0.0	-5.0	-5.0		
100/14-27-080-10 W4/00	14-27-080-10W4	6202402	469880	694.3	481.0	255.0	439.3	39.0	298.0	396.3	337.0	357.3	343.0	351.3	0.0	0.0	-5.0	-5.0		
100/14-28-080-10 W4/00	14-28-080-10W4	6202414	468250	693.4	487.0	257.0	436.4	39.0	301.0	392.4	340.0	353.4	344.0	349.4	0.0	0.0	-5.0	-5.0		
100/09-31-080-10 W4/00	09-31-080-10W4	6203639	465805	695.0	480.0	260.0	435.0	39.0	304.0	391.0	343.0	352.0	350.0	345.0	0.0	0.0	-5.0	-5.0		
100/09-33-080-10 W4/00	09-33-080-10W4	6203615	469063	695.7	482.0	258.0	437.7	36.0	304.0	391.7	340.0	355.7	346.0	349.7	0.0	0.0	-5.0	-5.0		
100/05-35-080-10 W4/00	05-35-080-10W4	6203198	471112	698.3	480.0	260.0	438.3	22.0	317.0	381.3	339.0	359.3	344.0	354.3	0.0	0.0	-5.0	-5.0		
1AA/08-35-080-10 W4/00	08-35-080-10W4	6203190	472319	697.1	497.0	256.0	441.1	44.0	301.0	396.1	345.0	352.1	346.0	351.1	0.0	0.0	-5.0	-5.0		
100/14-35-080-10 W4/00	14-35-080-10W4	6204000	471520	698.2	483.0	260.0	438.2	40.0	305.0	393.2	345.0	353.2	350.0	348.2	0.0	0.0	-5.0	-5.0		
1AA/03-36-080-10 W4/00	03-36-080-10W4	6202783	473141	697.2	495.0	258.0	439.2	36.0	302.0	395.2	338.0	359.2	345.0	352.2	0.0	0.0	-5.0	-5.0		

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Upper Clearwater Watersand Base (m bKB)	Upper Clearwater Watersand Base (m asl)	Middle Clearwater Watersand Top (m bKB)	Middle Clearwater Watersand Top (m asl)	Middle Clearwater Watersand Base (m bKB)	Middle Clearwater Watersand Base (m asl)	Top Wabiskaw (m bKB)	Top Wabiskaw (m asl)	Top McMurray (m bKB)	Top McMurray (m asl)	Paleo Surface (m bKB)	Paleo Surface (m asl)	Watersand Thickness (m)	Watersand Thickness (Surfer) (m)	Watersand Surface Elevation (m asl)	Log Analysis Notes:
100/10-15-080-09 W4/00	10-15-080-09W4							440.0	284.5	449.0	275.5	496.0	228.5	4.0	4.0	232.5	
100/12-17-080-09 W4/00	12-17-080-09W4							418.0	283.3	430.0	271.3	484.0	217.3	0.0	-5.0	217.3	
1AA/04-19-080-09 W4/00	04-19-080-09W4							417.0	279.3	427.0	269.3	482.0	214.3	0.0	-5.0	214.3	
1AA/09-19-080-09 W4/00	09-19-080-09W4							418.0	282.3	429.0	271.3	481.0	219.3	0.0	-5.0	219.3	
1AA/14-19-080-09 W4/00	14-19-080-09W4							423.0	278.5	434.0	267.5	482.0	219.5	0.0	-5.0	219.5	
100/08-20-080-09 W4/00	08-20-080-09W4							419.0	281.7	430.0	270.7	482.0	218.7	0.0	-5.0	218.7	
100/08-29-080-09 W4/00	08-29-080-09W4							415.0	284.9	425.0	274.9	473.0	226.9	0.0	-5.0	226.9	
100/10-29-080-09 W4/00	10-29-080-09W4							421.0	281.6	432.0	270.6	480.0	222.6	0.0	-5.0	222.6	
1AA/07-30-080-09 W4/00	07-30-080-09W4							415.0	283.6	425.0	273.6	476.0	222.6	0.0	-5.0	222.6	
1AA/13-30-080-09 W4/00	13-30-080-09W4							412.0	285.3	423.0	274.3	472.0	225.3	0.0	-5.0	225.3	
1AA/15-30-080-09 W4/00	15-30-080-09W4							413.0	284.5	423.0	274.5	479.0	218.5	0.0	-5.0	218.5	
100/05-31-080-09 W4/00	05-31-080-09W4							411.0	287.7	421.0	277.7	473.0	225.7	0.0	-5.0	225.7	
1AA/15-31-080-09 W4/00	15-31-080-09W4							406.0	292.9	416.0	282.9	476.0	222.9	0.0	-5.0	222.9	
100/12-32-080-09 W4/00	12-32-080-09W4							408.0	289.6	418.0	279.6	474.0	223.6	0.0	-5.0	223.6	
100/10-36-080-09 W4/00	10-36-080-09W4							437.0	290.1	448.0	279.1	481.0	246.1	0.0	-5.0	246.1	
100/11-04-080-09W400	11-04-080-09W4							417.0	282.5	426.0	273.5						
100/07-05-080-09W400	07-05-080-09W4							422.5	280.4	433.0	269.9						
100/06-06-080-09W400	06-06-080-09W4							425.0	280.5	434.2	271.3						
100/10-14-080-09W400	10-14-080-09W4							424.0	290.5	434.4	280.1						
100/12-16-080-09W400	12-16-080-09W4							422.0	282.6	432.0	272.6						
1AA/11-18-080-09W400	11-18-080-09W4							423.8	278.0								
1AA/07-20-080-09W400	07-20-080-09W4							421.3	280.8	431.9	270.2	486.9	215.2	2.0	2.0	217.2	
100/05-24-080-09W400	05-24-080-09W4							422.0	288.6	431.2	279.4						
1AA/09-32-080-09W400	09-32-080-09W4							422.3	285.2			483.0	224.5	0.0	-5.0	224.5	
100/11-34-080-09W400	11-34-080-09W4							429.5	284.9	440.0	274.4						
100/11-35-080-09W400	11-35-080-09W4							428.2	289.8	438.6	279.4						
100/08-01-080-10 W4/00	08-01-080-10W4							429.0	272.5	439.0	262.5	484.0	217.5	2.0	2.0	219.5	
100/06-02-080-10 W4/00	06-02-080-10W4							427.0	274.3	436.0	265.3	492.0	209.3	0.0	-5.0	209.3	
1AA/15-02-080-10 W4/00	15-02-080-10W4							427.0	274.6	437.0	264.6	490.0	211.6	0.0	-5.0	211.6	
1AA/10-04-080-10 W4/00	10-04-080-10W4							421.0	264.2	430.0	255.2	492.0	193.2	3.0	3.0	196.2	
1AA/10-09-080-10 W4/00	10-09-080-10W4							414.0	275.1	424.0	265.1	476.0	213.1	6.0	6.0	219.1	
100/12-10-080-10 W4/00	12-10-080-10W4							418.0	268.5	427.0	259.5	482.0	204.5	3.0	3.0	207.5	
100/15-10-080-10 W4/00	15-10-080-10W4							424.0	275.2	434.0	265.2	492.0	207.2	0.0	-5.0	207.2	
1AA/12-11-080-10 W4/00	12-11-080-10W4							432.0	272.4	441.0	263.4	497.0	207.4	2.0	2.0	209.4	
1AA/05-13-080-10 W4/00	05-13-080-10W4							422.0	273.6	431.0	264.6	487.0	208.6	0.0	-5.0	208.6	
100/10-13-080-10 W4/00	10-13-080-10W4							420.0	280.6	429.0	271.6	489.0	211.6	0.0	-5.0	211.6	
100/05-14-080-10 W4/00	05-14-080-10W4							419.0	279.6	428.0	270.6	487.0	211.6	0.0	-5.0	211.6	
100/07-14-080-10 W4/00	07-14-080-10W4							411.0	281.3	419.0	273.3	477.0	215.3	0.0	-5.0	215.3	
1AA/06-15-080-10 W4/00	06-15-080-10W4							417.0	280.8	426.0	271.8	479.0	218.8	0.0	-5.0	218.8	
100/08-15-080-10 W4/00	08-15-080-10W4							413.0	285.2	422.0	276.2	480.0	218.2	0.0	-5.0	218.2	
1AA/15-15-080-10 W4/00	15-15-080-10W4							409.0	285.0	418.0	276.0	475.0	219.0	0.0	-5.0	219.0	
1AA/11-19-080-10 W4/00	11-19-080-10W4							412.0	277.9	422.0	267.9	480.0	209.9	3.0	3.0	212.9	
1AA/08-20-080-10 W4/00	08-20-080-10W4							412.0	278.7	422.0	268.7	478.0	212.7	9.0	9.0	221.7	
100/01-22-080-10 W4/00	01-22-080-10W4							415.0	274.3	424.0	265.3	473.0	216.3	0.0	-5.0	216.3	
1AA/06-23-080-10 W4/00	06-23-080-10W4							407.0	285.5	416.0	276.5	468.0	224.5	0.0	-5.0	224.5	
100/08-23-080-10 W4/00	08-23-080-10W4							406.0	289.0	415.0	280.0	475.0	220.0	0.0	-5.0	220.0	
1AA/04-24-080-10 W4/00	04-24-080-10W4							408.0	283.3	417.0	274.3	480.0	211.3	0.0	-5.0	211.3	
100/08-25-080-10 W4/00	08-25-080-10W4							412.0	288.5	420.0	280.5	477.0	223.5	0.0	-5.0	223.5	
100/14-27-080-10 W4/00	14-27-080-10W4							407.0	287.3	415.0	279.3	472.0	222.3	0.0	-5.0	222.3	
100/14-28-080-10 W4/00	14-28-080-10W4							409.0	284.4	417.0	276.4	475.0	218.4	0.0	-5.0	218.4	
100/09-31-080-10 W4/00	09-31-080-10W4							411.0	284.0	419.0	276.0	477.0	218.0	0.0	-5.0	218.0	
100/09-33-080-10 W4/00	09-33-080-10W4							409.0	286.7	417.0	278.7	477.0	218.7	3.0	3.0	221.7	
100/05-35-080-10 W4/00	05-35-080-10W4							407.0	291.3	416.0	282.3	475.0	223.3	0.0	-5.0	223.3	
1AA/08-35-080-10 W4/00	08-35-080-10W4							410.0	287.1	419.0	278.1	471.0	226.1	0.0	-5.0	226.1	
100/14-35-080-10 W4/00	14-35-080-10W4							415.0	283.2	423.0	275.2	478.0	220.2	0.0	-5.0	220.2	
1AA/03-36-080-10 W4/00	03-36-080-10W4							407.0	290.2	416.0	281.2	477.0	220.2	0.0	-5.0	220.2	

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Northing (m) NAD 27	Easting (m) NAD 27	KB (m asl)	TD (m)	Top Grand Rapids (m bKB)	Top Grand Rapids (m asl)	Grand Rapids Watersand Thickness (m)	Grand Rapids Watersand Top (m bKB)	Grand Rapids Watersand Top (m asl)	Grand Rapids Watersand Base (m bKB)	Grand Rapids Watersand Base (m asl)	Top Clearwater (m bKB)	Top Clearwater (m asl)	Upper Clearwater Watersand Thickness (m)	Middle Clearwater Watersand Thickness (m)	Upper Clearwater Watersand Thickness (Surfer) (m)	Middle Clearwater Watersand Thickness (Surfer) (m)	Upper Clearwater Watersand Top (m bKB)	Upper Clearwater Watersand Top (m asl)
100/10-36-080-10 W4/00	10-36-080-10W4	6203585	473548	697.8	478.0	259.0	438.8	38.0	301.0	396.8	339.0	358.8	345.0	352.8	0.0	0.0	-5.0	-5.0		
100/16-24-080-10W400	16-24-080-10W4	6200865	473906	697.3	472.0	262.5	434.8	34.0	307.0	390.3	341.0	356.3	350.6	346.7	0.0	0.0	-5.0	-5.0		
100/05-04-080-11 W4/00	05-04-080-11W4	6195222	458000	685.9	493.0	256.0	429.9	41.0	302.0	383.9	343.0	342.9	350.0	335.9	0.0	0.0	-5.0	-5.0		
100/13-05-080-11 W4/00	13-05-080-11W4	6196042	456376	688.4	488.0	259.0	429.4	43.0	304.0	384.4	347.0	341.4	354.0	334.4	0.0	0.0	-5.0	-5.0		
100/06-06-080-11 W4/00	06-06-080-11W4	6195250	455139	688.8	498.0	257.0	431.8	45.0	303.0	385.8	348.0	340.8	351.0	337.8	0.0	0.0	-5.0	-5.0		
100/07-07-080-11 W4/00	07-07-080-11W4	6196855	455558	690.2	490.0	262.0	428.2						356.0	334.2						
100/15-09-080-11 W4/00	15-09-080-11W4	6197627	458829	687.7	481.0	257.0	430.7	42.0	301.0	386.7	343.0	344.7	350.0	337.7	0.0	0.0	-5.0	-5.0		
100/08-13-080-11 W4/00	08-13-080-11W4	6198404	464133	688.4	482.0	260.0	428.4	39.0	304.0	384.4	343.0	345.4	350.0	338.4	0.0	0.0	-5.0	-5.0		
100/05-15-080-11 W4/00	05-15-080-11W4	6198443	459663	687.1	485.0	256.0	431.1	41.0	299.0	388.1	340.0	347.1	347.0	340.1	0.0	0.0	-5.0	-5.0		
100/08-18-080-11 W4/00	08-18-080-11W4	6198479	455978	692.6	498.0	263.0	429.6	40.0	309.0	383.6	349.0	343.6	357.0	335.6	0.0	0.0	-5.0	-5.0		
100/10-20-080-11 W4/00	10-20-080-11W4	6200478	457226	691.5	496.0	261.0	430.5	38.0	305.0	386.5	343.0	348.5	353.0	338.5	0.0	0.0	-5.0	-5.0		
100/14-22-080-11 W4/00	14-22-080-11W4	6200853	460088	691.9	495.0	260.0	431.9	29.0	309.0	382.9	338.0	353.9	353.0	338.9	0.0	0.0	-5.0	-5.0		
100/14-27-080-11 W4/00	14-27-080-11W4	6202481	460103	693.1	492.0	260.0	433.1	32.0	306.0	387.1	338.0	355.1	353.0	340.1	0.0	0.0	-5.0	-5.0		
100/14-30-080-11 W4/00	14-30-080-11W4	6202529	455214	697.6	494.0	266.0	431.6	38.0	312.0	385.6	350.0	347.6	358.0	339.6	0.0	0.0	-5.0	-5.0		
100/06-32-080-11 W4/00	06-32-080-11W4	6203317	456852	697.2	489.0	266.0	431.2	37.0	312.0	385.2	349.0	348.2	360.0	337.2	0.0	0.0	-5.0	-5.0		
100/07-02-080-12W400	07-02-080-12W4	6195679	452050	688.7	487.0	260.4	428.3	47.0	303.0	385.7	350.0	338.7	353.0	335.7	0.0	0.0	-5.0	-5.0		
100/06-03-080-12W400	06-03-080-12W4	6195388	450024	690.4	505.0	263.3	427.1	39.0	311.0	379.4	350.0	340.4	359.0	331.4	0.0	0.0	-5.0	-5.0		
100/08-04-080-12W400	08-04-080-12W4	6195591	449227	690.3	501.0	265.5	424.8	36.0	312.0	378.3	348.0	342.3	361.0	329.3	0.0	0.0	-5.0	-5.0		
100/04-05-080-12W400	04-05-080-12W4	6195307	446713	686.6	512.0	265.6	421.0	28.0	321.0	365.6	349.0	337.6	358.9	327.7	0.0	0.0	-5.0	-5.0		
100/10-05-080-12W400	10-05-080-12W4	6195831	447441	690.4	498.0	270.6	419.8	35.0	319.0	371.4	354.0	336.4	364.0	326.4	0.0	0.0	-5.0	-5.0		
100/06-06-080-12W400	06-06-080-12W4	6195633	445453	686.9	495.0	264.7	422.2	16.0	320.0	366.9	336.0	350.9	357.9	329.0	0.0	0.0	-5.0	-5.0		
100/13-07-080-12W400	13-07-080-12W4	6197832	444984	709.1	517.0	288.0	421.1	20.0	336.0	373.1	356.0	353.1	380.3	328.8	0.0	0.0	-5.0	-5.0		
100/12-10-080-12W400	12-10-080-12W4	6197431	449903	690.4	502.0	264.6	425.8	40.0	314.0	376.4	354.0	336.4	358.3	332.1	0.0	0.0	-5.0	-5.0		
100/12-11-080-12W400	12-11-080-12W4	6197376	451536	685.4	491.0	258.0	427.4	45.0	305.0	380.4	350.0	335.4	352.7	332.7	0.0	0.0	-5.0	-5.0		
100/10-12-080-12W400	10-12-080-12W4	6197523	453774	687.8	490.0	258.9	428.9	44.0	305.0	382.8	349.0	338.8	355.1	332.7	0.0	0.0	-5.0	-5.0		
100/10-13-080-12W400	10-13-080-12W4	6199115	453948	688.0	492.0	258.1	429.9	45.0	309.0	379.0	354.0	334.0	354.3	333.7	0.0	0.0	-5.0	-5.0		
100/05-14-080-12W400	05-14-080-12W4	6198704	451552	689.7	495.0	262.2	427.5	42.0	310.0	379.7	352.0	337.7	357.0	332.7	0.0	0.0	-5.0	-5.0		
100/08-16-080-12W400	08-16-080-12W4	6198742	449299	698.3	510.0	275.9	422.4	40.0	325.0	373.3	365.0	333.3	371.0	327.3	0.0	0.0	-5.0	-5.0		
100/07-17-080-12W400	07-17-080-12W4	6198897	447478	702.6	510.0	280.6	422.0	25.0	330.0	372.6	355.0	347.6	375.8	326.8	0.0	0.0	-5.0	-5.0		
100/10-18-080-12W400	10-18-080-12W4	6199403	445922	716.0	531.0	296.6	419.4	23.0	347.0	369.0	370.0	346.0	392.8	323.2	0.0	0.0	-5.0	-5.0		
100/09-19-080-12W400	09-19-080-12W4	6200922	446057	716.0	511.0	294.8	421.2	27.0	344.0	372.0	371.0	345.0	388.7	327.3	0.0	0.0	-5.0	-5.0		
100/05-20-080-12W400	05-20-080-12W4	6200257	446691	708.2	540.0	287.5	420.7	26.0	337.0	371.2	363.0	345.2	382.3	326.0	0.0	0.0	-5.0	-5.0		
100/11-20-080-12W400	11-20-080-12W4	6200905	447024	723.6	550.0	299.5	424.1	24.0	349.0	374.6	373.0	350.6	393.0	330.6	0.0	0.0	-5.0	-5.0		
100/06-21-080-12W400	06-21-080-12W4	6200200	448628	714.1	545.0	287.6	426.5	25.0	337.0	377.1	362.0	352.1	381.9	332.2	0.0	0.0	-5.0	-5.0		
100/02-22-080-12W400	02-22-080-12W4	6200134	450556	701.8	517.0	275.3	426.5	27.0	322.0	379.8	349.0	352.8	369.3	332.5	0.0	0.0	-5.0	-5.0		
100/13-23-080-12W400	13-23-080-12W4	6201214	451410	703.6	507.0	275.5	428.1	25.0	323.0	380.6	348.0	355.6	370.6	333.0	0.0	0.0	-5.0	-5.0		
100/10-24-080-12W400	10-24-080-12W4	6200737	453909	692.5	495.0	265.1	427.4	16.0	315.0	377.5	331.0	361.5	357.0	335.5	0.0	0.0	-5.0	-5.0		
100/07-26-080-12W400	07-26-080-12W4	6201877	452221	701.9	512.0	276.0	425.9	24.0	321.0	380.9	345.0	356.9	368.4	333.5	0.0	0.0	-5.0	-5.0		
100/13-27-080-12W400	13-27-080-12W4	6202644	450019	708.3	511.0	281.6	426.7	26.0	328.0	380.3	354.0	354.3	374.1	334.2	0.0	0.0	-5.0	-5.0		
100/06-28-080-12W400	06-28-080-12W4	6201876	448566	709.6	515.0	287.1	422.5	23.0	336.0	373.6	359.0	350.6	380.0	329.6	0.0	0.0	-5.0	-5.0		
100/08-32-080-12W400	08-32-080-12W4	6203685	447834	722.3	522.6	295.2	427.1	20.0	344.0	378.3	364.0	358.3	390.8	331.5	0.0	0.0	-5.0	-5.0		
100/16-33-080-12W400	16-33-080-12W4	6204271	449355	719.7	575.0	300.8	418.9	29.0	338.0	381.7	367.0	352.7	386.0	333.7	0.0	0.0	-5.0	-5.0		
100/05-01-080-13W400	05-01-080-13W4	6195489	443376	688.5	510.0	269.3	419.3	21.0	323.0	365.5	344.0	344.5	362.0	326.5	0.0	0.0	-5.0	-5.0		
100/12-01-080-13W400	12-01-080-13W4	6195903	443438	695.9	511.0	279.6	416.3	26.0	329.0	366.9	355.0	340.9	372.3	323.6	0.0	0.0	-5.0	-5.0		
100/08-02-080-13W400	08-02-080-13W4	6195805	442893	692.7	503.0	274.0	418.7	23.0	325.0	367.7	348.0	344.7	366.6	326.1	0.0	0.0	-5.0	-5.0		
100/02-03-080-13W400	02-03-080-13W4	6195437	440678	685.0	492.0	272.1	412.9	17.0	319.0	366.0	336.0	349.0	359.5	325.6	0.0	0.0	-5.0	-5.0		
100/08-03-080-13W400	08-03-080-13W4	6195704	441091	686.9	502.0	272.2	414.7	22.0	319.0	367.9	341.0	345.9	359.3	327.6	0.0	0.0	-5.0	-5.0		
100/06-04-080-13W400	06-04-080-13W4	6195654	438739	685.8	507.0	274.0	411.8	21.0	322.0	363.8	343.0	342.8	362.0	323.8	0.0	0.0	-5.0	-5.0		
100/01-06-080-13W400	01-06-080-13W4	6195483	436387	689.4	496.0	276.1	413.3	20.0	324.0	365.4	344.0	345.4	367.9	321.5	0.0	0.0	-5.0	-5.0		
100/09-06-080-13W400	09-06-080-13W4	6195937	436377	689.6	511.0	282.3	407.3	28.0	330.0	359.6	358.0	331.6	374.9	314.7	0.0	0.0	-5.0	-5.0		
100/16-07-080-13W400	16-07-080-13W4	6198022	436468	689.5	505.0	276.4	413.1	27.0	323.0	366.5	350.0	339.5	369.1	320.4	0.0	0.0	-5.0	-5.0		
100/01-09-080-13W400	01-09-080-13W4	6197044	439593	685.0	504.0	274.4	410.6	23.0	322.0	363.0	345.0	340.0	363.3	321.7	0.0	0.0	-5.0	-5.0		
100/14-10-080-13W400	14-10-080-13W4	6197910	440520	688.0	519.0	275.4	412.6	27.0	324.0	364.0	351.0	337.0	367.7	320.3	0.0	0.0	-5.0	-5.0		
100/03-11-080-13W400	03-11-080-13W4	6196947	442224	689.4	503.0	272.6	416.8	22.0	323.0	366.4	345.0	344.4	365.0	324.5	0.0	0.0	-5.0	-5.0		
100/15-11-080-13W400	15-11-080-13W4	6197890	442577	694.5	510.0	277.6	416.9	29.0	328.0	366.5	357.0	337.5	371.0	323.5	0.0	0.0	-5.0	-5.0		
100/08-12-080-13W400	08-12-080-13W4	6197096	444370	700.7	512.0	281.6	419.1	16.0	335.0	365.7	351.0	349.7	373.0	327.7	0.0	0.0	-5.0	-5.0		

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Upper Clearwater Watersand Base (m bKB)	Upper Clearwater Watersand Base (m asl)	Middle Clearwater Watersand Top (m bKB)	Middle Clearwater Watersand Top (m asl)	Middle Clearwater Watersand Base (m bKB)	Middle Clearwater Watersand Base (m asl)	Top Wabiskaw (m bKB)	Top Wabiskaw (m asl)	Top McMurray (m bKB)	Top McMurray (m asl)	Paleo Surface (m bKB)	Paleo Surface (m asl)	Watersand Thickness (m)	Watersand Thickness (Surfer) (m)	Watersand Surface Elevation (m asl)	Log Analysis Notes:
100/10-36-080-10 W4/00	10-36-080-10W4							409.0	288.8	418.0	279.8	473.0	224.8	0.0	-5.0	224.8	
100/16-24-080-10W400	16-24-080-10W4							409.0	288.3	418.6	278.7	469.9	227.4	0.0	-5.0	227.4	
100/05-04-080-11 W4/00	05-04-080-11W4							413.0	272.9	422.0	263.9	478.0	207.9	3.0	3.0	210.9	
100/13-05-080-11 W4/00	13-05-080-11W4							419.0	269.4	428.0	260.4	480.0	208.4	4.0	4.0	212.4	
100/06-06-080-11 W4/00	06-06-080-11W4							415.0	273.8	424.0	264.8	483.0	205.8	6.0	6.0	211.8	
100/07-07-080-11 W4/00	07-07-080-11W4							419.0	271.2	428.0	262.2	483.0	207.2	4.0	4.0	211.2	gamma ran high
100/15-09-080-11 W4/00	15-09-080-11W4							413.0	274.7	424.0	263.7	478.0	209.7	12.0	12.0	221.7	
100/08-13-080-11 W4/00	08-13-080-11W4							413.0	275.4	422.0	266.4	475.0	213.4	0.0	-5.0	213.4	
100/05-15-080-11 W4/00	05-15-080-11W4							408.0	279.1	418.0	269.1	476.0	211.1	0.0	-5.0	211.1	
100/08-18-080-11 W4/00	08-18-080-11W4							420.0	272.6	429.0	263.6	484.0	208.6	5.0	5.0	213.6	
100/10-20-080-11 W4/00	10-20-080-11W4							414.0	277.5	425.0	266.5	481.0	210.5	0.0	-5.0	210.5	
100/14-22-080-11 W4/00	14-22-080-11W4							415.0	276.9	425.0	266.9	480.0	211.9	2.0	2.0	213.9	
100/14-27-080-11 W4/00	14-27-080-11W4							415.0	278.1	425.0	268.1	477.0	216.1	0.0	-5.0	216.1	
100/14-30-080-11 W4/00	14-30-080-11W4							419.0	278.6	429.0	268.6	486.0	211.6				
100/06-32-080-11 W4/00	06-32-080-11W4							417.0	280.2	427.0	270.2	484.0	213.2	4.0	4.0	217.2	
100/07-02-080-12W400	07-02-080-12W4							417.4	271.3	431.0	257.7	479.2	209.5	4.9	4.9	214.4	
100/06-03-080-12W400	06-03-080-12W4							424.0	266.4	437.8	252.6	481.7	208.7	1.0	1.0	209.7	
100/08-04-080-12W400	08-04-080-12W4							424.7	265.6	437.9	252.4	490.5	199.8	7.0	7.0	206.8	
100/04-05-080-12W400	04-05-080-12W4							422.8	263.8	436.4	250.2	484.4	202.2	6.0	6.0	208.2	
100/10-05-080-12W400	10-05-080-12W4							425.9	264.5	440.0	250.4	486.9	203.6	10.5	10.5	214.0	
100/06-06-080-12W400	06-06-080-12W4							422.1	264.8	433.9	253.0	483.1	203.8	2.0	2.0	205.8	
100/13-07-080-12W400	13-07-080-12W4							443.5	265.6	454.5	254.6	507.0	202.1	7.5	7.5	209.7	
100/12-10-080-12W400	12-10-080-12W4							420.5	269.9	433.0	257.4	485.5	204.9	2.5	2.5	207.5	
100/12-11-080-12W400	12-11-080-12W4							416.6	268.8	429.6	255.9	479.6	205.8	3.0	3.0	208.8	
100/10-12-080-12W400	10-12-080-12W4							417.6	270.2	431.3	256.5	483.2	204.6	0.0	-5.0	204.6	
100/10-13-080-12W400	10-13-080-12W4							415.2	272.8	429.7	258.3	479.6	208.4	0.0	-5.0	208.4	
100/05-14-080-12W400	05-14-080-12W4							419.5	270.3	432.9	256.8	482.4	207.3	6.0	6.0	213.3	
100/08-16-080-12W400	08-16-080-12W4							434.0	264.3	443.0	255.3	495.8	202.6	13.0	13.0	215.6	
100/07-17-080-12W400	07-17-080-12W4							438.5	264.1	450.9	251.7	500.8	201.8				
100/10-18-080-12W400	10-18-080-12W4							455.6	260.4	464.9	251.1	516.7	199.3	2.0	2.0	201.3	
100/09-19-080-12W400	09-19-080-12W4							452.0	264.0	461.1	254.9						
100/05-20-080-12W400	05-20-080-12W4							446.9	261.3	459.6	248.7	507.8	200.4	1.0	1.0	201.4	
100/11-20-080-12W400	11-20-080-12W4							454.4	269.2	468.0	255.6	522.6	201.0	0.0	-5.0	201.0	
100/06-21-080-12W400	06-21-080-12W4							443.6	270.5	456.1	258.0	509.8	204.3	5.0	5.0	209.3	
100/02-22-080-12W400	02-22-080-12W4							430.8	271.0	445.0	256.8	495.8	206.0	2.1	2.1	208.1	
100/13-23-080-12W400	13-23-080-12W4							431.0	272.6	445.3	258.4						
100/10-24-080-12W400	10-24-080-12W4							418.6	273.9	433.2	259.3	483.0	209.6	4.0	4.0	213.6	
100/07-26-080-12W400	07-26-080-12W4							428.6	273.3	442.9	259.0	493.8	208.1	3.0	3.0	211.1	
100/13-27-080-12W400	13-27-080-12W4							434.7	273.6	447.3	261.0	501.4	206.9	0.0	-5.0	206.9	
100/06-28-080-12W400	06-28-080-12W4							441.6	268.0	455.3	254.3	510.4	199.2	4.0	4.0	203.2	
100/08-32-080-12W400	08-32-080-12W4							452.5	269.8	462.0	260.3						
100/16-33-080-12W400	16-33-080-12W4							448.0	271.7	457.0	262.7						
100/05-01-080-13W400	05-01-080-13W4							426.9	261.7	439.0	249.5	486.8	201.8	8.0	8.0	209.8	
100/12-01-080-13W400	12-01-080-13W4							437.7	258.2	451.2	244.7	499.4	196.5	14.4	14.4	210.9	
100/08-02-080-13W400	08-02-080-13W4							426.9	265.9	438.5	254.2	491.8	200.9	9.0	9.0	209.9	
100/02-03-080-13W400	02-03-080-13W4							426.0	259.0	439.9	245.1	486.5	198.5	0.0	-5.0	198.5	
100/08-03-080-13W400	08-03-080-13W4							427.4	259.5	439.3	247.6	487.0	199.9	0.0	-5.0	199.9	
100/06-04-080-13W400	06-04-080-13W4							431.5	254.3	443.9	241.9	495.1	190.7	0.0	-5.0	190.7	
100/01-06-080-13W400	01-06-080-13W4							434.8	254.7	448.2	241.2	494.3	195.1	0.0	-5.0	195.1	
100/09-06-080-13W400	09-06-080-13W4							440.2	249.4	453.2	236.4	501.9	187.7	0.0	-5.0	187.7	
100/16-07-080-13W400	16-07-080-13W4							432.4	257.1	446.5	243.0	495.3	194.2	1.0	1.0	195.2	
100/01-09-080-13W400	01-09-080-13W4							430.3	254.7	442.4	242.6	493.9	191.1	7.0	7.0	198.1	
100/14-10-080-13W400	14-10-080-13W4							433.2	254.8	445.7	242.3	504.5	183.5	15.6	15.6	199.1	
100/03-11-080-13W400	03-11-080-13W4							431.5	257.9	444.3	245.1	494.0	195.5	16.0	16.0	211.5	
100/15-11-080-13W400	15-11-080-13W4							438.3	256.2	451.3	243.2	500.9	193.6	10.3	10.3	203.9	
100/08-12-080-13W400	08-12-080-13W4							438.1	262.6	450.3	250.4	500.3	200.4	4.2	4.2	204.6	

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Northing (m) NAD 27	Easting (m) NAD 27	KB (m asl)	TD (m)	Top Grand Rapids (m bKB)	Top Grand Rapids (m asl)	Grand Rapids Watersand Thickness (m)	Grand Rapids Watersand Top (m bKB)	Grand Rapids Watersand Top (m asl)	Grand Rapids Watersand Base (m bKB)	Grand Rapids Watersand Base (m asl)	Top Clearwater (m bKB)	Top Clearwater (m asl)	Upper Clearwater Watersand Thickness (m)	Middle Clearwater Watersand Thickness (m)	Upper Clearwater Watersand Thickness (Surfer) (m)	Middle Clearwater Watersand Thickness (Surfer) (m)	Upper Clearwater Watersand Top (m bKB)	Upper Clearwater Watersand Top (m asl)
100/09-12-080-13W400	09-12-080-13W4	6197476	444381	701.4	517.0	284.1	417.3	24.0	335.0	366.4	359.0	342.4	377.0	324.4	0.0	0.0	-5.0	-5.0		
100/11-15-080-13W400	11-15-080-13W4	6199477	440266	688.0	503.0	273.0	415.0	27.0	322.0	366.0	349.0	339.0	367.1	320.9	0.0	0.0	-5.0	-5.0		
100/05-16-080-13W400	05-16-080-13W4	6199117	438569	689.8	507.0	272.4	417.5	26.0	321.0	368.8	347.0	342.8	365.1	324.8	0.0	0.0	-5.0	-5.0		
100/08-18-080-13W400	08-18-080-13W4	6199137	436261	686.4	494.0	270.4	416.0	26.0	319.0	367.4	345.0	341.4	364.9	321.5	0.0	0.0	-5.0	-5.0		
100/01-19-080-13W400	01-19-080-13W4	6200265	436263	693.2	483.0	277.3	415.9	26.0	327.0	366.2	353.0	340.2	373.6	319.6	0.0	0.0	-5.0	-5.0		
100/05-20-080-13W400	05-20-080-13W4	6200466	436782	692.9	501.0	274.7	418.2	29.0	322.0	370.9	351.0	341.9	369.0	323.9	0.0	0.0	-5.0	-5.0		
100/05-21-080-13W400	05-21-080-13W4	6200436	438589	691.4	509.0	271.5	419.9	29.0	319.0	372.4	348.0	343.4	364.7	326.8	0.0	0.0	-5.0	-5.0		
100/10-23-080-13W400	10-23-080-13W4	6200972	442685	699.8	525.2	285.7	414.1	31.0	332.0	367.8	363.0	336.8	379.7	320.2	0.0	0.0	-5.0	-5.0		
100/11-27-080-13W400	11-27-080-13W4	6202603	440346	698.6	509.0	278.2	420.5	28.0	327.0	371.6	355.0	343.6	374.0	324.6	0.0	0.0	-5.0	-5.0		
100/12-28-080-13W400	12-28-080-13W4	6202621	438365	700.2	494.5	278.6	421.6	28.0	329.0	371.2	357.0	343.2	374.9	325.3	0.0	0.0	-5.0	-5.0		
100/02-29-080-13W400	02-29-080-13W4	6201937	437582	701.6	510.0	280.3	421.3	28.0	331.0	370.6	359.0	342.6	375.9	325.7	0.0	0.0	-5.0	-5.0		
100/03-30-080-13W400	03-30-080-13W4	6201955	435457	698.9	519.0	281.0	417.9	27.0	330.0	368.9	357.0	341.9	376.0	322.9	0.0	0.0	-5.0	-5.0		
100/04-31-080-13W400	04-31-080-13W4	6203330	435205	691.7	507.0	271.3	420.4	32.0	319.0	372.7	351.0	340.7	365.5	326.3	0.0	0.0	-5.0	-5.0		
100/05-32-080-13W400	05-32-080-13W4	6203986	436999	691.5	502.0	271.2	420.3	27.0	320.0	371.5	347.0	344.5	363.0	328.5	0.0	0.0	-5.0	-5.0		
100/10-03-080-14 W4/00	10-03-080-14 W4	6195967	431068	700.1	531.9	292.0	408.1	25.0	340.0	360.1	365.0	335.1	384.0	316.1	0.0	0.0	-5.0	-5.0		
1AA/10-08-080-14 W4/00	10-08-080-14 W4	6197629	427831	652.5	477.0	246.0	406.5	23.0	297.0	355.5	320.0	332.5	340.0	312.5	0.0	0.0	-5.0	-5.0		
100/10-10-080-14 W4/00	10-10-080-14 W4	6197576	431094	684.0	479.0	273.0	411.0	22.0	323.0	361.0	345.0	339.0	365.0	319.0	0.0	0.0	-5.0	-5.0		
100/06-11-080-14 W4/00	06-11-080-14 W4	6197154	432316	691.1	502.0	281.0	410.1	31.0	329.0	362.1	360.0	331.1	372.0	319.1	0.0	0.0	-5.0	-5.0		
100/07-14-080-14 W4/00	07-14-080-14 W4	6198777	432744	690.6	503.0	274.0	416.6	23.0	324.0	366.6	347.0	343.6	368.0	322.6	0.0	0.0	-5.0	-5.0		
100/07-15-080-14 W4/00	07-15-080-14 W4	6198802	431114	678.6	506.0	264.0	414.6	33.0	312.0	366.6	345.0	333.6	357.0	321.6	0.0	0.0	-5.0	-5.0		
100/07-17-080-14 W4/00	07-17-080-14 W4	6198856	427852	650.5	462.0	239.0	411.5	30.0	292.0	358.5	322.0	328.5	334.0	316.5	0.0	0.0	-5.0	-5.0		
100/10-20-080-14 W4/00	10-20-080-14 W4	6200866	427885	646.2	464.0	230.0	416.2	26.0	283.0	363.2	309.0	337.2	324.0	322.2	0.0	0.0	-5.0	-5.0		
100/06-22-080-14 W4/00	06-22-080-14 W4	6200417	430737	667.5	487.0	252.0	415.5	29.0	303.0	364.5	332.0	335.5	345.0	322.5	0.0	0.0	-5.0	-5.0		
100/01-27-080-14 W4/00	01-27-080-14 W4	6201631	431561	667.1	477.0	250.0	417.1	32.0	299.0	368.1	331.0	336.1	347.0	320.1	0.0	0.0	-5.0	-5.0		
100/10-35-080-14 W4/00	10-35-080-14 W4	6204025	432826	662.5	484.0	241.0	421.5	30.0	290.0	372.5	320.0	342.5	340.0	322.5	0.0	0.0	-5.0	-5.0		
100/04-01-080-14W400	04-01-080-14W4	6195469	433588	701.0	515.0	292.1	408.9	21.0	341.0	360.0	362.0	339.0	383.2	317.8	0.0	0.0	-5.0	-5.0		
100/06-12-080-14W400	06-12-080-14W4	6197155	433926	697.8	507.0	289.1	408.7	25.0	336.0	361.8	361.0	336.8	380.5	317.3	0.0	0.0	-5.0	-5.0		
100/11-12-080-14W400	11-12-080-14W4	6197942	433837	692.3	506.0	279.0	413.3	21.0	328.0	364.3	349.0	343.3	373.9	318.4	0.0	0.0	-5.0	-5.0		
100/10-13-080-14W400	10-13-080-14W4	6199278	434402	698.0	502.4	284.0	414.0	27.0	332.0	366.0	359.0	339.0	377.9	320.1	0.0	0.0	-5.0	-5.0		
100/16-25-080-14W400	16-25-080-14W4	6202905	434672	689.6	487.0	270.5	419.1	31.0	319.0	370.6	350.0	339.6	366.2	323.4	0.0	0.0	-5.0	-5.0		
100/11-36-080-14W400	11-36-080-14W4	6204098	434169	676.7	472.8	256.5	420.2	35.0	306.0	370.7	341.0	335.7	349.5	327.2	0.0	0.0	-5.0	-5.0		
102/15-02-081-06 W4/00	15-02-081-06 W4	6205551	511002	486.4	302.4			19.0	115.0	371.4	134.0	352.4	138.0	348.4	0.0	0.0	-5.0	-5.0		
100/11-03-081-06 W4/00	11-03-081-06 W4	6205144	508973	495.3	288.0								145.0	350.3						
100/07-04-081-06 W4/00	07-04-081-06 W4	6204740	507747	501.0	292.0															
100/07-05-081-06 W4/00	07-05-081-06 W4	6204737	506119	511.8	294.4								156.0	355.8						
100/07-06-081-06 W4/00	07-06-081-06 W4	6204735	504490	522.7	321.0			23.0	146.0	376.7	169.0	353.7	169.0	353.7	0.0	0.0	-5.0	-5.0		
100/15-06-081-06 W4/00	15-06-081-06 W4	6205539	504489	522.4	325.3			24.0	147.0	375.4	171.0	351.4	171.0	351.4	0.0	0.0	-5.0	-5.0		
100/07-07-081-06 W4/00	07-07-081-06 W4	6206344	504488	516.1	325.0			24.0	140.0	376.1	164.0	352.1	164.0	352.1	0.0	0.0	-5.0	-5.0		
100/09-08-081-06 W4/00	09-08-081-06 W4	6206749	506518	501.1	291.0															
100/11-09-081-06 W4/00	11-09-081-06 W4	6206750	507342	494.8	287.0			24.0	116.0	378.8	140.0	354.8	140.0	354.8	0.0	0.0	-5.0	-5.0		
100/10-10-081-06 W4/00	10-10-081-06 W4	6206754	509372	484.2	270.0			16.0	108.0	376.2	124.0	360.2	132.0	352.2	0.0	0.0	-5.0	-5.0		
100/11-12-081-06 W4/00	11-12-081-06 W4	6206761	512225	479.8	283.5			19.0	106.0	373.8	125.0	354.8	127.0	352.8	11.0	0.0	11.0	-5.0	150.0	329.8
100/04-13-081-06 W4/00	04-13-081-06 W4	6207584	511821	481.6	316.5			21.0	103.0	378.6	124.0	357.6	131.0	350.6	15.0	0.0	15.0	-5.0	150.0	331.6
100/07-13-081-06 W4/00	07-13-081-06 W4	6207989	512624	483.7	278.0			20.0	104.0	379.7	124.0	359.7	125.0	358.7	18.0	0.0	18.0	-5.0	142.0	341.7
100/07-14-081-06 W4/00	07-14-081-06 W4	6207984	510996	479.0	270.0			22.0	93.0	386.0	115.0	364.0	121.0	358.0	15.0	0.0	15.0	-5.0	140.0	339.0
100/07-15-081-06 W4/00	07-15-081-06 W4	6207980	509369	489.3	275.0			21.0	107.0	382.3	128.0	361.3	134.0	355.3	11.0	0.0	11.0	-5.0	154.0	335.3
100/06-17-081-06 W4/00	06-17-081-06 W4	6207974	505712	502.2	298.0															
100/08-19-081-06 W4/00	08-19-081-06 W4	6209582	504887	519.8	317.0			27.0	140.0	379.8	167.0	352.8	167.0	352.8	17.0	0.0	17.0	-5.0	182.0	337.8
100/14-20-081-06 W4/00	14-20-081-06 W4	6210387	505709	504.1	278.0			17.0	121.0	383.1	138.0	366.1	144.0	360.1	15.0	0.0	15.0	-5.0	164.0	340.1
100/03-21-081-06 W4/00	03-21-081-06 W4	6209183	507338	493.5	277.0			22.0	109.0	384.5	131.0	362.5	131.0	362.5	15.0	0.0	15.0	-5.0	153.0	340.5
100/11-22-081-06 W4/00	11-22-081-06 W4	6209990	508963	480.6	253.0			20.0	95.0	385.6	115.0	365.6	115.0	365.6	14.0	0.0	14.0	-5.0	140.0	340.6
100/07-23-081-06 W4/00	07-23-081-06 W4	6209593	510992	493.6	276.0			21.0	110.0	383.6	131.0	362.6	134.0	359.6	21.0	0.0	21.0	-5.0	153.0	340.6
100/02-25-081-06 W4/00	02-25-081-06 W4	6210824	512615	488.1	296.0			15.0	108.0	380.1	123.0	365.1	131.0	357.1	23.0	0.0	23.0	-5.0	145.0	343.1
100/02-26-081-06 W4/00	02-26-081-06 W4	6210820	510989	489.5	280.0			17.0	105.0	384.5	122.0	367.5	125.0	364.5	18.0	0.0	18.0	-5.0	149.0	340.5
100/12-27-081-06 W4/00	12-27-081-06 W4	6211618	508558	492.4	264.0			24.0	102.0	390.4	126.0	366.4	126.0	366.4	14.0	0.0	14.0	-5.0	152.0	340.4
100/11-28-081-06 W4/00	11-28-081-06 W4	6211616	507333	501.1	273.0			27.0	112.0	389.1	139.0	362.1	139.0	362.1	15.0	0.0	15.0	-5.0	162.0	339.1

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Upper Clearwater Watersand Base (m bKB)	Upper Clearwater Watersand Base (m asl)	Middle Clearwater Watersand Top (m bKB)	Middle Clearwater Watersand Top (m asl)	Middle Clearwater Watersand Base (m bKB)	Middle Clearwater Watersand Base (m asl)	Top Wabiskaw (m bKB)	Top Wabiskaw (m asl)	Top McMurray (m bKB)	Top McMurray (m asl)	Paleo Surface (m bKB)	Paleo Surface (m asl)	Watersand Thickness (m)	Watersand Thickness (Surfer) (m)	Watersand Surface Elevation (m asl)	Log Analysis Notes:
100/09-12-080-13W400	09-12-080-13W4							442.3	259.1	454.8	246.6	503.2	198.2	5.0	5.0	203.2	
100/11-15-080-13W400	11-15-080-13W4							432.6	255.4	442.7	245.4	493.0	195.0	0.0	-5.0	195.0	
100/05-16-080-13W400	05-16-080-13W4							429.1	260.7	440.8	249.0	492.5	197.4	4.4	4.4	201.7	
100/08-18-080-13W400	08-18-080-13W4							428.4	258.0	441.9	244.5	491.6	194.8	1.0	1.0	195.8	
100/01-19-080-13W400	01-19-080-13W4							438.7	254.5	450.7	242.5						
100/05-20-080-13W400	05-20-080-13W4							431.9	261.0	444.3	248.6	494.7	198.2	0.0	-5.0	198.2	
100/05-21-080-13W400	05-21-080-13W4							428.5	262.9	440.8	250.6	492.0	199.4	0.0	-5.0	199.4	
100/10-23-080-13W400	10-23-080-13W4							444.8	255.0	455.1	244.8						
100/11-27-080-13W400	11-27-080-13W4							437.8	260.9	451.4	247.2						
100/12-28-080-13W400	12-28-080-13W4							440.4	259.9	453.5	246.7						
100/02-29-080-13W400	02-29-080-13W4							439.5	262.1	452.0	249.6	500.2	201.4	0.0	-5.0	201.4	
100/03-30-080-13W400	03-30-080-13W4							440.7	258.2	454.2	244.7	499.3	199.6	0.0	-5.0	199.6	
100/04-31-080-13W400	04-31-080-13W4							429.9	261.8	442.2	249.5	496.6	195.2	8.0	8.0	203.2	
100/05-32-080-13W400	05-32-080-13W4							428.2	263.3	439.8	251.7	491.3	200.2	5.0	5.0	205.2	
100/10-03-080-14 W4/00	10-03-080-14 W4							450.0	250.1	458.0	242.1	510.0	190.1	10.0	10.0	200.1	
1AA/10-08-080-14 W4/00	10-08-080-14 W4							408.0	244.5	417.0	235.5	469.0	183.5	0.0	-5.0	183.5	
100/10-10-080-14 W4/00	10-10-080-14 W4							432.0	252.0	441.0	243.0	481.0	203.0	0.0	-5.0	203.0	
100/06-11-080-14 W4/00	06-11-080-14 W4							439.0	252.1	447.0	244.1	497.0	194.1	2.0	2.0	196.1	
100/07-14-080-14 W4/00	07-14-080-14 W4							434.0	256.6	442.0	248.6	495.0	195.6	4.0	4.0	199.6	
100/07-15-080-14 W4/00	07-15-080-14 W4							421.0	257.6	429.0	249.6	488.0	190.6	3.0	3.0	193.6	
100/07-17-080-14 W4/00	07-17-080-14 W4							403.0	247.5	411.0	239.5	460.0	190.5	0.0	-5.0	190.5	
100/10-20-080-14 W4/00	10-20-080-14 W4							393.0	253.2	402.0	244.2	453.0	193.2	0.0	-5.0	193.2	
100/06-22-080-14 W4/00	06-22-080-14 W4							411.0	256.5	420.0	247.5	474.0	193.5	0.0	-5.0	193.5	
100/01-27-080-14 W4/00	01-27-080-14 W4							410.0	257.1	418.0	249.1	471.0	196.1	0.0	-5.0	196.1	
100/10-35-080-14 W4/00	10-35-080-14 W4							400.0	262.5	408.0	254.5	465.0	197.5	0.0	-5.0	197.5	
100/04-01-080-14W400	04-01-080-14W4							450.7	250.3	463.7	237.3						
100/06-12-080-14W400	06-12-080-14W4							447.1	250.7	460.6	237.2	505.6	192.3	0.0	-5.0	192.3	
100/11-12-080-14W400	11-12-080-14W4							440.5	251.8	453.4	238.9	497.8	194.5	0.0	-5.0	194.5	
100/10-13-080-14W400	10-13-080-14W4							444.5	253.5	457.5	240.5	501.6	196.4	0.0	-5.0	196.4	
100/16-25-080-14W400	16-25-080-14W4							430.1	259.5	442.3	247.3						
100/11-36-080-14W400	11-36-080-14W4							417.2	259.5	429.5	247.2						
102/15-02-081-06 W4/00	15-02-081-06 W4							202.0	284.4	217.0	269.4	285.0	201.4	0.0	-5.0	201.4	
100/11-03-081-06 W4/00	11-03-081-06 W4							204.0	291.3	219.0	276.3	287.0	208.3	0.0	-5.0	208.3	gamma runs high
100/07-04-081-06 W4/00	07-04-081-06 W4							212.0	289.0	226.0	275.0	286.0	215.0	0.0	-5.0	215.0	no grand rapids on log
100/07-05-081-06 W4/00	07-05-081-06 W4							221.0	290.8	236.0	275.8	292.0	219.8	4.0	4.0	223.8	gamma runs high
100/07-06-081-06 W4/00	07-06-081-06 W4							236.0	286.7	250.0	272.7	307.0	215.7	0.0	-5.0	215.7	
100/15-06-081-06 W4/00	15-06-081-06 W4							235.0	287.4	250.0	272.4	311.0	211.4	4.0	4.0	215.4	
100/07-07-081-06 W4/00	07-07-081-06 W4							232.0	284.1	242.0	274.1	301.0	215.1	4.0	4.0	219.1	
100/09-08-081-06 W4/00	09-08-081-06 W4							213.0	288.1	227.0	274.1	285.0	216.1	0.0	-5.0	216.1	no grand rapids on log
100/11-09-081-06 W4/00	11-09-081-06 W4							206.0	288.8	220.0	274.8	280.0	214.8	4.0	4.0	218.8	
100/10-10-081-06 W4/00	10-10-081-06 W4							199.0	285.2	214.0	270.2	265.0	219.2	0.0	-5.0	219.2	
100/11-12-081-06 W4/00	11-12-081-06 W4	161.0	318.8					193.0	286.8	207.0	272.8	279.0	200.8	0.0	-5.0	200.8	
100/04-13-081-06 W4/00	04-13-081-06 W4	165.0	316.6					199.0	282.6	214.0	267.6	290.0	191.6	4.0	4.0	195.6	
100/07-13-081-06 W4/00	07-13-081-06 W4	160.0	323.7					191.0	292.7	207.0	276.7	270.0	213.7	0.0	-5.0	213.7	
100/07-14-081-06 W4/00	07-14-081-06 W4	155.0	324.0					187.0	292.0	207.0	272.0	263.0	216.0	0.0	-5.0	216.0	
100/07-15-081-06 W4/00	07-15-081-06 W4	165.0	324.3					197.0	292.3	213.0	276.3	266.0	223.3	5.0	5.0	228.3	
100/06-17-081-06 W4/00	06-17-081-06 W4							213.0	289.2	228.0	274.2	292.0	210.2	0.0	-5.0	210.2	no grand rapids on log
100/08-19-081-06 W4/00	08-19-081-06 W4	199.0	320.8					231.0	288.8	247.0	272.8	302.0	217.8	3.0	3.0	220.8	
100/14-20-081-06 W4/00	14-20-081-06 W4	179.0	325.1					210.0	294.1	226.0	278.1	277.0	227.1	0.0	-5.0	227.1	
100/03-21-081-06 W4/00	03-21-081-06 W4	168.0	325.5					200.0	293.5	219.0	274.5	268.0	225.5	0.0	-5.0	225.5	
100/11-22-081-06 W4/00	11-22-081-06 W4	154.0	326.6					189.0	291.6	205.0	275.6	245.0	235.6	0.0	-5.0	235.6	
100/07-23-081-06 W4/00	07-23-081-06 W4	174.0	319.6					206.0	287.6	221.0	272.6	272.0	221.6				
100/02-25-081-06 W4/00	02-25-081-06 W4	168.0	320.1					199.0	289.1	215.0	273.1	291.0	197.1	0.0	-5.0	197.1	
100/02-26-081-06 W4/00	02-26-081-06 W4	167.0	322.5					198.0	291.5	215.0	274.5	272.0	217.5	0.0	-5.0	217.5	
100/12-27-081-06 W4/00	12-27-081-06 W4	166.0	326.4					197.0	295.4	214.0	278.4	253.0	239.4	0.0	-5.0	239.4	
100/11-28-081-06 W4/00	11-28-081-06 W4	177.0	324.1					208.0	293.1	225.0	276.1	271.0	230.1	0.0	-5.0	230.1	

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Northing (m) NAD 27	Easting (m) NAD 27	KB (m asl)	TD (m)	Top Grand Rapids (m bKB)	Top Grand Rapids (m asl)	Grand Rapids Watersand Thickness (m)	Grand Rapids Watersand Top (m bKB)	Grand Rapids Watersand Top (m asl)	Grand Rapids Watersand Base (m bKB)	Grand Rapids Watersand Base (m asl)	Top Clearwater (m bKB)	Top Clearwater (m asl)	Upper Clearwater Watersand Thickness (m)	Middle Clearwater Watersand Thickness (m)	Upper Clearwater Watersand Thickness (Surfer) (m)	Middle Clearwater Watersand Thickness (Surfer) (m)	Upper Clearwater Watersand Top (m bKB)	Upper Clearwater Watersand Top (m asl)
1AA/12-30-081-06 W4/00	12-30-081-06 W4	6211611	503680	579.2	374.0	143.0	436.2	20.0	202.0	377.2	222.0	357.2	230.0	349.2	17.0	0.0	17.0	-5.0	248.0	331.2
100/03-32-081-06 W4/00	03-32-081-06 W4	6212418	505706	511.1	289.0			22.0	130.0	381.1	152.0	359.1	153.0	358.1	15.0	0.0	15.0	-5.0	170.0	341.1
100/08-33-081-06 W4/00	08-33-081-06 W4	6212824	508134	497.9	265.0			18.0	114.0	383.9	132.0	365.9	132.0	365.9	12.0	0.0	12.0	-5.0	158.0	339.9
100/11-34-081-06 W4/00	11-34-081-06 W4	6213228	508956	490.8	253.0			13.0	105.0	385.8	118.0	372.8	124.0	366.8	10.0	0.0	10.0	-5.0	151.0	339.8
100/09-36-081-06 W4/00	09-36-081-06 W4	6213238	513010	481.8	263.5			18.0	105.0	376.8	123.0	358.8	123.0	358.8	17.0	0.0	17.0	-5.0	145.0	336.8
100/07-02-081-07 W4/00	07-02-081-07 W4	6204733	501232	594.0	400.0	158.0	436.0	26.0	220.0	374.0	246.0	348.0	247.0	347.0	0.0	0.0	-5.0	-5.0		
1AA/10-05-081-07 W4/00	10-05-081-07 W4	6205137	496346	644.5	438.0	213.0	431.5	19.0	270.0	374.5	289.0	355.5	289.0	355.5	0.0	0.0	-5.0	-5.0		
100/08-07-081-07 W4/00	08-07-081-07 W4	6206345	495121	656.6	457.0	223.0	433.6	15.0	281.0	375.6	296.0	360.6	300.0	356.6	0.0	0.0	-5.0	-5.0		
100/05-10-081-07 W4/00	05-10-081-07 W4	6206342	498799	610.5	410.0	177.0	433.5	29.0	236.0	374.5	265.0	345.5	265.0	345.5	0.0	0.0	-5.0	-5.0		
100/08-11-081-07 W4/00	08-11-081-07 W4	6206342	501633	603.2	408.0	169.0	434.2	21.0	231.0	372.2	252.0	351.2	259.0	344.2	0.0	0.0	-5.0	-5.0		
100/07-12-081-07 W4/00	07-12-081-07 W4	6206343	502859	551.4	365.0	119.0	432.4	17.0	178.0	373.4	195.0	356.4	203.0	348.4	0.0	0.0	-5.0	-5.0		
100/12-13-081-07 W4/00	12-13-081-07 W4	6208373	502054	614.2	418.0	176.0	438.2	26.0	237.0	377.2	263.0	351.2	264.0	350.2	5.0	0.0	5.0	-5.0	289.0	325.2
1AA/15-13-081-07 W4/00	15-13-081-07 W4	6208776	502858	618.5	419.0	180.0	438.5	21.0	240.0	378.5	261.0	357.5	267.0	351.5	0.0	0.0	-5.0	-5.0		
100/14-15-081-07 W4/00	14-15-081-07 W4	6208775	499202	627.8	431.0	189.0	438.8	19.0	252.0	375.8	271.0	356.8	277.0	350.8	0.0	0.0	-5.0	-5.0		
100/10-16-081-07 W4/00	10-16-081-07 W4	6208373	497976	654.3	462.0	217.0	437.3	20.0	278.0	376.3	298.0	356.3	304.0	350.3	0.0	0.0	-5.0	-5.0		
100/06-17-081-07 W4/00	06-17-081-07 W4	6207973	495947	650.9	457.0	217.0	433.9	19.0	278.0	372.9	297.0	353.9	303.0	347.9	0.0	0.0	-5.0	-5.0		
100/11-20-081-07 W4/00	11-20-081-07 W4	6209983	495949	683.4	485.0	245.0	438.4	15.0	303.0	380.4	318.0	365.4	327.0	356.4	8.0	0.0	8.0	-5.0	351.0	332.4
100/11-22-081-07 W4/00	11-22-081-07 W4	6209982	499202	638.0	431.0	204.0	434.0	16.0	259.0	379.0	275.0	363.0	283.0	355.0	15.0	0.0	15.0	-5.0	300.0	338.0
100/10-23-081-07 W4/00	10-23-081-07 W4	6209982	501230	634.0	437.0	197.0	437.0	24.0	258.0	376.0	282.0	352.0	282.0	352.0	12.0	0.0	12.0	-5.0	304.0	330.0
1AA/10-26-081-07 W4/00	10-26-081-07 W4	6211610	501230	632.5	437.0	196.0	436.5	16.0	259.0	373.5	275.0	357.5	282.0	350.5	15.0	0.0	15.0	-5.0	303.0	329.5
100/07-27-081-07 W4/00	07-27-081-07 W4	6211208	499604	654.5	477.0	213.0	441.5	19.0	271.0	383.5	290.0	364.5	296.0	358.5	14.0	0.0	14.0	-5.0	317.0	337.5
100/10-27-081-07 W4/00	10-27-081-07 W4	6211610	499604	659.7	510.0	222.0	437.7	17.0	281.0	378.7	298.0	361.7	305.0	354.7	12.0	0.0	12.0	-5.0	328.0	331.7
100/06-29-081-07 W4/00	06-29-081-07 W4	6211210	495950	691.4	482.0	253.0	438.4	15.0	310.0	381.4	325.0	366.4	325.0	366.4	13.0	0.0	13.0	-5.0	353.0	338.4
100/06-30-081-07 W4/00	06-30-081-07 W4	6211212	494324	707.6	497.0	269.0	438.6	12.0	329.0	378.6	341.0	366.6	341.0	366.6	18.0	0.0	18.0	-5.0	367.0	340.6
100/08-33-081-07 W4/00	08-33-081-07 W4	6212817	498380	687.9	527.0	252.0	435.9	17.0	315.0	372.9	332.0	355.9	332.0	355.9	19.0	0.0	19.0	-5.0	359.0	328.9
100/08-34-081-07 W4/00	08-34-081-07 W4	6212817	500005	678.3	472.0	238.0	440.3	18.0	296.0	382.3	314.0	364.3	314.0	364.3	16.0	0.0	16.0	-5.0	341.0	337.3
100/11-36-081-07 W4/00	11-36-081-07 W4	6213220	502453	651.4	440.0	209.0	442.4	22.0	268.0	383.4	290.0	361.4	290.0	361.4	19.0	0.0	19.0	-5.0	309.0	342.4
100/14-01-081-08W400	14-01-081-08W4	6205651	492825	677.7	455.0	245.4	432.3	15.0	300.0	377.7	315.0	362.7	330.3	347.4	0.0	0.0	-5.0	-5.0		
100/09-02-081-08W400	09-02-081-08W4	6205469	491648	690.7	460.0	256.0	434.7	15.0	315.0	375.7	330.0	360.7	345.6	345.2	0.0	0.0	-5.0	-5.0		
100/01-04-081-08W400	01-04-081-08W4	6204773	488531	720.4	500.0	286.3	434.1	20.0	339.0	381.4	359.0	361.4	373.7	346.7	0.0	0.0	-5.0	-5.0		
1AA/04-04-081-08W400	04-04-081-08W4	6204576	487350	731.4	505.9	297.1	434.3	30.0	342.0	389.4	372.0	359.4	384.8	346.6	0.0	0.0	-5.0	-5.0		
1AA/10-04-081-08W400	10-04-081-08W4	6205377	488156	723.9	515.0	291.6	432.3	28.0	337.0	386.9	365.0	358.9	377.8	346.1	0.0	0.0	-5.0	-5.0		
1AA/12-04-081-08W400	12-04-081-08W4	6205380	487352	738.3	528.4	301.0	437.3	25.0	351.0	387.3	376.0	362.3	388.8	349.4	0.0	0.0	-5.0	-5.0		
1AA/14-04-081-08W400	14-04-081-08W4	6205881	487755	730.3	508.3	292.7	437.7	25.0	344.0	386.3	369.0	361.3	381.9	348.5	0.0	0.0	-5.0	-5.0		
1AA/16-04-081-08W400	16-04-081-08W4	6205779	488559	731.2	511.4	297.8	433.3	32.0	341.0	390.2	373.0	358.2	386.4	344.8	0.0	0.0	-5.0	-5.0		
1AA/04-05-081-08W400	04-05-081-08W4	6204545	485720	735.4	510.5	298.8	436.6	31.0	344.0	391.4	375.0	360.4	387.8	347.6	0.0	0.0	-5.0	-5.0		
100/06-05-081-08W400	06-05-081-08W4	6205175	486108	743.8	512.0	307.6	436.2	31.0	351.0	392.8	382.0	361.8	394.8	349.0	0.0	0.0	-5.0	-5.0		
1AA/08-05-081-08W400	08-05-081-08W4	6205039	486929	738.5	514.8	302.4	436.2	28.0	350.0	388.5	378.0	360.5	390.8	347.8	0.0	0.0	-5.0	-5.0		
1AA/10-05-081-08W400	10-05-081-08W4	6205382	486528	740.6	531.6	303.4	437.3	32.0	347.0	393.6	379.0	361.6	392.1	348.6	0.0	0.0	-5.0	-5.0		
1AA/12-05-081-08W400	12-05-081-08W4	6205364	485709	747.7	525.5	309.6	438.1	34.0	352.0	395.7	386.0	361.7	394.6	353.1	0.0	0.0	-5.0	-5.0		
1AA/14-05-081-08W400	14-05-081-08W4	6205791	486127	745.1	525.9	304.9	440.2	35.0	351.0	394.1	386.0	359.1	397.9	347.2	0.0	0.0	-5.0	-5.0		
1AA/16-05-081-08W400	16-05-081-08W4	6205783	486931	738.9	525.6	302.4	436.5	30.0	347.0	391.9	377.0	361.9	389.9	349.0	0.0	0.0	-5.0	-5.0		
1AA/03-06-081-08W400	03-06-081-08W4	6204583	484534	732.0	506.8	295.3	436.6	32.0	340.0	392.0	372.0	360.0	380.0	352.0	0.0	0.0	-5.0	-5.0		
100/05-06-081-08W400	05-06-081-08W4	6205069	484204	732.9	520.0	301.1	431.8	28.0	341.0	391.9	369.0	363.9	386.1	346.8	0.0	0.0	-5.0	-5.0		
1AA/07-06-081-08W400	07-06-081-08W4	6204984	484898	735.0	511.0	295.3	439.7	31.0	343.0	392.0	374.0	361.0	385.6	349.4	0.0	0.0	-5.0	-5.0		
1AA/08-06-081-08W400	08-06-081-08W4	6204983	485299	738.9	515.4	307.0	432.0	33.0	346.0	392.9	379.0	359.9	387.6	351.4	0.0	0.0	-5.0	-5.0		
1AA/11-06-081-08W400	11-06-081-08W4	6205387	484497	737.7	517.1	300.9	436.8	31.0	347.0	390.7	378.0	359.7	389.2	348.5	0.0	0.0	-5.0	-5.0		
1AA/13-06-081-08W400	13-06-081-08W4	6205790	484190	734.2	518.0	300.1	434.1	28.0	352.0	382.2	380.0	354.2	390.5	343.6	0.0	0.0	-5.0	-5.0		
1AA/15-06-081-08W400	15-06-081-08W4	6205788	484901	742.6	521.6	305.9	436.7	31.0	354.0	388.6	385.0	357.6	396.2	346.4	0.0	0.0	-5.0	-5.0		
1AA/01-07-081-08W400	01-07-081-08W4	6206188	485304	744.3	520.3	310.1	434.2	31.0	356.0	388.3	387.0	357.3	398.5	345.8	0.0	0.0	-5.0	-5.0		
1AA/01-08-081-08W400	01-08-081-08W4	6206185	486931	737.3	513.0	301.6	435.7	31.0	346.0	391.3	377.0	360.3	389.9	347.4	0.0	0.0	-5.0	-5.0		
1AA/02-09-081-08W400	02-09-081-08W4	6206182	488158	735.9	520.8	298.6	437.3	30.0	344.0	391.9	374.0	361.9	388.5	347.4	0.0	0.0	-5.0	-5.0		
1AA/04-09-081-08W400	04-09-081-08W4	6206184	487354	735.2	521.0	299.2	436.0	28.0	346.0	389.2	374.0	361.2	387.9	347.3	0.0	0.0	-5.0	-5.0		
100/06-09-081-08W400	06-09-081-08W4	6206560	487832	735.9	522.0	299.0	436.9	33.0	341.0	394.9	374.0	361.9	388.2	347.7	0.0	0.0	-5.0	-5.0		
1AA/08-09-081-08W400	08-09-081-08W4	6206580	488561	734.5	517.3	299.7	434.8	28.0	349.0	385.5	377.0	357.5	390.1	344.4	0.0	0.0	-5.0	-5.0		
1AA/10-09-081-08W400	10-09-081-08W4	6206926	488156	740.7	531.4	304.4	436.3	37.0	344.0	396.7	381.0	359.7	394.4	346.3	0.0	0.0	-5.0	-5.0		

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Upper Clearwater Watersand Base (m bKB)	Upper Clearwater Watersand Base (m asl)	Middle Clearwater Watersand Top (m bKB)	Middle Clearwater Watersand Top (m asl)	Middle Clearwater Watersand Base (m bKB)	Middle Clearwater Watersand Base (m asl)	Top Wabiskaw (m bKB)	Top Wabiskaw (m asl)	Top McMurray (m bKB)	Top McMurray (m asl)	Paleo Surface (m bKB)	Paleo Surface (m asl)	Watersand Thickness (m)	Watersand Thickness (Surfer) (m)	Watersand Surface Elevation (m asl)	Log Analysis Notes:
1AA/12-30-081-06 W4/00	12-30-081-06 W4	265.0	314.2					298.0	281.2	308.0	271.2	359.0	220.2	0.0	-5.0	220.2	
100/03-32-081-06 W4/00	03-32-081-06 W4	185.0	326.1					219.0	292.1	236.0	275.1	282.0	229.1	0.0	-5.0	229.1	
100/08-33-081-06 W4/00	08-33-081-06 W4	170.0	327.9					201.0	296.9	218.0	279.9	257.0	240.9	0.0	-5.0	240.9	
100/11-34-081-06 W4/00	11-34-081-06 W4	161.0	329.8					191.0	299.8	207.0	283.8	246.0	244.8	0.0	-5.0	244.8	
100/09-36-081-06 W4/00	09-36-081-06 W4	162.0	319.8					193.0	288.8	208.0	273.8	261.0	220.8	0.0	-5.0	220.8	
100/07-02-081-07 W4/00	07-02-081-07 W4							309.0	285.0	323.0	271.0	388.0	206.0	3.0	3.0	209.0	
1AA/10-05-081-07 W4/00	10-05-081-07 W4							359.0	285.5	371.0	273.5	432.0	212.5	0.0	-5.0	212.5	
100/08-07-081-07 W4/00	08-07-081-07 W4							366.0	290.6	381.0	275.6	443.0	213.6	0.0	-5.0	213.6	
100/05-10-081-07 W4/00	05-10-081-07 W4							330.0	280.5	339.0	271.5	396.0	214.5	4.0	4.0	218.5	
100/08-11-081-07 W4/00	08-11-081-07 W4							325.0	278.2	338.0	265.2	393.0	210.2	10.0	10.0	220.2	
100/07-12-081-07 W4/00	07-12-081-07 W4							269.0	282.4	289.0	262.4	339.0	212.4	2.0	2.0	214.4	
100/12-13-081-07 W4/00	12-13-081-07 W4	294.0	320.2					329.0	285.2	344.0	270.2	403.0	211.2	5.0	5.0	216.2	
1AA/15-13-081-07 W4/00	15-13-081-07 W4							332.0	286.5	341.0	277.5	404.0	214.5	4.0	4.0	218.5	
100/14-15-081-07 W4/00	14-15-081-07 W4							340.0	287.8	353.0	274.8	417.0	210.8	0.0	-5.0	210.8	
100/10-16-081-07 W4/00	10-16-081-07 W4							367.0	287.3	381.0	273.3	445.0	209.3	7.0	7.0	216.3	
100/06-17-081-07 W4/00	06-17-081-07 W4							366.0	284.9	379.0	271.9	441.0	209.9	3.0	3.0	212.9	
100/11-20-081-07 W4/00	11-20-081-07 W4	359.0	324.4					393.0	290.4	407.0	276.4	465.0	218.4	0.0	-5.0	218.4	
100/11-22-081-07 W4/00	11-22-081-07 W4	315.0	323.0					347.0	291.0	362.0	276.0	427.0	211.0	0.0	-5.0	211.0	
100/10-23-081-07 W4/00	10-23-081-07 W4	316.0	318.0					347.0	287.0	363.0	271.0	423.0	211.0	9.0	9.0	220.0	
1AA/10-26-081-07 W4/00	10-26-081-07 W4	318.0	314.5					352.0	280.5	361.0	271.5	423.0	209.5	12.0	12.0	221.5	
100/07-27-081-07 W4/00	07-27-081-07 W4	331.0	323.5					363.0	291.5	382.0	272.5	440.0	214.5	0.0	-5.0	214.5	
100/10-27-081-07 W4/00	10-27-081-07 W4	340.0	319.7					374.0	285.7	389.0	270.7	447.0	212.7	0.0	-5.0	212.7	
100/06-29-081-07 W4/00	06-29-081-07 W4	366.0	325.4					399.0	292.4	411.0	280.4	476.0	215.4	7.0	7.0	222.4	
100/06-30-081-07 W4/00	06-30-081-07 W4	385.0	322.6					416.0	291.6	428.0	279.6	495.0	212.6	6.0	6.0	218.6	
100/08-33-081-07 W4/00	08-33-081-07 W4	378.0	309.9									476.0	211.9	8.0	8.0	219.9	
100/08-34-081-07 W4/00	08-34-081-07 W4	357.0	321.3					388.0	290.3	404.0	274.3	463.0	215.3	6.0	6.0	221.3	
100/11-36-081-07 W4/00	11-36-081-07 W4	328.0	323.4					358.0	293.4	367.0	284.4	434.0	217.4	4.0	4.0	221.4	
100/14-01-081-08W400	14-01-081-08W4							387.2	290.5	399.0	278.7						
100/09-02-081-08W400	09-02-081-08W4							402.0	288.7	414.2	276.5						
100/01-04-081-08W400	01-04-081-08W4							429.0	291.4	442.0	278.4	484.9	235.5	0.0	-5.0	235.5	
1AA/04-04-081-08W400	04-04-081-08W4							439.9	291.5	451.7	279.7	492.7	238.7	0.0	-5.0	238.7	
1AA/10-04-081-08W400	10-04-081-08W4							432.6	291.4	444.3	279.6	493.8	230.2	0.0	-5.0	230.2	
1AA/12-04-081-08W400	12-04-081-08W4							444.4	293.9	457.7	280.6	505.3	232.9	0.0	-5.0	232.9	
1AA/14-04-081-08W400	14-04-081-08W4							437.0	293.3	447.3	283.0	501.0	229.4	0.0	-5.0	229.4	
1AA/16-04-081-08W400	16-04-081-08W4							442.6	288.5	453.9	277.2	500.0	231.2	0.0	-5.0	231.2	
1AA/04-05-081-08W400	04-05-081-08W4							443.0	292.4	453.5	281.9	501.2	234.2	0.0	-5.0	234.2	
100/06-05-081-08W400	06-05-081-08W4							450.0	293.8	462.0	281.8	511.6	232.2	0.0	-5.0	232.2	
1AA/08-05-081-08W400	08-05-081-08W4							446.0	292.5	459.3	279.3	503.7	234.8	0.0	-5.0	234.8	
1AA/10-05-081-08W400	10-05-081-08W4							446.5	294.1	458.1	282.5	513.6	227.1	0.0	-5.0	227.1	
1AA/12-05-081-08W400	12-05-081-08W4							454.0	293.7	465.2	282.6	513.8	233.9	2.0	2.0	235.9	
1AA/14-05-081-08W400	14-05-081-08W4							453.1	292.1	465.0	280.1	509.8	235.3	2.0	2.0	237.3	
1AA/16-05-081-08W400	16-05-081-08W4							445.3	293.7	457.8	281.1	514.0	224.9	2.0	2.0	226.9	
1AA/03-06-081-08W400	03-06-081-08W4							440.1	291.9	451.0	280.9	494.7	237.2	0.0	-5.0	237.2	
100/05-06-081-08W400	05-06-081-08W4							437.2	295.7	447.5	285.4	495.6	237.3	0.0	-5.0	237.3	
1AA/07-06-081-08W400	07-06-081-08W4							441.2	293.8	450.1	284.9	499.5	235.5	0.0	-5.0	235.5	
1AA/08-06-081-08W400	08-06-081-08W4							446.5	292.4	454.5	284.4	506.3	232.6	0.0	-5.0	232.6	
1AA/11-06-081-08W400	11-06-081-08W4							444.0	293.7	454.1	283.7	503.5	234.2	0.0	-5.0	234.2	
1AA/13-06-081-08W400	13-06-081-08W4							447.0	287.2	457.9	276.2	504.5	229.7	4.0	4.0	233.7	
1AA/15-06-081-08W400	15-06-081-08W4							452.2	290.4	462.4	280.2	510.6	232.0	3.0	3.0	235.0	
1AA/01-07-081-08W400	01-07-081-08W4							455.0	289.3	466.5	277.8	511.5	232.8	2.0	2.0	234.8	
1AA/01-08-081-08W400	01-08-081-08W4							446.6	290.7	458.8	278.5	505.0	232.3	0.0	-5.0	232.3	
1AA/02-09-081-08W400	02-09-081-08W4							444.0	291.9	455.7	280.3	505.8	230.1	0.0	-5.0	230.1	
1AA/04-09-081-08W400	04-09-081-08W4							443.4	291.8	455.3	279.9	507.9	227.4	0.0	-5.0	227.4	
100/06-09-081-08W400	06-09-081-08W4							443.3	292.6	455.8	280.1	506.4	229.5	2.0	2.0	231.5	
1AA/08-09-081-08W400	08-09-081-08W4							447.6	286.9	458.3	276.2	506.9	227.6	0.0	-5.0	227.6	
1AA/10-09-081-08W400	10-09-081-08W4							449.9	290.8	461.8	278.9	513.9	226.8	0.0	-5.0	226.8	

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Northing (m) NAD 27	Easting (m) NAD 27	KB (m asl)	TD (m)	Top Grand Rapids (m bKB)	Top Grand Rapids (m asl)	Grand Rapids Watersand Thickness (m)	Grand Rapids Watersand Top (m bKB)	Grand Rapids Watersand Top (m asl)	Grand Rapids Watersand Base (m bKB)	Grand Rapids Watersand Base (m asl)	Top Clearwater (m bKB)	Top Clearwater (m asl)	Upper Clearwater Watersand Thickness (m)	Middle Clearwater Watersand Thickness (m)	Upper Clearwater Watersand Thickness (Surfer) (m)	Middle Clearwater Watersand Thickness (Surfer) (m)	Upper Clearwater Watersand Top (m bKB)	Upper Clearwater Watersand Top (m asl)
1AA/12-09-081-08W400	12-09-081-08W4	6206988	487356	745.7	525.9	311.2	434.5	36.0	350.0	395.7	386.0	359.7	399.4	346.3	0.0	0.0	-5.0	-5.0		
1AA/14-09-081-08W400	14-09-081-08W4	6207389	487759	740.5	521.9	302.1	438.4	34.0	348.0	392.5	382.0	358.5	395.9	344.6	0.0	0.0	-5.0	-5.0		
100/06-11-081-08W400	06-11-081-08W4	6206472	491056	710.5	474.0	276.7	433.8	14.0	336.0	374.5	350.0	360.5	366.0	344.5	0.0	0.0	-5.0	-5.0		
100/11-13-081-08W400	11-13-081-08W4	6208414	492839	717.0	495.0	283.8	433.2	12.0	341.0	376.0	353.0	364.0	371.2	345.8	0.0	0.0	-5.0	-5.0		

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Upper Clearwater Watersand Base (m bKB)	Upper Clearwater Watersand Base (m asl)	Middle Clearwater Watersand Top (m bKB)	Middle Clearwater Watersand Top (m asl)	Middle Clearwater Watersand Base (m bKB)	Middle Clearwater Watersand Base (m asl)	Top Wabiskaw (m bKB)	Top Wabiskaw (m asl)	Top McMurray (m bKB)	Top McMurray (m asl)	Paleo Surface (m bKB)	Paleo Surface (m asl)	Watersand Thickness (m)	Watersand Thickness (Surfer) (m)	Watersand Surface Elevation (m asl)	Log Analysis Notes:
1AA/12-09-081-08W400	12-09-081-08W4							456.5	289.2	468.6	277.1	511.4	234.3	1.0	1.0	235.3	
1AA/14-09-081-08W400	14-09-081-08W4							451.8	288.7	462.0	278.5	515.7	224.8	0.0	-5.0	224.8	
100/06-11-081-08W400	06-11-081-08W4							421.8	288.7	434.0	276.5						
100/11-13-081-08W400	11-13-081-08W4							427.6	289.4	439.7	277.3						

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Northing (m) NAD 27	Easting (m) NAD 27	KB (m asl)	TD (m)	Top Grand Rapids (m bKB)	Top Grand Rapids (m asl)	Grand Rapids Watersand Thickness (m)	Grand Rapids Watersand Top (m bKB)	Grand Rapids Watersand Top (m asl)	Grand Rapids Watersand Base (m bKB)	Grand Rapids Watersand Base (m asl)	Top Clearwater (m bKB)	Top Clearwater (m asl)	Upper Clearwater Watersand Thickness (m)	Middle Clearwater Watersand Thickness (m)	Upper Clearwater Watersand Thickness (Surfer) (m)	Middle Clearwater Watersand Thickness (Surfer) (m)	Upper Clearwater Watersand Top (m bKB)	Upper Clearwater Watersand Top (m asl)
100/10-14-081-08W400	10-14-081-08W4	6208653	491457	729.9	507.0	295.3	434.6	21.0	348.0	381.9	369.0	360.9	384.0	345.9	0.0	0.0	-5.0	-5.0		
100/16-15-081-08W400	16-15-081-08W4	6208902	490085	734.6	527.0	299.1	435.5	29.0	344.0	390.6	373.0	361.6	388.1	346.5	0.0	0.0	-5.0	-5.0		
1AA/06-16-081-08W400	06-16-081-08W4	6208219	487766	737.6	530.4	302.9	434.7	32.0	346.0	391.6	378.0	359.6	387.1	350.4	0.0	0.0	-5.0	-5.0		
1AA/09-16-081-08W400	09-16-081-08W4	6208487	488583	734.8	523.1	294.9	439.9	33.0	341.0	393.8	374.0	360.8	387.1	347.7	0.0	0.0	-5.0	-5.0		
100/16-16-081-08W400	16-16-081-08W4	6208835	488454	737.2	515.0	299.1	438.1	32.0	342.0	395.2	374.0	363.2	387.4	349.8	0.0	0.0	-5.0	-5.0		
1AA/07-17-081-08W400	07-17-081-08W4	6208217	486536	735.8	517.4	303.2	432.6	31.0	351.0	384.8	382.0	353.8	391.7	344.1	0.0	0.0	-5.0	-5.0		
1AA/12-17-081-08W400	12-17-081-08W4	6208578	485710	724.9	509.5	294.3	430.6	32.0	341.0	383.9	373.0	351.9	381.5	343.5	0.0	0.0	-5.0	-5.0		
100/07-18-081-08W400	07-18-081-08W4	6208114	485014	726.9	507.8	296.7	430.2	29.0	345.0	381.9	374.0	352.9	382.8	344.1	0.0	0.0	-5.0	-5.0		
100/09-19-081-08W400	09-19-081-08W4	6210180	485277	714.4	494.0	273.7	440.7	23.0	322.0	392.4	345.0	369.4	360.1	354.3	0.0	0.0	-5.0	-5.0		
100/10-20-081-08W400	10-20-081-08W4	6210175	486475	716.5	489.0	277.3	439.2	28.0	328.0	388.5	356.0	360.5	361.9	354.6	0.0	0.0	-5.0	-5.0		
100/03-21-081-08W400	03-21-081-08W4	6209581	487613	727.6	508.4	295.4	432.2	28.0	343.0	384.6	371.0	356.6	382.4	345.2	0.0	0.0	-5.0	-5.0		
100/08-21-081-08W400	08-21-081-08W4	6209793	488446	729.0	508.0	293.7	435.4	27.0	339.0	390.0	366.0	363.0	378.5	350.5	12.0	0.0	12.0	-5.0	389.0	340.0
100/11-22-081-08W400	11-22-081-08W4	6210307	489554	724.7	514.0	287.6	437.1	30.0	331.0	393.7	361.0	363.7	375.4	349.3	0.0	0.0	-5.0	-5.0		
1AA/10-23-081-08W400	10-23-081-08W4	6210370	491578	722.6	501.0	283.9	438.7	27.0	330.0	392.6	357.0	365.6	372.8	349.8	0.0	0.0	-5.0	-5.0		
100/12-23-081-08W400	12-23-081-08W4	6210329	490660	721.9	505.0	284.9	437.1	30.0	328.0	393.9	358.0	363.9	372.2	349.7	0.0	0.0	-5.0	-5.0		
100/03-24-081-08W400	03-24-081-08W4	6209529	492694	716.1	511.0	283.1	433.0	16.0	337.0	379.1	353.0	363.1	369.8	346.3	0.0	0.0	-5.0	-5.0		
100/11-25-081-08W400	11-25-081-08W4	6211941	492802	722.5	516.0	285.4	437.1	28.0	329.0	393.5	357.0	365.5	372.9	349.6	14.0	0.0	14.0	-5.0	383.0	339.5
100/15-26-081-08W400	15-26-081-08W4	6212063	491425	722.3	504.0	281.7	440.6	26.0	327.0	395.3	353.0	369.3	367.7	354.6	13.0	0.0	13.0	-5.0	380.0	342.3
102/15-27-081-08W400	15-27-081-08W4	6212084	489746	722.3	489.0	281.9	440.4	24.0	333.0	389.3	357.0	365.3	371.4	350.9	0.0	0.0	-5.0	-5.0		
100/15-28-081-08W400	15-28-081-08W4	6212218	488017	714.9	488.0	278.5	436.4	28.0	327.0	387.9	355.0	359.9	360.0	354.9	0.0	0.0	-5.0	-5.0		
100/11-29-081-08W400	11-29-081-08W4	6211957	486045	712.0	494.4	274.3	437.7	12.0	333.0	379.0	345.0	367.0	358.3	353.7	0.0	0.0	-5.0	-5.0		
100/07-31-081-08W400	07-31-081-08W4	6212941	484992	714.5	488.0	277.4	437.1	29.0	319.0	395.5	348.0	366.5	358.7	355.8	7.0	0.0	7.0	-5.0	377.0	337.5
100/06-33-081-08W400	06-33-081-08W4	6212979	487719	716.9	491.3	284.7	432.2	17.0	325.0	391.9	342.0	374.9	358.0	358.9	7.0	0.0	7.0	-5.0	381.0	335.9
100/09-34-081-08W400	09-34-081-08W4	6213417	490013	721.0	504.0	289.2	431.9	15.0	338.0	383.0	353.0	368.0			17.0	0.0	17.0	-5.0	377.0	344.0
100/07-35-081-08W400	07-35-081-08W4	6213000	491350	724.0	505.0	288.0	436.0	28.0	326.0	398.0	354.0	370.0	363.2	360.8	21.0	0.0	21.0	-5.0	377.0	347.0
100/11-36-081-08W400	11-36-081-08W4	6213447	492753	725.1	516.0	296.9	428.2	15.0	340.0	385.1	355.0	370.1	368.2	356.9	11.0	0.0	11.0	-5.0	389.0	336.1
1AA/01-01-081-09W400	01-01-081-09W4	6204455	483670	729.5	509.8	296.1	433.5	31.0	343.0	386.5	374.0	355.5	386.2	343.3	0.0	0.0	-5.0	-5.0		
1AA/03-01-081-09W400	03-01-081-09W4	6204630	482898	722.0	497.5	295.8	426.3	32.0	338.0	384.0	370.0	352.0	374.9	347.1	0.0	0.0	-5.0	-5.0		
100/05-01-081-09W400	05-01-081-09W4	6205060	482481	720.2	497.0	294.2	426.0	30.0	339.0	381.2	369.0	351.2	371.4	348.8	0.0	0.0	-5.0	-5.0		
1AA/07-01-081-09W400	07-01-081-09W4	6205164	483094	726.9	506.5	297.3	429.6	35.0	338.0	388.9	373.0	353.9	376.8	350.1	0.0	0.0	-5.0	-5.0		
1AA/09-01-081-09W400	09-01-081-09W4	6205390	483673	729.2	504.4	291.7	437.5	32.0	341.0	388.2	373.0	356.2	381.9	347.3	0.0	0.0	-5.0	-5.0		
1AA/13-01-081-09W400	13-01-081-09W4	6205781	482486	722.3	506.3	293.1	429.2	32.0	343.0	379.3	375.0	347.3	376.6	345.8	0.0	0.0	-5.0	-5.0		
1AA/15-01-081-09W400	15-01-081-09W4	6205833	483313	727.2	517.1	296.5	430.7	32.0	345.0	382.2	377.0	350.2	383.0	344.2	0.0	0.0	-5.0	-5.0		
1AA/01-02-081-09W400	01-02-081-09W4	6204443	482041	716.3	497.1	290.0	426.3	30.0	332.0	384.3	362.0	354.3	369.7	346.6	0.0	0.0	-5.0	-5.0		
1AA/07-02-081-09W400	07-02-081-09W4	6205067	481570	711.9	496.9	283.6	428.3	32.0	335.0	376.9	367.0	344.9	370.4	341.5	0.0	0.0	-5.0	-5.0		
1AA/09-02-081-09W400	09-02-081-09W4	6205397	482168	718.1	498.5	291.5	426.6	31.0	336.0	382.1	367.0	351.1	368.5	349.6	0.0	0.0	-5.0	-5.0		
1AA/11-02-081-09W400	11-02-081-09W4	6205401	481281	707.1	496.0	276.6	430.5	22.0	325.0	382.1	347.0	360.1	362.1	345.0	0.0	0.0	-5.0	-5.0		
1AA/13-02-081-09W400	13-02-081-09W4	6205805	480840	709.8	498.9	280.8	429.0	24.0	330.0	379.8	354.0	355.8	354.7	355.1	0.0	0.0	-5.0	-5.0		
1AA/15-02-081-09W400	15-02-081-09W4	6205870	481641	715.0	501.1	281.5	433.5	23.0	332.0	383.0	355.0	360.0	360.6	354.4	0.0	0.0	-5.0	-5.0		
100/10-03-081-09W400	10-03-081-09W4	6205366	479920	706.5	499.9	280.3	426.2	28.0	329.0	377.5	357.0	349.5	357.3	349.2	0.0	0.0	-5.0	-5.0		
1AA/15-03-081-09W400	15-03-081-09W4	6205809	480017	704.6	503.5	273.5	431.1	25.0	327.0	377.6	352.0	352.6	364.3	340.3	0.0	0.0	-5.0	-5.0		
100/14-04-081-09W400	14-04-081-09W4	6205806	478069	704.6	496.0	267.2	437.4	36.0	311.0	393.6	347.0	357.6	347.5	357.1	0.0	0.0	-5.0	-5.0		
100/09-05-081-09W400	09-05-081-09W4	6205331	477256	705.0	470.0	266.5	438.5	36.0	313.0	392.0	349.0	356.0	348.8	356.2	0.0	0.0	-5.0	-5.0		
1AA/10-05-081-09W400	10-05-081-09W4	6205350	476827	704.6	495.0	265.2	439.4	38.0	309.0	395.6	347.0	357.6	350.4	354.2	0.0	0.0	-5.0	-5.0		
100/06-07-081-09W400	06-07-081-09W4	6206487	474580	703.0	485.0	264.7	438.3	26.0	320.0	383.0	346.0	357.0	352.8	350.2	0.0	0.0	-5.0	-5.0		
100/06-08-081-09W400	06-08-081-09W4	6206815	476549	701.3	495.3	264.7	436.6	38.0	310.0	391.3	348.0	353.3	353.6	347.7	0.0	0.0	-5.0	-5.0		
100/15-08-081-09W400	15-08-081-09W4	6207278	476808	701.1	496.0	262.1	439.0	41.0	306.0	395.1	347.0	354.1	352.1	349.0	0.0	0.0	-5.0	-5.0		
100/12-09-081-09W400	12-09-081-09W4	6207150	477719	700.9	496.0	259.1	441.8	35.0	305.0	395.9	340.0	360.9	347.1	353.8	0.0	0.0	-5.0	-5.0		
100/13-09-081-09W400	13-09-081-09W4	6207414	477713	702.0	487.7	261.2	440.8	34.0	309.0	393.0	343.0	359.0	347.5	354.5	0.0	0.0	-5.0	-5.0		
1AA/01-10-081-09W400	01-10-081-09W4	6206209	480420	709.5	499.6	278.0	431.4	25.0	329.0	380.5	354.0	355.5	366.2	343.3	0.0	0.0	-5.0	-5.0		
1AA/03-10-081-09W400	03-10-081-09W4	6206255	479708	702.4	483.6	266.5	435.9	29.0	315.0	387.4	344.0	358.4	353.7	348.7	0.0	0.0	-5.0	-5.0		
1AA/07-10-081-09W400	07-10-081-09W4	6206649	480026	708.1	487.0	270.6	437.5	28.0	319.0	389.1	347.0	361.1	356.7	351.4	0.0	0.0	-5.0	-5.0		
100/09-10-081-09W400	09-10-081-09W4	6206910	480453	711.8	487.0	274.1	437.7	28.0	323.0	388.8	351.0	360.8	361.4	350.4	0.0	0.0	-5.0	-5.0		
1AA/11-10-081-09W400	11-10-081-09W4	6207113	479589	705.5	494.4	265.3	440.2	37.0	309.0	396.5	346.0	359.5	354.5	351.0	0.0	0.0	-5.0	-5.0		
1AA/15-10-081-09W400	15-10-081-09W4	6207387	479958	705.3	495.5	267.1	438.2	36.0	313.0	392.3	349.0	356.3	357.8	347.5	0.0	0.0	-5.0	-5.0		
1AA/01-11-081-09W400	01-11-081-09W4	6206201	482048	721.5	498.3	292.5	429.0	18.0	344.0	377.5	362.0	359.5	378.3	343.1	0.0	0.0	-5.0	-5.0		

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Upper Clearwater Watersand Base (m bKB)	Upper Clearwater Watersand Base (m asl)	Middle Clearwater Watersand Top (m bKB)	Middle Clearwater Watersand Top (m asl)	Middle Clearwater Watersand Base (m bKB)	Middle Clearwater Watersand Base (m asl)	Top Wabiskaw (m bKB)	Top Wabiskaw (m asl)	Top McMurray (m bKB)	Top McMurray (m asl)	Paleo Surface (m bKB)	Paleo Surface (m asl)	Watersand Thickness (m)	Watersand Thickness (Surfer) (m)	Watersand Surface Elevation (m asl)	Log Analysis Notes:
100/10-14-081-08W400	10-14-081-08W4							441.1	288.8	453.4	276.5	501.7	228.2	0.0	-5.0	228.2	
100/16-15-081-08W400	16-15-081-08W4							445.4	289.2	458.5	276.1	508.2	226.4	0.0	-5.0	226.4	
1AA/06-16-081-08W400	06-16-081-08W4							448.3	289.2	460.2	277.4	510.0	227.6	0.0	-5.0	227.6	
1AA/09-16-081-08W400	09-16-081-08W4							443.0	291.8			509.0	225.8	0.0	-5.0	225.8	
100/16-16-081-08W400	16-16-081-08W4							442.1	295.1	454.6	282.7	506.9	230.3	0.0	-5.0	230.3	
1AA/07-17-081-08W400	07-17-081-08W4							448.3	287.5	460.0	275.8	508.9	226.9	2.0	2.0	228.9	
1AA/12-17-081-08W400	12-17-081-08W4							436.9	288.0	447.1	277.8	500.8	224.1	11.0	11.0	235.1	
100/07-18-081-08W400	07-18-081-08W4							440.0	286.9	451.4	275.5	496.8	230.1	0.0	-5.0	230.1	
100/09-19-081-08W400	09-19-081-08W4							418.2	296.3	430.3	284.1	479.4	235.0	0.0	-5.0	235.0	
100/10-20-081-08W400	10-20-081-08W4							420.1	296.4	432.8	283.7	479.6	236.9	3.0	3.0	239.9	
100/03-21-081-08W400	03-21-081-08W4							440.8	286.8	452.7	274.9	496.6	231.0	0.0	-5.0	231.0	
100/08-21-081-08W400	08-21-081-08W4	401.0	328.0					435.3	293.7	449.1	279.9	498.3	230.7	1.0	1.0	231.7	
100/11-22-081-08W400	11-22-081-08W4							431.0	293.7	444.5	280.2	495.5	229.2	6.0	6.0	235.2	
1AA/10-23-081-08W400	10-23-081-08W4							431.0	291.6	443.5	279.1	488.1	234.5	0.0	-5.0	234.5	
100/12-23-081-08W400	12-23-081-08W4							428.9	293.0	443.3	278.7	490.1	231.8	0.0	-5.0	231.8	
100/03-24-081-08W400	03-24-081-08W4							427.3	288.8	440.1	276.0	496.7	219.4	5.0	5.0	224.4	
100/11-25-081-08W400	11-25-081-08W4	397.0	325.5					431.3	291.2	443.0	279.5	502.3	220.2	4.0	4.0	224.2	
100/15-26-081-08W400	15-26-081-08W4	393.0	329.3					427.0	295.3	438.2	284.1	488.3	234.0	4.0	4.0	238.0	
102/15-27-081-08W400	15-27-081-08W4							429.9	292.4	442.2	280.1						
100/15-28-081-08W400	15-28-081-08W4							419.9	295.0	433.0	281.9	482.6	232.3	3.0	3.0	235.3	
100/11-29-081-08W400	11-29-081-08W4							418.7	293.3	430.4	281.6	478.7	233.4	0.0	-5.0	233.4	
100/07-31-081-08W400	07-31-081-08W4	384.0	330.5					420.4	294.1	433.0	281.5	480.3	234.2	0.0	-5.0	234.2	
100/06-33-081-08W400	06-33-081-08W4	388.0	328.9					421.0	295.9	432.3	284.6	481.3	235.7	0.0	-5.0	235.7	
100/09-34-081-08W400	09-34-081-08W4	394.0	327.0					425.4	295.6	437.7	283.3	489.2	231.8	0.0	-5.0	231.8	
100/07-35-081-08W400	07-35-081-08W4	398.0	326.0					428.6	295.4			490.4	233.6	5.0	5.0	238.6	
100/11-36-081-08W400	11-36-081-08W4	400.0	325.1					434.1	291.0	446.3	278.8	505.8	219.4	7.0	7.0	226.4	
1AA/01-01-081-09W400	01-01-081-09W4							442.8	286.8	453.2	276.4	496.4	233.1	0.0	-5.0	233.1	
1AA/03-01-081-09W400	03-01-081-09W4							435.8	286.2	446.3	275.8	487.9	234.2	0.0	-5.0	234.2	
100/05-01-081-09W400	05-01-081-09W4							430.0	290.2			489.0	231.2	0.0	-5.0	231.2	
1AA/07-01-081-09W400	07-01-081-09W4							436.0	290.9	447.0	279.9	491.1	235.8	0.0	-5.0	235.8	
1AA/09-01-081-09W400	09-01-081-09W4							437.2	292.0	446.6	282.6	491.3	237.9	0.0	-5.0	237.9	
1AA/13-01-081-09W400	13-01-081-09W4							436.6	285.7	446.7	275.7	497.1	225.3	5.0	5.0	230.3	
1AA/15-01-081-09W400	15-01-081-09W4							438.9	288.3	449.9	277.4	503.3	223.9	4.0	4.0	227.9	
1AA/01-02-081-09W400	01-02-081-09W4							426.2	290.1	436.4	279.9	486.0	230.3	3.0	3.0	233.3	
1AA/07-02-081-09W400	07-02-081-09W4							429.1	282.8	440.0	271.9	484.0	227.9	2.0	2.0	229.9	
1AA/09-02-081-09W400	09-02-081-09W4							427.0	291.1	437.5	280.6	490.6	227.5	0.0	-5.0	227.5	
1AA/11-02-081-09W400	11-02-081-09W4							417.6	289.5	427.9	279.2	482.4	224.7	2.0	2.0	226.7	
1AA/13-02-081-09W400	13-02-081-09W4							423.8	286.0	433.7	276.1	487.4	222.5	0.0	-5.0	222.5	
1AA/15-02-081-09W400	15-02-081-09W4							425.7	289.3	436.4	278.6	490.6	224.4	7.0	7.0	231.4	
100/10-03-081-09W400	10-03-081-09W4							429.0	277.5			489.2	217.3	5.0	5.0	222.3	
1AA/15-03-081-09W400	15-03-081-09W4							421.0	283.6	431.7	272.9	489.8	214.8	0.0	-5.0	214.8	
100/14-04-081-09W400	14-04-081-09W4							414.4	290.2	425.1	279.6	489.3	215.3	0.0	-5.0	215.3	
100/09-05-081-09W400	09-05-081-09W4							415.4	289.6	426.0	279.0						
1AA/10-05-081-09W400	10-05-081-09W4							411.9	292.7	422.0	282.7	476.8	227.8	0.0	-5.0	227.8	
100/06-07-081-09W400	06-07-081-09W4							411.6	291.4	421.1	281.9	477.7	225.3	0.0	-5.0	225.3	
100/06-08-081-09W400	06-08-081-09W4							416.0	285.3	425.8	275.5	491.9	209.4	3.0	3.0	212.4	
100/15-08-081-09W400	15-08-081-09W4							412.0	289.1	423.1	278.0	490.0	211.1	8.0	8.0	219.1	
100/12-09-081-09W400	12-09-081-09W4							407.0	293.9	417.7	283.2	475.5	225.4	5.0	5.0	230.4	
100/13-09-081-09W400	13-09-081-09W4							410.0	292.0	418.8	283.2	474.5	227.6	4.0	4.0	231.6	
1AA/01-10-081-09W400	01-10-081-09W4							422.2	287.2	432.6	276.8	488.8	220.6	0.0	-5.0	220.6	
1AA/03-10-081-09W400	03-10-081-09W4							411.5	290.9	422.1	280.3	474.9	227.4	0.0	-5.0	227.4	
1AA/07-10-081-09W400	07-10-081-09W4							414.1	294.0	424.9	283.3	478.8	229.3	0.0	-5.0	229.3	
100/09-10-081-09W400	09-10-081-09W4							419.0	292.8	429.9	281.9	481.2	230.6	0.0	-5.0	230.6	
1AA/11-10-081-09W400	11-10-081-09W4							412.6	292.9	423.3	282.3	477.8	227.7	5.0	5.0	232.7	
1AA/15-10-081-09W400	15-10-081-09W4							416.5	288.8	427.2	278.1	483.4	221.9	0.0	-5.0	221.9	
1AA/01-11-081-09W400	01-11-081-09W4							435.8	285.7	446.1	275.4						

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Northing (m) NAD 27	Easting (m) NAD 27	KB (m asl)	TD (m)	Top Grand Rapids (m bKB)	Top Grand Rapids (m asl)	Grand Rapids Watersand Thickness (m)	Grand Rapids Watersand Top (m bKB)	Grand Rapids Watersand Top (m asl)	Grand Rapids Watersand Base (m bKB)	Grand Rapids Watersand Base (m asl)	Top Clearwater (m bKB)	Top Clearwater (m asl)	Upper Clearwater Watersand Thickness (m)	Middle Clearwater Watersand Thickness (m)	Upper Clearwater Thickness (Surfer) (m)	Middle Clearwater Watersand Thickness (Surfer) (m)	Upper Clearwater Watersand Top (m bKB)	Upper Clearwater Watersand Top (m asl)
1AA/03-11-081-09W400	03-11-081-09W4	6206220	481260	716.8	512.0	289.3	427.5	19.0	343.0	373.8	362.0	354.8	375.2	341.6	0.0	0.0	-5.0	-5.0		
1AA/05-11-081-09W400	05-11-081-09W4	6206605	480839	714.2	501.5	281.3	432.9	26.0	331.0	383.2	357.0	357.2	368.9	345.3	0.0	0.0	-5.0	-5.0		
1AA/07-11-081-09W400	07-11-081-09W4	6206606	481648	717.1	516.5	290.3	426.8	22.0	341.0	376.1	363.0	354.1	376.6	340.5	0.0	0.0	-5.0	-5.0		
100/13-11-081-09W400	13-11-081-09W4	6207277	480975	712.2	487.0	273.5	438.7	26.0	323.0	389.2	349.0	363.2	359.5	352.7	0.0	0.0	-5.0	-5.0		
1AA/03-12-081-09W400	03-12-081-09W4	6206204	482865	724.6	507.0	296.1	428.5	31.0	348.0	376.6	379.0	345.6	383.6	341.0	0.0	0.0	-5.0	-5.0		
100/02-14-081-09W400	02-14-081-09W4	6207810	481469	715.1	493.8	275.7	439.4	25.0	327.0	388.1	352.0	363.1	364.1	351.0	0.0	0.0	-5.0	-5.0		
100/11-14-081-09W400	11-14-081-09W4	6208637	481265	712.2	513.0	272.0	440.2	33.0	319.0	393.2	352.0	360.2	361.8	350.5	0.0	0.0	-5.0	-5.0		
100/04-15-081-09W400	04-15-081-09W4	6207913	479351	705.0	489.2	265.5	439.5	36.0	312.0	393.0	348.0	357.0	356.4	348.6	0.0	0.0	-5.0	-5.0		
100/12-16-081-09W400	12-16-081-09W4	6208619	477711	702.8	491.0	258.9	443.9	39.0	304.0	398.8	343.0	359.8	348.2	354.6	0.0	0.0	-5.0	-5.0		
102/12-16-081-09W400	12-16-081-09W4	6208634	477711	702.9	500.0	259.3	443.6	40.0	303.0	399.9	343.0	359.9	349.5	353.4	0.0	0.0	-5.0	-5.0		
100/16-17-081-09W400	16-17-081-09W4	6209013	477141	703.8	495.3	264.5	439.3	35.0	315.0	388.8	350.0	353.8	356.3	347.5	0.0	0.0	-5.0	-5.0		
1AA/14-18-081-09W400	14-18-081-09W4	6209071	474751	706.5	483.5	268.0	438.5	41.0	314.0	392.5	355.0	351.5	361.4	345.2	0.0	0.0	-5.0	-5.0		
100/16-18-081-09W400	16-18-081-09W4	6209258	475659	705.2	493.0	265.1	440.1	35.0	315.0	390.2	350.0	355.2	356.7	348.5	0.0	0.0	-5.0	-5.0		
100/07-19-081-09W400	07-19-081-09W4	6209918	475234	706.8	493.8	267.6	439.2	34.0	317.0	389.8	351.0	355.8	357.6	349.2	0.0	0.0	-5.0	-5.0		
100/11-19-081-09W400	11-19-081-09W4	6210196	474901	706.4	485.0	266.0	440.4	33.0	315.0	391.4	348.0	358.4	353.6	352.8	0.0	0.0	-5.0	-5.0		
1AA/10-21-081-09W400	10-21-081-09W4	6210245	478414	703.5	489.9	278.2	425.3	38.0	310.0	393.5	348.0	355.5	353.9	349.6	0.0	0.0	-5.0	-5.0		
1AA/06-22-081-09W400	06-22-081-09W4	6209859	479627	713.7	793.1	271.1	442.5	34.0	319.0	394.7	353.0	360.7	360.5	353.1	0.0	0.0	-5.0	-5.0		
100/10-23-081-09W400	10-23-081-09W4	6210198	481615	712.6	502.9	271.8	440.8	32.0	319.0	393.6	351.0	361.6	360.7	351.9	0.0	0.0	-5.0	-5.0		
100/10-24-081-09W400	10-24-081-09W4	6210185	483115	711.3	491.0	271.5	439.8	28.0	321.0	390.3	349.0	362.3	358.7	352.6	0.0	0.0	-5.0	-5.0		
100/06-25-081-09W400	06-25-081-09W4	6211586	482893	709.3	484.6	268.9	440.4	32.0	318.0	391.3	350.0	359.3	356.8	352.5	6.0	0.0	6.0	-5.0	375.0	334.3
100/07-25-081-09W400	07-25-081-09W4	6211559	483147	709.3	480.0			31.0	317.0	392.3	348.0	361.3	354.2	355.1	0.0	0.0	-5.0	-5.0		
100/07-26-081-09W400	07-26-081-09W4	6211477	481656	710.5	491.0	267.9	442.6	33.0	315.0	395.5	348.0	362.5	356.4	354.1	0.0	0.0	-5.0	-5.0		
100/06-27-081-09W400	06-27-081-09W4	6211668	479540	707.4	484.0	260.9	446.5	39.0	304.0	403.4	343.0	364.4	349.2	358.2	0.0	0.0	-5.0	-5.0		
1AA/08-27-081-09W400	08-27-081-09W4	6211614	480285	704.9	498.1	261.8	443.1	38.0	307.0	397.9	345.0	359.9	351.2	353.6	10.0	0.0	10.0	-5.0	364.0	340.9
1AA/09-28-081-09W400	09-28-081-09W4	6211744	478616	704.3	490.9	260.5	443.8	40.0	304.0	400.3	344.0	360.3	348.4	355.9	0.0	0.0	-5.0	-5.0		
100/10-28-081-09W400	10-28-081-09W4	6211713	478342	706.0	484.0	260.9	445.1	40.0	304.0	402.0	344.0	362.0	348.2	357.8	10.0	0.0	10.0	-5.0	361.0	345.0
100/09-29-081-09W400	09-29-081-09W4	6211758	477231	705.0	487.7	283.9	421.1	39.0	309.0	396.0	348.0	357.0	353.2	351.8	9.0	0.0	9.0	-5.0	365.0	340.0
100/12-30-081-09W400	12-30-081-09W4	6211839	474548	707.4	487.0	267.2	440.2	39.0	312.0	395.4	351.0	356.4	355.4	352.0	0.0	0.0	-5.0	-5.0		
1AA/10-33-081-09W400	10-33-081-09W4	6213661	478586	707.7	488.3	263.0	444.8	35.0	312.0	395.7	347.0	360.7	351.0	356.7	16.0	0.0	16.0	-5.0	362.0	345.7
100/09-36-081-09W400	09-36-081-09W4	6213476	483766	714.6	489.0	269.6	445.0	29.0	318.0	396.6	347.0	367.6	354.9	359.7	14.0	0.0	14.0	-5.0	367.0	347.6
100/06-01-081-10 W4/00	06-01-081-10 W4	6204813	473154	699.9	483.0	257.0	442.9	30.0	311.0	388.9	341.0	358.9	348.0	351.9	0.0	0.0	-5.0	-5.0		
100/03-03-081-10 W4/00	03-03-081-10 W4	6204433	469894	698.2	490.0	263.0	435.2	37.0	308.0	390.2	345.0	353.2	345.0	353.2	0.0	0.0	-5.0	-5.0		
100/08-04-081-10 W4/00	08-04-081-10 W4	6204841	469072	697.4	492.0	262.0	435.4	25.0	315.0	382.4	340.0	357.4	351.0	346.4	0.0	0.0	-5.0	-5.0		
100/08-05-081-10 W4/00	08-05-081-10 W4	6204853	467444	695.8	484.0	261.0	434.8	35.0	306.0	389.8	341.0	354.8	350.0	345.8	0.0	0.0	-5.0	-5.0		
100/10-07-081-10 W4/00	10-07-081-10 W4	6206879	465429	696.5	500.0	262.0	434.5	33.0	307.0	389.5	340.0	356.5	355.0	341.5	0.0	0.0	-5.0	-5.0		
100/11-08-081-10 W4/00	11-08-081-10 W4	6206869	466655	703.3	505.0	271.0	432.3	31.0	318.0	385.3	349.0	354.3	364.0	339.3	0.0	0.0	-5.0	-5.0		
100/09-09-081-10 W4/00	09-09-081-10 W4	6206851	469087	712.3	506.0	278.0	434.3	39.0	324.0	388.3	363.0	349.3	369.0	343.3	0.0	0.0	-5.0	-5.0		
100/09-10-081-10 W4/00	09-10-081-10 W4	6206840	470714	706.4	491.0	270.0	436.4	39.0	315.0	391.4	354.0	352.4	359.0	347.4	0.0	0.0	-5.0	-5.0		
100/10-11-081-10 W4/00	10-11-081-10 W4	6206832	471940	705.7	489.0	266.0	439.7	37.0	311.0	394.7	348.0	357.7	353.0	352.7	0.0	0.0	-5.0	-5.0		
100/03-12-081-10 W4/00	03-12-081-10 W4	6206020	473161	703.4	487.0	264.0	439.4	39.0	309.0	394.4	348.0	355.4	355.0	348.4	0.0	0.0	-5.0	-5.0		
100/12-13-081-10 W4/00	12-13-081-10 W4	6208455	472774	705.8	485.0	265.0	440.8	38.0	309.0	396.8	347.0	358.8	352.0	353.8	0.0	0.0	-5.0	-5.0		
100/10-14-081-10 W4/00	10-14-081-10 W4	6208461	471951	708.4	485.0	268.0	440.4	38.0	313.0	395.4	351.0	357.4	352.0	356.4	0.0	0.0	-5.0	-5.0		
100/12-15-081-10 W4/00	12-15-081-10 W4	6208477	469520	708.2	491.0	270.0	438.2	24.0	322.0	386.2	346.0	362.2	355.0	353.2	0.0	0.0	-5.0	-5.0		
100/05-16-081-10 W4/00	05-16-081-10 W4	6208087	467890	709.3	499.0	271.0	438.3	31.0	319.0	390.3	350.0	359.3	356.0	353.3	0.0	0.0	-5.0	-5.0		
100/09-20-081-10 W4/00	09-20-081-10 W4	6210101	467483	707.6	483.0	268.0	439.6	32.0	315.0	392.6	347.0	360.6	356.0	351.6	0.0	0.0	-5.0	-5.0		
100/09-21-081-10 W4/00	09-21-081-10 W4	6210089	469110	708.9	487.0	268.0	440.9	30.0	315.0	393.9	345.0	363.9	353.0	355.9	0.0	0.0	-5.0	-5.0		
100/07-22-081-10 W4/00	07-22-081-10 W4	6209678	470332	711.4	503.0	271.0	440.4	31.0	316.0	395.4	347.0	364.4	360.0	351.4	0.0	0.0	-5.0	-5.0		
100/10-26-081-10 W4/00	10-26-081-10 W4	6211698	471972	709.3	490.7	268.0	441.3	36.0	311.0	398.3	347.0	362.3	347.0	362.3	0.0	0.0	-5.0	-5.0		
100/12-28-081-10 W4/00	12-28-081-10 W4	6211726	467917	705.7	484.0	262.0	443.7	23.0	310.0	395.7	333.0	372.7	350.0	355.7	0.0	0.0	-5.0	-5.0		
100/11-29-081-10 W4/00	11-29-081-10 W4	6211736	466692	704.1	490.0	262.0	442.1	27.0	309.0	395.1	336.0	368.1	350.0	354.1	0.0	0.0	-5.0	-5.0		

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Upper Clearwater Watersand Base (m bKB)	Upper Clearwater Watersand Base (m asl)	Middle Clearwater Watersand Top (m bKB)	Middle Clearwater Watersand Top (m asl)	Middle Clearwater Watersand Base (m bKB)	Middle Clearwater Watersand Base (m asl)	Top Wabiskaw (m bKB)	Top Wabiskaw (m asl)	Top McMurray (m bKB)	Top McMurray (m asl)	Paleo Surface (m bKB)	Paleo Surface (m asl)	Watersand Thickness (m)	Watersand Thickness (Surfer) (m)	Watersand Surface Elevation (m asl)	Log Analysis Notes:
1AA/03-11-081-09W400	03-11-081-09W4							432.2	284.6	443.1	273.6	497.4	219.3	3.0	3.0	222.3	
1AA/05-11-081-09W400	05-11-081-09W4							427.1	287.1	437.8	276.4	490.6	223.7	0.0	-5.0	223.7	
1AA/07-11-081-09W400	07-11-081-09W4							433.1	284.0	443.3	273.9	496.4	220.7	0.0	-5.0	220.7	
100/13-11-081-09W400	13-11-081-09W4							419.0	293.2			479.3	232.9	0.0	-5.0	232.9	
1AA/03-12-081-09W400	03-12-081-09W4							441.3	283.3	453.5	271.1	498.0	226.6	2.0	2.0	228.6	
100/02-14-081-09W400	02-14-081-09W4							421.9	293.2	431.8	283.3	481.5	233.6				
100/11-14-081-09W400	11-14-081-09W4							419.6	292.6	430.5	281.7	486.8	225.4	3.0	3.0	228.4	
100/04-15-081-09W400	04-15-081-09W4							415.0	290.0	424.2	280.8	476.7	228.3	5.0	5.0	233.3	
100/12-16-081-09W400	12-16-081-09W4							408.7	294.1	419.5	283.3	487.6	215.2	16.0	16.0	231.2	
102/12-16-081-09W400	12-16-081-09W4							409.0	293.9	419.0	283.9	486.1	216.8	14.0	14.0	230.8	
100/16-17-081-09W400	16-17-081-09W4							418.5	285.3	428.2	275.6	485.4	218.4	2.0	2.0	220.4	
1AA/14-18-081-09W400	14-18-081-09W4							422.0	284.5	433.3	273.2	477.0	229.6	0.0	-5.0	229.6	
100/16-18-081-09W400	16-18-081-09W4							418.0	287.2	427.2	278.0	488.7	216.6	7.0	7.0	223.6	
100/07-19-081-09W400	07-19-081-09W4							418.1	288.7	428.8	278.0	480.9	225.9	4.0	4.0	229.9	
100/11-19-081-09W400	11-19-081-09W4							412.7	293.7	422.8	283.6	480.7	225.8	4.0	4.0	229.8	
1AA/10-21-081-09W400	10-21-081-09W4							416.0	287.5	425.8	277.8	483.7	219.8	6.0	6.0	225.8	
1AA/06-22-081-09W400	06-22-081-09W4							420.0	293.7	430.2	283.5	482.8	230.9	0.0	-5.0	230.9	
100/10-23-081-09W400	10-23-081-09W4							419.3	293.3	431.5	281.1	499.8	212.8	4.0	4.0	216.8	
100/10-24-081-09W400	10-24-081-09W4							418.0	293.3	429.8	281.5	483.4	227.9	2.0	2.0	229.9	
100/06-25-081-09W400	06-25-081-09W4	381.0	328.3					417.5	291.8	428.3	281.0	476.0	233.3	0.0	-5.0	233.3	
100/07-25-081-09W400	07-25-081-09W4							416.0	293.3	426.4	282.9	475.0	234.3	0.0	-5.0	234.3	
100/07-26-081-09W400	07-26-081-09W4							414.9	295.7	424.9	285.6	485.3	225.3	6.0	6.0	231.3	
100/06-27-081-09W400	06-27-081-09W4							408.0	299.4	418.6	288.8	478.0	229.4	0.0	-5.0	229.4	
1AA/08-27-081-09W400	08-27-081-09W4	374.0	330.9					410.0	294.9	421.0	283.9	491.0	213.9	1.0	1.0	214.9	
1AA/09-28-081-09W400	09-28-081-09W4							408.8	295.5	418.6	285.7	477.4	226.9	0.0	-5.0	226.9	
100/10-28-081-09W400	10-28-081-09W4	371.0	335.0					407.6	298.4	418.9	287.1	479.5	226.6	0.0	-5.0	226.6	
100/09-29-081-09W400	09-29-081-09W4	374.0	331.0					414.8	290.2	424.3	280.7	475.2	229.8	2.0	2.0	231.8	
100/12-30-081-09W400	12-30-081-09W4							414.6	292.8	425.0	282.4	482.0	225.4	5.0	5.0	230.4	
1AA/10-33-081-09W400	10-33-081-09W4	378.0	329.7					413.5	294.2	423.9	283.9	478.4	229.3				
100/09-36-081-09W400	09-36-081-09W4	381.0	333.6					416.0	298.6	427.9	286.7	475.2	239.4	7.0	7.0	246.4	
100/06-01-081-10 W4/00	06-01-081-10 W4							410.0	289.9	419.0	280.9	477.0	222.9	0.0	-5.0	222.9	
100/03-03-081-10 W4/00	03-03-081-10 W4							412.0	286.2	422.0	276.2	479.0	219.2	0.0	-5.0	219.2	
100/08-04-081-10 W4/00	08-04-081-10 W4							413.0	284.4	423.0	274.4	488.0	209.4	2.0	2.0	211.4	
100/08-05-081-10 W4/00	08-05-081-10 W4							410.0	285.8	420.0	275.8	478.0	217.8	0.0	-5.0	217.8	
100/10-07-081-10 W4/00	10-07-081-10 W4							414.0	282.5	424.0	272.5	475.0	221.5	0.0	-5.0	221.5	
100/11-08-081-10 W4/00	11-08-081-10 W4							425.0	278.3	433.0	270.3	499.0	204.3	3.0	3.0	207.3	
100/09-09-081-10 W4/00	09-09-081-10 W4							431.0	281.3	442.0	270.3	501.0	211.3	13.0	13.0	224.3	
100/09-10-081-10 W4/00	09-10-081-10 W4							420.0	286.4	431.0	275.4	486.0	220.4	0.0	-5.0	220.4	
100/10-11-081-10 W4/00	10-11-081-10 W4							415.0	290.7	427.0	278.7	482.0	223.7	0.0	-5.0	223.7	
100/03-12-081-10 W4/00	03-12-081-10 W4							416.0	287.4	425.0	278.4	481.0	222.4	2.0	2.0	224.4	
100/12-13-081-10 W4/00	12-13-081-10 W4							413.0	292.8	422.0	283.8	479.0	226.8	0.0	-5.0	226.8	
100/10-14-081-10 W4/00	10-14-081-10 W4							418.0	290.4	427.0	281.4	481.0	227.4	0.0	-5.0	227.4	
100/12-15-081-10 W4/00	12-15-081-10 W4							421.0	287.2	430.0	278.2	487.0	221.2	9.0	9.0	230.2	
100/05-16-081-10 W4/00	05-16-081-10 W4							424.0	285.3	433.0	276.3	495.0	214.3	1.0	1.0	215.3	
100/09-20-081-10 W4/00	09-20-081-10 W4							419.0	288.6	429.0	278.6	487.0	220.6	9.0	9.0	229.6	
100/09-21-081-10 W4/00	09-21-081-10 W4							419.0	289.9	428.0	280.9	483.0	225.9	0.0	-5.0	225.9	
100/07-22-081-10 W4/00	07-22-081-10 W4							422.0	289.4	432.0	279.4	488.0	223.4	7.0	7.0	230.4	
100/10-26-081-10 W4/00	10-26-081-10 W4							416.0	293.3	427.0	282.3	482.0	227.3	0.0	-5.0	227.3	
100/12-28-081-10 W4/00	12-28-081-10 W4							413.0	292.7	423.0	282.7	479.0	226.7	0.0	-5.0	226.7	
100/11-29-081-10 W4/00	11-29-081-10 W4							412.0	292.1	422.0	282.1	486.0	218.1	0.0	-5.0	218.1	

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Northing (m) NAD 27	Easting (m) NAD 27	KB (m asl)	TD (m)	Top Grand Rapids (m bKB)	Top Grand Rapids (m asl)	Grand Rapids Watersand Thickness (m)	Grand Rapids Watersand Top (m bKB)	Grand Rapids Watersand Top (m asl)	Grand Rapids Watersand Base (m bKB)	Grand Rapids Watersand Base (m asl)	Top Clearwater (m bKB)	Top Clearwater (m asl)	Upper Clearwater Watersand Thickness (m)	Middle Clearwater Watersand Thickness (m)	Upper Clearwater Watersand Thickness (Surfer) (m)	Middle Clearwater Watersand Thickness (Surfer) (m)	Upper Clearwater Watersand Top (m bKB)	Upper Clearwater Watersand Top (m asl)
100/05-32-081-10 W4/00	05-32-081-10 W4	6212945	466300	701.8	482.0	260.0	441.8	28.0	309.0	392.8	337.0	364.8	355.0	346.8	0.0	0.0	-5.0	-5.0		
100/10-33-081-10 W4/00	10-33-081-10 W4	6213329	468732	705.7	484.0	263.0	442.7	26.0	309.0	396.7	335.0	370.7	353.0	352.7	0.0	0.0	-5.0	-5.0		
1AA/05-24-081-10W400	05-24-081-10W4	6210030	472631	708.6	498.0	267.1	441.6	42.0	313.0	395.6	355.0	353.6	358.6	350.0	0.0	0.0	-5.0	-5.0		
100/10-25-081-10W400	10-25-081-10W4	6211873	473392	709.9	490.0	270.6	439.4	36.0	319.0	390.9	355.0	354.9	359.3	350.6	0.0	0.0	-5.0	-5.0		
100/11-01-081-11 W4/00	11-01-081-11 W4	6205287	463386	694.7	490.0	265.0	429.7	31.0	310.0	384.7	341.0	353.7	358.0	336.7	0.0	0.0	-5.0	-5.0		
100/11-13-081-11 W4/00	11-13-081-11 W4	6208524	463413	698.0	488.0	263.0	435.0	21.0	309.0	389.0	330.0	368.0	355.0	343.0	0.0	0.0	-5.0	-5.0		
100/11-22-081-11 W4/00	11-22-081-11 W4	6210162	460174	708.4	491.0	274.0	434.4	26.0	319.0	389.4	345.0	363.4	366.0	342.4	0.0	0.0	-5.0	-5.0		
1AA/15-23-081-11 W4/00	15-23-081-11 W4	6210546	462205	703.9	500.3	267.0	436.9	26.0	314.0	389.9	340.0	363.9	359.0	344.9	0.0	0.0	-5.0	-5.0		
1AA/12-26-081-11 W4/00	12-26-081-11 W4	6211779	461413	709.0	490.1	271.0	438.0	29.0	318.0	391.0	347.0	362.0	367.0	342.0	0.0	0.0	-5.0	-5.0		
100/09-28-081-11 W4/00	09-28-081-11 W4	6211798	459366	730.9	518.0	293.0	437.9	26.0	339.0	391.9	365.0	365.9	387.0	343.9	0.0	0.0	-5.0	-5.0		
100/09-32-081-11 W4/00	09-32-081-11 W4	6213423	457755	734.6	546.0	293.0	441.6	27.0	340.0	394.6	367.0	367.6	388.0	346.6	0.0	0.0	-5.0	-5.0		
100/08-34-081-11 W4/00	08-34-081-11 W4	6212990	461003	711.4	512.0	273.0	438.4	27.0	320.0	391.4	347.0	364.4	366.0	345.4	0.0	0.0	-5.0	-5.0		
100/09-09-081-12 W4/00	09-09-081-12 W4	6207035	449553	729.7	536.0	301.0	428.7	24.0	347.0	382.7	371.0	358.7	398.0	331.7	0.0	0.0	-5.0	-5.0		
100/15-10-081-12 W4/00	15-10-081-12 W4	6207423	450784	723.8	527.0	292.0	431.8						386.0	337.8						
100/02-11-081-12 W4/00	02-11-081-12 W4	6206198	452398	715.8	511.0	285.0	430.8	26.0	328.0	387.8	354.0	361.8	377.0	338.8	0.0	0.0	-5.0	-5.0		
100/03-13-081-12 W4/00	03-13-081-12 W4	6207814	453642	726.9	519.0	295.0	431.9	24.0	339.0	387.9	363.0	363.9	388.0	338.9	0.0	0.0	-5.0	-5.0		
100/03-15-081-12 W4/00	03-15-081-12 W4	6207850	450387	731.4	523.0	298.0	433.4	31.0	344.0	387.4	375.0	356.4	392.0	339.4	0.0	0.0	-5.0	-5.0		
100/10-16-081-12 W4/00	10-16-081-12 W4	6208669	449171	729.6	531.0	298.0	431.6	30.0	344.0	385.6	374.0	355.6	394.0	335.6	0.0	0.0	-5.0	-5.0		
100/09-18-081-12 W4/00	09-18-081-12 W4	6208703	446318	729.8	542.0	301.0	428.8	35.0	347.0	382.8	382.0	347.8	397.0	332.8	0.0	0.0	-5.0	-5.0		
100/10-19-081-12 W4/00	10-19-081-12 W4	6210317	445937	726.7	548.0	294.0	432.7	34.0	341.0	385.7	375.0	351.7	391.0	335.7	0.0	0.0	-5.0	-5.0		
100/09-20-081-12 W4/00	09-20-081-12 W4	6210292	447965	736.2	545.0	306.0	430.2	32.0	352.0	384.2	384.0	352.2	402.0	334.2	0.0	0.0	-5.0	-5.0		
100/16-21-081-12 W4/00	16-21-081-12 W4	6210675	449596	729.0	526.0	297.0	432.0	31.0	343.0	386.0	374.0	355.0	394.0	335.0	0.0	0.0	-5.0	-5.0		
100/15-23-081-12 W4/00	15-23-081-12 W4	6210642	452447	738.4	529.0	305.0	433.4	28.0	351.0	387.4	379.0	359.4	401.0	337.4	0.0	0.0	-5.0	-5.0		
100/11-29-081-12 W4/00	11-29-081-12 W4	6211930	447182	736.0	547.0	304.0	432.0	29.0	350.0	386.0	379.0	357.0	400.0	336.0	0.0	0.0	-5.0	-5.0		
100/14-31-081-12 W4/00	14-31-081-12 W4	6213961	445581	728.4	521.0	294.0	434.4	29.0	343.0	385.4	372.0	356.4	387.0	341.4	0.0	0.0	-5.0	-5.0		
100/06-32-081-12 W4/00	06-32-081-12 W4	6213137	447196	741.8	550.0	306.0	435.8	26.0	354.0	387.8	380.0	361.8	401.0	340.8	0.0	0.0	-5.0	-5.0		
100/05-33-081-12 W4/00	05-33-081-12 W4	6213122	448420	748.0	546.0	312.0	436.0	30.0	358.0	390.0	388.0	360.0	408.0	340.0	0.0	0.0	-5.0	-5.0		
100/07-34-081-12 W4/00	07-34-081-12 W4	6213093	450849	744.8	542.0	308.0	436.8	23.0	355.0	389.8	378.0	366.8	404.0	340.8	0.0	0.0	-5.0	-5.0		
100/10-36-081-12 W4/00	10-36-081-12 W4	6213460	454104	755.7	542.0	319.0	436.7	24.0	363.0	392.7	387.0	368.7	411.0	344.7	0.0	0.0	-5.0	-5.0		
100/14-01-081-12W400	14-01-081-12W4	6206038	453457	707.8	515.0	276.0	431.8	23.0	322.0	385.8	345.0	362.8	367.9	339.9	0.0	0.0	-5.0	-5.0		
1AA/10-08-081-13 W4/00	10-08-081-13 W4	6207188	437758	670.7	478.0	246.0	424.7	25.0	293.0	377.7	318.0	352.7	342.0	328.7	0.0	0.0	-5.0	-5.0		
100/14-09-081-13 W4/00	14-09-081-13 W4	6207573	438990	693.8	497.0	268.0	425.8	32.0	316.0	377.8	348.0	345.8	364.0	329.8	0.0	0.0	-5.0	-5.0		
1AA/12-11-081-13 W4/00	12-11-081-13 W4	6207131	441838	711.1	516.3	289.0	422.1						384.0	327.1						
100/07-16-081-13 W4/00	07-16-081-13 W4	6208392	439403	689.4	481.0	262.0	427.4	28.0	311.0	378.4	339.0	350.4	359.0	330.4	0.0	0.0	-5.0	-5.0		
100/04-18-081-13 W4/00	04-18-081-13 W4	6208049	435339	652.1	454.0	228.0	424.1	24.0	278.0	374.1	302.0	350.1	326.0	326.1	0.0	0.0	-5.0	-5.0		
100/09-21-081-13 W4/00	09-21-081-13 W4	6210397	439833	679.8	472.0	251.0	428.8	33.0	298.0	381.8	331.0	348.8	346.0	333.8	0.0	0.0	-5.0	-5.0		
100/15-25-081-13 W4/00	15-25-081-13 W4	6212367	444338	710.6	520.0	277.0	433.6	35.0	324.0	386.6	359.0	351.6	373.0	337.6	0.0	0.0	-5.0	-5.0		
100/11-26-081-13 W4/00	11-26-081-13 W4	6211992	442305	703.6	518.0	275.0	428.6	28.0	325.0	378.6	353.0	350.6	370.0	333.6	0.0	0.0	-5.0	-5.0		
100/06-27-081-13 W4/00	06-27-081-13 W4	6211612	440673	677.2	473.0	247.0	430.2	33.0	295.0	382.2	328.0	349.2	343.0	334.2	0.0	0.0	-5.0	-5.0		
100/06-30-081-13 W4/00	06-30-081-13 W4	6211682	435795	628.5	414.0	197.0	431.5	31.0	246.0	382.5	277.0	351.5	291.0	337.5	0.0	0.0	-5.0	-5.0		
100/13-35-081-13 W4/00	13-35-081-13 W4	6214008	441931	671.4	479.0	239.0	432.4	28.0	286.0	385.4	314.0	357.4	333.0	338.4	0.0	0.0	-5.0	-5.0		
100/08-36-081-13 W4/00	08-36-081-13 W4	6213167	444749	722.7	530.0	296.0	426.7	30.0	336.0	386.7	366.0	356.7	384.0	338.7	0.0	0.0	-5.0	-5.0		
100/05-05-081-13W400	05-05-081-13W4	6205529	436899	692.5	499.0	271.8	420.7	26.0	321.0	371.5	347.0	345.5	368.6	323.9	0.0	0.0	-5.0	-5.0		
100/06-06-081-13W400	06-06-081-13W4	6205559	435730	683.0	498.0	261.0	422.0	28.0	310.0	373.0	338.0	345.0	357.9	325.1	0.0	0.0	-5.0	-5.0		
100/08-01-081-14 W4/00	08-01-081-14 W4	6205219	434876	672.7	481.0	251.0	421.7	23.0	300.0	372.7	323.0	349.7	357.0	315.7	0.0	0.0	-5.0	-5.0		
100/08-02-081-14 W4/00	08-02-081-14 W4	6205244	433247	657.7	467.5	234.0	423.7	27.0	283.0	374.7	310.0	347.7	338.0	319.7	0.0	0.0	-5.0	-5.0		
100/06-04-081-14 W4/00	06-04-081-14 W4	6205309	429186	636.6	436.0	216.0	420.6	23.0	267.0	369.6	290.0	346.6	322.0	314.6	0.0	0.0	-5.0	-5.0		
100/05-05-081-14 W4/00	05-05-081-14 W4	6205343	427156	603.1	403.0	183.0	420.1	27.0	234.0	369.1	261.0	342.1	290.0	313.1	0.0	0.0	-5.0	-5.0		
100/07-06-081-14 W4/00	07-06-081-14 W4	6205357	426331	593.9	396.0	175.0	418.9	28.0	225.0	368.9	253.0	340.9	281.0	312.9	0.0	0.0	-5.0	-5.0		
1AA/10-08-081-14 W4/00	10-08-081-14 W4	6207340	427993	590.9	389.0	164.0	426.9	28.0	216.0	374.9	244.0	346.9	272.0	318.9	0.0	0.0	-5.0	-5.0		
100/13-09-081-14 W4/00	13-09-081-14 W4	6207729	428824	596.0	393.0	172.0	424.0	24.0	222.0	374.0	246.0	350.0	280.0	316.0	0.0	0.0	-5.0	-5.0		
100/10-13-081-14 W4/00	10-13-081-14 W4	6208865	434529	647.9	450.0	222.0	425.9	21.0	270.0	377.9	291.0	356.9	325.0	322.9	0.0	0.0	-5.0	-5.0		
100/09-14-081-14 W4/00	09-14-081-14 W4	6208884	433304	646.4	432.0	218.0	428.4	28.0	267.0	379.4	295.0	351.4	324.0	322.4	0.0	0.0	-5.0	-5.0		
100/07-25-081-14 W4/00	07-25-081-14 W4	6211700	434572	619.7	408.0	188.0	431.7	26.0	237.0	382.7	263.0	356.7	293.0	326.7	0.0	0.0	-5.0	-5.0		
1AA/10-26-081-14 W4/00	10-26-081-14 W4	6212127	432952	596.2	389.0	163.0	433.2	28.0	212.0	384.2	240.0	356.2	270.0	326.2	0.0	0.0	-5.0	-5.0		
1AA/10-29-081-14 W4/00	10-29-081-14 W4	6212206	428075	588.6	384.0	155.0	433.6	28.0	205.0	383.6	233.0	355.6	265.0	323.6	0.0	0.0	-5.0	-5.0		

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Upper Clearwater Watersand Base (m bKB)	Upper Clearwater Watersand Base (m asl)	Middle Clearwater Watersand Top (m bKB)	Middle Clearwater Watersand Top (m asl)	Middle Clearwater Watersand Base (m bKB)	Middle Clearwater Watersand Base (m asl)	Top Wabiskaw (m bKB)	Top Wabiskaw (m asl)	Top McMurray (m bKB)	Top McMurray (m asl)	Paleo Surface (m bKB)	Paleo Surface (m asl)	Watersand Thickness (m)	Watersand Thickness (Surfer) (m)	Watersand Surface Elevation (m asl)	Log Analysis Notes:
100/05-32-081-10 W4/00	05-32-081-10 W4							415.0	286.8	425.0	276.8	476.0	225.8	0.0	-5.0	225.8	
100/10-33-081-10 W4/00	10-33-081-10 W4							414.0	291.7	424.0	281.7	480.0	225.7	0.0	-5.0	225.7	
1AA/05-24-081-10W400	05-24-081-10W4							419.8	288.8	429.6	279.0	482.8	225.8				
100/10-25-081-10W400	10-25-081-10W4							418.9	291.0	429.6	280.4	481.7	228.2	0.0	-5.0	228.2	
100/11-01-081-11 W4/00	11-01-081-11 W4							416.0	278.7	426.0	268.7	482.0	212.7	0.0	-5.0	212.7	
100/11-13-081-11 W4/00	11-13-081-11 W4							416.0	282.0	426.0	272.0	478.0	220.0	1.0	1.0	221.0	
100/11-22-081-11 W4/00	11-22-081-11 W4							426.0	282.4	436.0	272.4	488.0	220.4				
1AA/15-23-081-11 W4/00	15-23-081-11 W4							421.0	282.9	431.0	272.9	485.0	218.9	2.0	2.0	220.9	
1AA/12-26-081-11 W4/00	12-26-081-11 W4							426.0	283.0	435.0	274.0	489.0	220.0	0.0	-5.0	220.0	
100/09-28-081-11 W4/00	09-28-081-11 W4							447.0	283.9	456.0	274.9	510.0	220.9	0.0	-5.0	220.9	
100/09-32-081-11 W4/00	09-32-081-11 W4							448.0	286.6	458.0	276.6	515.0	219.6	3.0	3.0	222.6	
100/08-34-081-11 W4/00	08-34-081-11 W4							428.0	283.4	438.0	273.4	502.0	209.4	1.0	1.0	210.4	
100/09-09-081-12 W4/00	09-09-081-12 W4							459.0	270.7	469.0	260.7	526.0	203.7	1.0	1.0	204.7	
100/15-10-081-12 W4/00	15-10-081-12 W4							447.0	276.8	456.0	267.8	511.0	212.8	0.0	-5.0	212.8	gamma ran low
100/02-11-081-12 W4/00	02-11-081-12 W4							438.0	277.8	446.0	269.8	503.0	212.8	0.0	-5.0	212.8	
100/03-13-081-12 W4/00	03-13-081-12 W4							449.0	277.9	458.0	268.9	510.0	216.9	0.0	-5.0	216.9	
100/03-15-081-12 W4/00	03-15-081-12 W4							453.0	278.4	462.0	269.4	518.0	213.4	2.0	2.0	215.4	
100/10-16-081-12 W4/00	10-16-081-12 W4							456.0	273.6	465.0	264.6	518.0	211.6	0.0	-5.0	211.6	
100/09-18-081-12 W4/00	09-18-081-12 W4							459.0	270.8	468.0	261.8	523.0	206.8	12.0	12.0	218.8	
100/10-19-081-12 W4/00	10-19-081-12 W4							454.0	272.7	462.0	264.7	528.0	198.7	0.0	-5.0	198.7	
100/09-20-081-12 W4/00	09-20-081-12 W4							463.0	273.2	472.0	264.2	525.0	211.2	0.0	-5.0	211.2	
100/16-21-081-12 W4/00	16-21-081-12 W4							455.0	274.0	464.0	265.0	517.0	212.0	0.0	-5.0	212.0	
100/15-23-081-12 W4/00	15-23-081-12 W4							462.0	276.4	472.0	266.4	521.0	217.4	0.0	-5.0	217.4	
100/11-29-081-12 W4/00	11-29-081-12 W4							462.0	274.0	471.0	265.0	530.0	206.0	4.0	4.0	210.0	
100/14-31-081-12 W4/00	14-31-081-12 W4							451.0	277.4	460.0	268.4	517.0	211.4	0.0	-5.0	211.4	
100/06-32-081-12 W4/00	06-32-081-12 W4							465.0	276.8	474.0	267.8	534.0	207.8	0.0	-5.0	207.8	
100/05-33-081-12 W4/00	05-33-081-12 W4							470.0	278.0	481.0	267.0	531.0	217.0	0.0	-5.0	217.0	
100/07-34-081-12 W4/00	07-34-081-12 W4							466.0	278.8	474.0	270.8	533.0	211.8	2.0	2.0	213.8	
100/10-36-081-12 W4/00	10-36-081-12 W4							472.0	283.7	481.0	274.7	532.0	223.7	0.0	-5.0	223.7	
100/14-01-081-12W400	14-01-081-12W4							428.1	279.7	443.8	264.1	495.3	212.5	0.0	-5.0	212.5	
1AA/10-08-081-13 W4/00	10-08-081-13 W4							404.0	266.7	412.0	258.7	465.0	205.7	9.0	9.0	214.7	
100/14-09-081-13 W4/00	14-09-081-13 W4							425.0	268.8	434.0	259.8	487.0	206.8	0.0	-5.0	206.8	
1AA/12-11-081-13 W4/00	12-11-081-13 W4							448.0	263.1	457.0	254.1	507.0	204.1	0.0	-5.0	204.1	gamma ran high
100/07-16-081-13 W4/00	07-16-081-13 W4							422.0	267.4	431.0	258.4	480.0	209.4	0.0	-5.0	209.4	
100/04-18-081-13 W4/00	04-18-081-13 W4							390.0	262.1	399.0	253.1	444.0	208.1	0.0	-5.0	208.1	
100/09-21-081-13 W4/00	09-21-081-13 W4							409.0	270.8	418.0	261.8						
100/15-25-081-13 W4/00	15-25-081-13 W4							436.0	274.6	444.0	266.6	495.0	215.6	11.0	11.0	226.6	
100/11-26-081-13 W4/00	11-26-081-13 W4							434.0	269.6	443.0	260.6	497.0	206.6	0.0	-5.0	206.6	
100/06-27-081-13 W4/00	06-27-081-13 W4							408.0	269.2	416.0	261.2	467.0	210.2	0.0	-5.0	210.2	
100/06-30-081-13 W4/00	06-30-081-13 W4							355.0	273.5	364.0	264.5	411.0	217.5	0.0	-5.0	217.5	
100/13-35-081-13 W4/00	13-35-081-13 W4							397.0	274.4	405.0	266.4	459.0	212.4	0.0	-5.0	212.4	
100/08-36-081-13 W4/00	08-36-081-13 W4							448.0	274.7	456.0	266.7	517.0	205.7	3.0	3.0	208.7	
100/05-05-081-13W400	05-05-081-13W4							431.7	260.8	444.6	247.9	491.7	200.8	0.0	-5.0	200.8	
100/06-06-081-13W400	06-06-081-13W4							419.6	263.4	432.0	251.0	482.0	201.0	4.9	4.9	205.9	
100/08-01-081-14 W4/00	08-01-081-14 W4							411.0	261.7	420.0	252.7	471.0	201.7	0.0	-5.0	201.7	
100/08-02-081-14 W4/00	08-02-081-14 W4							393.0	264.7	403.0	254.7	455.0	202.7	0.0	-5.0	202.7	
100/06-04-081-14 W4/00	06-04-081-14 W4							380.0	256.6	389.0	247.6	430.0	206.6	0.0	-5.0	206.6	
100/05-05-081-14 W4/00	05-05-081-14 W4							347.0	256.1	356.0	247.1	403.0	200.1	0.0	-5.0	200.1	
100/07-06-081-14 W4/00	07-06-081-14 W4							338.0	255.9	347.0	246.9	395.0	198.9	0.0	-5.0	198.9	
1AA/10-08-081-14 W4/00	10-08-081-14 W4							328.0	262.9	337.0	253.9	382.0	208.9	0.0	-5.0	208.9	
100/13-09-081-14 W4/00	13-09-081-14 W4							336.0	260.0	346.0	250.0	390.0	206.0	0.0	-5.0	206.0	
100/10-13-081-14 W4/00	10-13-081-14 W4							380.0	267.9	389.0	258.9	440.0	207.9	0.0	-5.0	207.9	
100/09-14-081-14 W4/00	09-14-081-14 W4							380.0	266.4	388.0	258.4	429.0	217.4	0.0	-5.0	217.4	
100/07-25-081-14 W4/00	07-25-081-14 W4							348.0	271.7	357.0	262.7	403.0	216.7	0.0	-5.0	216.7	
1AA/10-26-081-14 W4/00	10-26-081-14 W4							326.0	270.2	334.0	262.2	374.0	222.2	0.0	-5.0	222.2	
1AA/10-29-081-14 W4/00	10-29-081-14 W4							320.0	268.6	328.0	260.6	372.0	216.6	0.0	-5.0	216.6	

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Northing (m) NAD 27	Easting (m) NAD 27	KB (m asl)	TD (m)	Top Grand Rapids (m bKB)	Top Grand Rapids (m asl)	Grand Rapids Watersand Thickness (m)	Grand Rapids Watersand Top (m bKB)	Grand Rapids Watersand Top (m asl)	Grand Rapids Watersand Base (m bKB)	Grand Rapids Watersand Base (m asl)	Top Clearwater (m bKB)	Top Clearwater (m asl)	Upper Clearwater Watersand Thickness (m)	Middle Clearwater Watersand Thickness (m)	Upper Clearwater Watersand Thickness (Surfer) (m)	Middle Clearwater Watersand Thickness (Surfer) (m)	Upper Clearwater Watersand Top (m bKB)	Upper Clearwater Watersand Top (m asl)
100/03-05-082-06 W4/00	03-05-082-06 W4	6214051	505707	534.3	307.0	88.0	446.3		147.0	387.3	164.0	370.3	173.0	361.3						
100/12-06-082-06 W4/00	12-06-082-06 W4	6214853	503680	619.8	421.0	177.0	442.8	21.0	235.0	384.8	256.0	363.8	265.0	354.8	14.0	0.0	14.0	-5.0	281.0	338.8
102/07-08-082-06 W4/00	07-08-082-06 W4	6216062	506106	539.4	316.0	92.0	447.4	21.0	151.0	388.4	172.0	367.4	178.0	361.4	26.0	0.0	26.0	-5.0	188.0	351.4
100/06-09-082-06 W4/00	06-09-082-06 W4	6216064	507329	510.4	296.0			23.0	122.0	388.4	145.0	365.4	148.0	362.4	27.0	0.0	27.0	-5.0	159.0	351.4
100/08-10-082-06 W4/00	08-10-082-06 W4	6216069	509755	494.5	278.0			12.0	113.0	381.5	125.0	369.5	127.0	367.5	31.0	0.0	31.0	-5.0	140.0	354.5
100/05-12-082-06 W4/00	05-12-082-06 W4	6216074	511801	478.9	268.0			16.0	98.0	380.9	114.0	364.9	114.0	364.9	30.0	0.0	30.0	-5.0	129.0	349.9
100/11-16-082-06 W4/00	11-16-082-06 W4	6218095	507325	511.0	279.0	60.0	451.0	11.0	126.0	385.0	137.0	374.0	139.0	372.0	28.0	0.0	28.0	-5.0	149.0	362.0
100/10-19-082-06 W4/00	10-19-082-06 W4	6219700	504478	610.9	392.0	157.0	453.9	14.0	216.0	394.9	230.0	380.9	237.0	373.9	25.0	0.0	25.0	-5.0	250.0	360.9
100/06-20-082-06 W4/00	06-20-082-06 W4	6219299	505700	570.7	336.0	117.0	453.7	18.0	177.0	393.7	195.0	375.7	197.0	373.7	24.0	0.0	24.0	-5.0	211.0	359.7
1AA/02-22-082-06 W4/00	02-22-082-06 W4	6218903	509348	489.0	280.1			12.0	115.0	374.0	127.0	362.0	127.0	362.0	26.0	0.0	26.0	-5.0	136.0	353.0
100/02-24-082-06 W4/00	02-24-082-06 W4	6218912	512595	472.3	279.0			21.0	96.0	376.3	117.0	355.3	117.0	355.3	24.0	0.0	24.0	-5.0	126.0	346.3
1AA/12-25-082-06 W4/00	12-25-082-06 W4	6221342	511786	488.7	321.0			13.0	118.0	370.7	131.0	357.7	131.0	357.7	28.0	0.0	28.0	-5.0	135.0	353.7
1AA/02-26-082-06 W4/00	02-26-082-06 W4	6220536	510967	480.3	304.1			11.0	116.0	364.3	127.0	353.3	127.0	353.3	26.0	0.0	26.0	-5.0	130.0	350.3
1AA/09-27-082-06 W4/00	09-27-082-06 W4	6221337	509743	486.0	289.0			31.0	100.0	386.0	131.0	355.0	131.0	355.0	31.0	0.0	31.0	-5.0	133.0	353.0
100/06-28-082-06 W4/00	06-28-082-06 W4	6220930	507321	517.6	295.0			27.0	123.0	394.6	150.0	367.6	150.0	367.6	27.0	0.0	27.0	-5.0	157.0	360.6
1AA/07-30-082-06 W4/00	07-30-082-06 W4	6220926	504476	537.7	325.0			14.0	146.0	391.7	160.0	377.7	167.0	370.7	21.0	0.0	21.0	-5.0	179.0	358.7
1AA/06-31-082-06 W4/00	06-31-082-06 W4	6222535	504074	596.6	385.0	146.0	450.6	12.0	202.0	394.6	214.0	382.6	224.0	372.6	22.0	0.0	22.0	-5.0	235.0	361.6
100/07-32-082-06 W4/00	07-32-082-06 W4	6222537	506096	523.7	320.0								148.0	375.7						
100/06-34-082-06 W4/00	06-34-082-06 W4	6222542	508940	491.0	280.0	41.0	450.0	33.0	96.0	395.0	129.0	362.0	129.0	362.0	22.0	0.0	22.0	-5.0	132.0	359.0
100/07-36-082-06 W4/00	07-36-082-06 W4	6222551	512584	492.9	294.0			25.0	98.0	394.9	123.0	369.9	125.0	367.9	29.0	0.0	29.0	-5.0	133.0	359.9
100/11-01-082-07 W4/00	11-01-082-07 W4	6214851	502454	656.1	455.0	214.0	442.1	15.0	271.0	385.1	286.0	370.1	294.0	362.1	14.0	0.0	14.0	-5.0	316.0	340.1
100/08-03-082-07 W4/00	08-03-082-07 W4	6214448	500007	692.4	500.0	250.0	442.4	16.0	307.0	385.4	323.0	369.4	331.0	361.4	17.0	0.0	17.0	-5.0	350.0	342.4
100/05-05-082-07 W4/00	05-05-082-07 W4	6214451	495553	724.0	503.0	278.0	446.0	26.0	329.0	395.0	355.0	369.0	355.0	369.0	18.0	0.0	18.0	-5.0	379.0	345.0
100/08-07-082-07 W4/00	08-07-082-07 W4	6216060	495134	726.8	506.0	287.0	439.8	20.0	346.0	380.8	366.0	360.8	371.0	355.8	18.0	0.0	18.0	-5.0	388.0	338.8
100/07-08-082-07 W4/00	07-08-082-07 W4	6216059	496357	745.5	533.4	306.0	439.5						390.0	355.5						
100/06-09-082-07 W4/00	06-09-082-07 W4	6216058	497580	733.4	513.0	285.0	448.4	20.0	343.0	390.4	363.0	370.4	370.0	363.4	14.0	0.0	14.0	-5.0	391.0	342.4
100/07-11-082-07 W4/00	07-11-082-07 W4	6216057	501230	676.7	484.6	240.0	436.7	18.0	304.0	372.7	322.0	354.7	328.0	348.7	8.0	0.0	8.0	-5.0	354.0	322.7
100/07-12-082-07 W4/00	07-12-082-07 W4	6216058	502854	673.3	458.0	231.0	442.3	14.0	295.0	378.3	309.0	364.3	316.0	357.3	6.0	0.0	6.0	-5.0	343.0	330.3
100/09-13-082-07 W4/00	09-13-082-07 W4	6218089	503254	641.1	426.0	191.0	450.1						269.0	372.1	25.0	0.0	25.0	-5.0	283.0	358.1
1AA/14-14-082-07 W4/00	14-14-082-07 W4	6218490	500829	699.0	490.0	252.0	447.0	1.0	324.0	375.0	325.0	374.0	333.0	366.0	29.0	0.0	29.0	-5.0	345.0	354.0
100/06-15-082-07 W4/00	06-15-082-07 W4	6217686	499205	717.4	510.0	271.0	446.4	2.0	345.0	372.4	347.0	370.4	353.0	364.4	28.0	0.0	28.0	-5.0	366.0	351.4
100/06-17-082-07 W4/00	06-17-082-07 W4	6217688	495958	745.9	513.0	296.0	449.9	28.0	348.0	397.9	376.0	369.9	383.0	362.9	8.0	0.0	8.0	-5.0	406.0	339.9
100/06-19-082-07 W4/00	06-19-082-07 W4	6219298	494336	746.0	530.0	302.0	444.0	16.0	355.0	391.0	371.0	375.0	382.0	364.0	27.0	0.0	27.0	-5.0	395.0	351.0
1AA/03-22-082-07 W4/00	03-22-082-07 W4	6218892	499205	725.2	517.0	276.0	449.2	18.0	334.0	391.2	352.0	373.2	360.0	365.2	29.0	0.0	29.0	-5.0	373.0	352.2
1AA/10-23-082-07 W4/00	10-23-082-07 W4	6219697	501229	681.0	484.0	230.0	451.0	19.0	289.0	392.0	308.0	373.0	315.0	366.0	23.0	0.0	23.0	-5.0	328.0	353.0
1AA/03-24-082-07 W4/00	03-24-082-07 W4	6218893	502452	630.6	445.0	179.0	451.6	18.0	239.0	391.6	257.0	373.6	264.0	366.6	28.0	0.0	28.0	-5.0	275.0	355.6
1AA/10-25-082-07 W4/00	10-25-082-07 W4	6221327	502851	649.8	481.0	200.0	449.8	18.0	260.0	389.8	278.0	371.8	286.0	363.8	27.0	0.0	27.0	-5.0	296.0	353.8
100/07-26-082-07 W4/00	07-26-082-07 W4	6220924	501229	655.6	457.0	208.0	447.6	16.0	267.0	388.6	283.0	372.6	290.0	365.6	21.0	0.0	21.0	-5.0	302.0	353.6
1AA/06-27-082-07 W4/00	06-27-082-07 W4	6220923	499206	683.7	470.0	231.0	452.7						317.0	366.7						
1AA/06-28-082-07 W4/00	06-28-082-07 W4	6220924	497583	722.5	521.0	278.0	444.5	18.0	326.0	396.5	344.0	378.5	355.0	367.5	26.0	0.0	26.0	-5.0	366.0	356.5
100/06-29-082-07 W4/00	06-29-082-07 W4	6220925	495961	730.7	500.0	277.0	453.7	18.0	330.0	400.7	348.0	382.7	352.0	378.7	27.0	0.0	27.0	-5.0	368.0	362.7
100/07-30-082-07 W4/00	07-30-082-07 W4	6220927	494739	733.9	501.0	281.0	452.9	15.0	335.0	398.9	350.0	383.9	356.0	377.9	25.0	0.0	25.0	-5.0	372.0	361.9
100/06-34-082-07 W4/00	06-34-082-07 W4	6222532	499206	702.5	489.0	252.0	450.5	17.0	303.0	399.5	320.0	382.5	331.0	371.5	27.0	0.0	27.0	-5.0	343.0	359.5
1AA/10-35-082-07 W4/00	10-35-082-07 W4	6222934	501228	644.9	440.0	195.0	449.9	18.0	249.0	395.9	267.0	377.9	275.0	369.9	27.0	0.0	27.0	-5.0	287.0	357.9
100/11-36-082-07 W4/00	11-36-082-07 W4	6222935	502450	592.6	380.0	140.0	452.6	17.0	197.0	395.6	214.0	378.6	221.0	371.6	28.0	0.0	28.0	-5.0	232.0	360.6
100/15-01-082-08 W4/00	15-01-082-08 W4	6215255	493112	725.7	513.0	282.0	443.7	14.0	345.0	380.7	359.0	366.7	366.0	359.7	19.0	0.0	19.0	-5.0	383.0	342.7
100/16-03-082-08 W4/00	16-03-082-08 W4	6215260	490264	722.7	512.0	283.0	439.7	17.0	339.0	383.7	356.0	366.7	367.0	355.7	21.0	0.0	21.0	-5.0	382.0	340.7
102/10-06-082-08 W4/00	10-06-082-08 W4	6214873	484988	716.2	495.0	270.0	446.2	34.0	315.0	401.2	349.0	367.2	349.0	367.2	18.0	0.0	18.0	-5.0	370.0	346.2
100/08-07-082-08 W4/00	08-07-082-08 W4	6216078	485393	718.4	491.0	270.0	448.4	32.0	318.0	400.4	350.0	368.4	352.0	366.4	15.0	0.0	15.0	-5.0	373.0	345.4
100/01-08-082-08 W4/00	01-08-082-08 W4	6215671	487016	718.6	497.0	267.0	451.6	30.0	319.0	399.6	349.0	369.6	350.0	368.6	18.0	0.0	18.0	-5.0	372.0	346.6
100/07-09-082-08 W4/00	07-09-082-08 W4	6216070	488241	728.6	505.0	282.0	446.6	24.0	331.0	397.6	355.0	373.6	355.0	373.6	16.0	0.0	16.0	-5.0	382.0	346.6
100/14-11-082-08 W4/00	14-11-082-08 W4	6216867	491090	725.6	495.0	276.0	449.6	15.0	330.0	395.6	345.0	380.6	347.0	378.6	14.0	0.0	14.0	-5.0	380.0	345.6
100/08-12-082-08 W4/00	08-12-082-08 W4	6216059	493515	726.2	503.0	283.0	443.2	26.0	335.0	391.2	361.0	365.2	367.0	359.2	18.0	0.0	18.0	-5.0	384.0	342.2
100/07-16-082-08 W4/00	07-16-082-08 W4	6217699	488245	738.2	511.0	288.0	450.2	30.0	341.0	397.2	371.0	367.2	375.0	363.2	9.0	0.0	9.0	-5.0	399.0	339.2
100/10-16-082-08 W4/00	10-16-082-08 W4	6218101	488246	740.5	517.0	289.0	451.5	29.0	343.0	397.5	372.0	368.5	372.0	368.5	9.0	0.0	9.0	-5.0	400.0	340.5

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Upper Clearwater Watersand Base (m bKB)	Upper Clearwater Watersand Base (m asl)	Middle Clearwater Watersand Top (m bKB)	Middle Clearwater Watersand Top (m asl)	Middle Clearwater Watersand Base (m bKB)	Middle Clearwater Watersand Base (m asl)	Top Wabiskaw (m bKB)	Top Wabiskaw (m asl)	Top McMurray (m bKB)	Top McMurray (m asl)	Paleo Surface (m bKB)	Paleo Surface (m asl)	Watersand Thickness (m)	Watersand Thickness (Surfer) (m)	Watersand Surface Elevation (m asl)	Log Analysis Notes:
100/03-05-082-06 W4/00	03-05-082-06 W4							237.0	297.3	249.0	285.3	303.0	231.3	0.0	-5.0	231.3	gamma ran high
100/12-06-082-06 W4/00	12-06-082-06 W4	295.0	324.8					324.0	295.8	333.0	286.8	396.0	223.8	2.0	2.0	225.8	
102/07-08-082-06 W4/00	07-08-082-06 W4	214.0	325.4					245.0	294.4	261.0	278.4	304.0	235.4	0.0	-5.0	235.4	
100/06-09-082-06 W4/00	06-09-082-06 W4	186.0	324.4					216.0	294.4	233.0	277.4	273.0	237.4	0.0	-5.0	237.4	
100/08-10-082-06 W4/00	08-10-082-06 W4	171.0	323.5					201.0	293.5	218.0	276.5	271.0	223.5	0.0	-5.0	223.5	
100/05-12-082-06 W4/00	05-12-082-06 W4	159.0	319.9					191.0	287.9	208.0	270.9	262.0	216.9	0.0	-5.0	216.9	
100/11-16-082-06 W4/00	11-16-082-06 W4	177.0	334.0					208.0	303.0	223.0	288.0	271.0	240.0	0.0	-5.0	240.0	
100/10-19-082-06 W4/00	10-19-082-06 W4	275.0	335.9					309.0	301.9	324.0	286.9	377.0	233.9	0.0	-5.0	233.9	
100/06-20-082-06 W4/00	06-20-082-06 W4	235.0	335.7					269.0	301.7	283.0	287.7	329.0	241.7	0.0	-5.0	241.7	
1AA/02-22-082-06 W4/00	02-22-082-06 W4	162.0	327.0					194.0	295.0	209.0	280.0	261.0	228.0	0.0	-5.0	228.0	
100/02-24-082-06 W4/00	02-24-082-06 W4	150.0	322.3					188.0	284.3	199.0	273.3	276.0	196.3	16.0	16.0	212.3	
1AA/12-25-082-06 W4/00	12-25-082-06 W4	163.0	325.7					197.0	291.7	211.0	277.7	288.0	200.7	0.0	-5.0	200.7	
1AA/02-26-082-06 W4/00	02-26-082-06 W4	156.0	324.3					192.0	288.3	206.0	274.3	282.0	198.3	0.0	-5.0	198.3	
1AA/09-27-082-06 W4/00	09-27-082-06 W4	164.0	322.0					200.0	286.0	210.0	276.0	267.0	219.0	0.0	-5.0	219.0	
100/06-28-082-06 W4/00	06-28-082-06 W4	184.0	333.6					219.0	298.6	233.0	284.6	293.0	224.6	0.0	-5.0	224.6	
1AA/07-30-082-06 W4/00	07-30-082-06 W4	200.0	337.7					243.0	294.7	251.0	286.7	312.0	225.7	0.0	-5.0	225.7	
1AA/06-31-082-06 W4/00	06-31-082-06 W4	257.0	339.6					296.0	300.6	310.0	286.6	363.0	233.6	0.0	-5.0	233.6	
100/07-32-082-06 W4/00	07-32-082-06 W4							222.0	301.7	237.0	286.7	312.0	211.7	0.0	-5.0	211.7	gamma ran high
100/06-34-082-06 W4/00	06-34-082-06 W4	154.0	337.0					195.0	296.0	209.0	282.0	270.0	221.0	0.0	-5.0	221.0	
100/07-36-082-06 W4/00	07-36-082-06 W4	162.0	330.9					199.0	293.9	215.0	277.9	289.0	203.9	0.0	-5.0	203.9	
100/11-01-082-07 W4/00	11-01-082-07 W4	330.0	326.1					360.0	296.1	373.0	283.1	439.0	217.1	6.0	6.0	223.1	
100/08-03-082-07 W4/00	08-03-082-07 W4	367.0	325.4					398.0	294.4	414.0	278.4	484.0	208.4	10.0	10.0	218.4	
100/05-05-082-07 W4/00	05-05-082-07 W4	397.0	327.0					429.0	295.0	443.0	281.0	493.0	231.0	0.0	-5.0	231.0	
100/08-07-082-07 W4/00	08-07-082-07 W4	406.0	320.8					437.0	289.8	449.0	277.8	505.0	221.8	9.0	9.0	230.8	
100/07-08-082-07 W4/00	07-08-082-07 W4							458.0	287.5	471.0	274.5	525.0	220.5	0.0	-5.0	220.5	gamma ran high
100/06-09-082-07 W4/00	06-09-082-07 W4	405.0	328.4					435.0	298.4	444.0	289.4	502.0	231.4	1.0	1.0	232.4	
100/07-11-082-07 W4/00	07-11-082-07 W4	362.0	314.7					395.0	281.7	409.0	267.7	471.0	205.7	5.0	5.0	210.7	
100/07-12-082-07 W4/00	07-12-082-07 W4	349.0	324.3					380.0	293.3	396.0	277.3	454.0	219.3	9.0	9.0	228.3	
100/09-13-082-07 W4/00	09-13-082-07 W4	308.0	333.1					341.0	300.1	355.0	286.1	417.0	224.1	0.0	-5.0	224.1	no GDRD on log
1AA/14-14-082-07 W4/00	14-14-082-07 W4	374.0	325.0					407.0	292.0	417.0	282.0	479.0	220.0	0.0	-5.0	220.0	
100/06-15-082-07 W4/00	06-15-082-07 W4	394.0	323.4					426.0	291.4	440.0	277.4	496.0	221.4	1.0	1.0	222.4	
100/06-17-082-07 W4/00	06-17-082-07 W4	414.0	331.9					444.0	301.9	458.0	287.9	508.0	237.9	0.0	-5.0	237.9	
100/06-19-082-07 W4/00	06-19-082-07 W4	422.0	324.0					455.0	291.0	468.0	278.0	516.0	230.0	0.0	-5.0	230.0	
1AA/03-22-082-07 W4/00	03-22-082-07 W4	402.0	323.2					435.0	290.2	446.0	279.2	503.0	222.2	0.0	-5.0	222.2	
1AA/10-23-082-07 W4/00	10-23-082-07 W4	351.0	330.0					388.0	293.0	402.0	279.0	467.0	214.0	1.0	1.0	215.0	
1AA/03-24-082-07 W4/00	03-24-082-07 W4	303.0	327.6					338.0	292.6	345.0	285.6	431.0	199.6	14.0	14.0	213.6	
1AA/10-25-082-07 W4/00	10-25-082-07 W4	323.0	326.8					359.0	290.8	368.0	281.8	465.0	184.8	18.0	18.0	202.8	
100/07-26-082-07 W4/00	07-26-082-07 W4	323.0	332.6					364.0	291.6	377.0	278.6	443.0	212.6	1.0	1.0	213.6	
1AA/06-27-082-07 W4/00	06-27-082-07 W4							391.0	292.7	404.0	279.7	454.0	229.7				gamma ran high
1AA/06-28-082-07 W4/00	06-28-082-07 W4	392.0	330.5					431.0	291.5	445.0	277.5	508.0	214.5	0.0	-5.0	214.5	
100/06-29-082-07 W4/00	06-29-082-07 W4	395.0	335.7					428.0	302.7	442.0	288.7	492.0	238.7	0.0	-5.0	238.7	
100/07-30-082-07 W4/00	07-30-082-07 W4	397.0	336.9					431.0	302.9	445.0	288.9	491.0	242.9	0.0	-5.0	242.9	
100/06-34-082-07 W4/00	06-34-082-07 W4	370.0	332.5					403.0	299.5	416.0	286.5	473.0	229.5	4.0	4.0	233.5	
1AA/10-35-082-07 W4/00	10-35-082-07 W4	314.0	330.9					350.0	294.9	362.0	282.9	419.0	225.9	0.0	-5.0	225.9	
100/11-36-082-07 W4/00	11-36-082-07 W4	260.0	332.6					293.0	299.6	303.0	289.6	366.0	226.6	0.0	-5.0	226.6	
100/15-01-082-08 W4/00	15-01-082-08 W4	402.0	323.7					432.0	293.7	444.0	281.7	500.0	225.7	0.0	-5.0	225.7	
100/16-03-082-08 W4/00	16-03-082-08 W4	403.0	319.7					434.0	288.7	448.0	274.7	499.0	223.7	13.0	13.0	236.7	minimum basal mcmurray thickness selected
102/10-06-082-08 W4/00	10-06-082-08 W4	388.0	328.2					422.0	294.2	432.0	284.2						
100/08-07-082-08 W4/00	08-07-082-08 W4	388.0	330.4					421.0	297.4	431.0	287.4	478.0	240.4	0.0	-5.0	240.4	
100/01-08-082-08 W4/00	01-08-082-08 W4	390.0	328.6					424.0	294.6	435.0	283.6	489.0	229.6	0.0	-5.0	229.6	
100/07-09-082-08 W4/00	07-09-082-08 W4	398.0	330.6					431.0	297.6	442.0	286.6	498.0	230.6	6.0	6.0	236.6	
100/14-11-082-08 W4/00	14-11-082-08 W4	394.0	331.6					426.0	299.6	438.0	287.6	485.0	240.6	2.0	2.0	242.6	
100/08-12-082-08 W4/00	08-12-082-08 W4	402.0	324.2					433.0	293.2	447.0	279.2	496.0	230.2	1.0	1.0	231.2	
100/07-16-082-08 W4/00	07-16-082-08 W4	408.0	330.2					441.0	297.2	452.0	286.2	505.0	233.2	4.0	4.0	237.2	
100/10-16-082-08 W4/00	10-16-082-08 W4	409.0	331.5					442.0	298.5	453.0	287.5	507.0	233.5	4.0	4.0	237.5	

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Northing (m) NAD 27	Easting (m) NAD 27	KB (m asl)	TD (m)	Top Grand Rapids (m bKB)	Top Grand Rapids (m asl)	Grand Rapids Watersand Thickness (m)	Grand Rapids Watersand Top (m bKB)	Grand Rapids Watersand Top (m asl)	Grand Rapids Watersand Base (m bKB)	Grand Rapids Watersand Base (m asl)	Top Clearwater (m bKB)	Top Clearwater (m asl)	Upper Clearwater Watersand Thickness (m)	Middle Clearwater Watersand Thickness (m)	Upper Clearwater Watersand Thickness (Surfer) (m)	Middle Clearwater Watersand Thickness (Surfer) (m)	Upper Clearwater Watersand Top (m bKB)	Upper Clearwater Watersand Top (m asl)
100/15-17-082-08 W4/00	15-17-082-08 W4	6218508	486624	740.0	522.0	292.0	448.0	36.0	338.0	402.0	374.0	366.0	382.0	358.0	11.0	0.0	11.0	-5.0	399.0	341.0
100/13-19-082-08 W4/00	13-19-082-08 W4	6220125	484205	746.2	508.0	290.0	456.2	33.0	335.0	411.2	368.0	378.2	368.0	378.2	28.0	0.0	28.0	-5.0	383.0	363.2
100/07-21-082-08 W4/00	07-21-082-08 W4	6219307	488250	741.7	508.0	283.0	458.7	28.0	334.0	407.7	362.0	379.7	367.0	374.7	29.0	0.0	29.0	-5.0	380.0	361.7
1AA/06-25-082-08 W4/00	06-25-082-08 W4	6220926	492721	736.1	515.0	285.0	451.1	18.0	338.0	398.1	356.0	380.1	361.0	375.1	25.0	0.0	25.0	-5.0	376.0	360.1
100/06-27-082-08 W4/00	06-27-082-08 W4	6220933	489476	739.3	504.0	283.0	456.3	29.0	331.0	408.3	360.0	379.3	368.0	371.3	27.0	0.0	27.0	-5.0	377.0	362.3
1AA/05-28-082-08 W4/00	05-28-082-08 W4	6220938	487453	738.7	519.0	285.0	453.7	31.0	330.0	408.7	361.0	377.7	361.0	377.7	28.0	0.0	28.0	-5.0	376.0	362.7
1AA/12-31-082-08 W4/00	12-31-082-08 W4	6222960	484215	727.6	508.0	275.0	452.6	30.0	319.0	408.6	349.0	378.6	350.0	377.6	24.0	0.0	24.0	-5.0	364.0	363.6
1AA/03-33-082-08 W4/00	03-33-082-08 W4	6222144	487857	747.2	524.0	292.0	455.2	31.0	337.0	410.2	368.0	379.2	368.0	379.2	27.0	0.0	27.0	-5.0	383.0	364.2
100/01-01-082-09W400	01-01-082-09W4	6214421	483799	715.3	486.0	271.0	444.3	32.0	318.0	397.3	350.0	365.3	357.6	357.7	0.0	0.0	-5.0	-5.0		
100/02-04-082-09W400	02-04-082-09W4	6214204	478420	709.8	483.5	265.5	444.3	39.0	310.0	399.8	349.0	360.8	352.6	357.2	0.0	0.0	-5.0	-5.0		
100/13-06-082-09W400	13-06-082-09W4	6215652	474553	707.6	481.0	264.5	443.1	31.0	309.0	398.6	340.0	367.6	349.4	358.2	0.0	0.0	-5.0	-5.0		
1AA/06-08-082-09W400	06-08-082-09W4	6216210	476486	711.7	495.3	281.3	430.5	30.0	311.0	400.7	341.0	370.7	352.0	359.7	17.0	0.0	17.0	-5.0	365.0	346.7
100/15-08-082-09W400	15-08-082-09W4	6216990	476998	713.6	485.0	268.3	445.3	29.0	313.0	400.6	342.0	371.6	352.8	360.8	18.0	0.0	18.0	-5.0	367.0	346.6
100/10-09-082-09W400	10-09-082-09W4	6216885	478443	723.6	508.4	277.8	445.8	26.0	323.0	400.6	349.0	374.6	361.8	361.8	16.0	0.0	16.0	-5.0	379.0	344.6
100/10-10-082-09W400	10-10-082-09W4	6216812	480119	732.7	518.2	285.9	446.8	35.0	331.0	401.7	366.0	366.7	372.0	360.7	17.0	0.0	17.0	-5.0	386.0	346.7
100/10-11-082-09W400	10-11-082-09W4	6216522	481749	736.9	510.0	287.2	449.7	34.0	333.0	403.9	367.0	369.9			14.0	0.0	14.0	-5.0	390.0	346.9
1AA/15-11-082-09W400	15-11-082-09W4	6217135	481710	741.0	521.2	292.8	448.2	32.0	339.0	402.0	371.0	370.0	379.4	361.6	3.0	0.0	3.0	-5.0	401.0	340.0
100/06-12-082-09W400	06-12-082-09W4	6216310	482912	738.5	519.7	290.4	448.1						378.5	360.0						
102/06-12-082-09W400	06-12-082-09W4	6216304	482732	737.3	519.0	289.5	447.9	34.0	333.0	404.3	367.0	370.3	375.9	361.5	16.0	0.0	16.0	-5.0	391.0	346.3
1AA/13-14-082-09W400	13-14-082-09W4	6218795	480898	744.1	541.5	299.6	444.5	35.0	347.0	397.1	382.0	362.1	387.0	357.1	13.0	0.0	13.0	-5.0	404.0	340.1
100/07-15-082-09W400	07-15-082-09W4	6217759	480144	739.7	511.0	293.1	446.6	36.0	337.0	402.7	373.0	366.7	377.0	362.7	17.0	0.0	17.0	-5.0	394.0	345.7
1AA/13-15-082-09W400	13-15-082-09W4	6218802	479280	738.8	532.0	289.7	449.2	27.0	341.0	397.8	368.0	370.8	377.5	361.3	15.0	0.0	15.0	-5.0	396.0	342.8
100/15-15-082-09W400	15-15-082-09W4	6218926	480132	737.4	519.0	295.8	441.6	25.0	341.0	396.4	366.0	371.4	378.9	358.5	10.0	0.0	10.0	-5.0	397.0	340.4
100/15-16-082-09W400	15-16-082-09W4	6218678	478448	735.1	512.0	287.5	447.6	26.0	334.0	401.1	360.0	375.1	370.7	364.4	11.0	0.0	11.0	-5.0	391.0	344.1
100/02-17-082-09W400	02-17-082-09W4	6217638	476872	724.3	504.0	279.3	445.0	27.0	325.0	399.3	352.0	372.3	362.0	362.3	16.0	0.0	16.0	-5.0	378.0	346.3
1AA/10-17-082-09W400	10-17-082-09W4	6218345	476839	722.4	506.0	275.1	447.3	27.0	322.0	400.4	349.0	373.4	358.8	363.7	15.0	0.0	15.0	-5.0	375.0	347.4
100/05-18-082-09W400	05-18-082-09W4	6218080	474549	713.3	488.0	266.6	446.7	23.0	311.0	402.3	334.0	379.3	350.2	363.1	12.0	0.0	12.0	-5.0	370.0	343.3
1AA/16-18-082-09W400	16-18-082-09W4	6218865	475421	715.9	503.0	266.0	450.0	25.0	311.0	404.9	336.0	379.9	351.5	364.4	12.0	0.0	12.0	-5.0	370.0	345.9
100/06-19-082-09W400	06-19-082-09W4	6219615	474804	717.4	499.0	270.1	447.3	26.0	315.0	402.4	341.0	376.4	355.1	362.3	14.0	0.0	14.0	-5.0	372.0	345.4
1AA/10-20-082-09W400	10-20-082-09W4	6219872	476876	737.3	519.7	288.8	448.5	25.0	332.0	405.3	357.0	380.3	370.9	366.4	24.0	0.0	24.0	-5.0	382.0	355.3
1AA/15-21-082-09W400	15-21-082-09W4	6220181	478419	734.4	524.0	285.9	448.5	17.0	331.0	403.4	348.0	386.4	366.1	368.4	29.0	0.0	29.0	-5.0	375.0	359.4
100/07-22-082-09W400	07-22-082-09W4	6219464	480138	745.9	515.6	295.9	450.0	22.0	343.0	402.9	365.0	380.9	377.8	368.1	17.0	0.0	17.0	-5.0	394.0	351.9
100/11-23-082-09W400	11-23-082-09W4	6219952	481286	743.3	511.0	292.2	451.1	30.0	335.0	408.3	365.0	378.3	373.4	369.9	27.0	0.0	27.0	-5.0	382.0	361.3
100/10-24-082-09W400	10-24-082-09W4	6220145	483424	751.8	447.5	299.1	452.7	31.0	343.0	408.8	374.0	377.8	381.0	370.9	27.0	0.0	27.0	-5.0	391.0	360.8
100/06-25-082-09W400	06-25-082-09W4	6221164	482931	741.6	515.1	290.5	451.2	32.0	334.0	407.6	366.0	375.6	372.2	369.4	28.0	0.0	28.0	-5.0	380.0	361.6
100/08-26-082-09W400	08-26-082-09W4	6221159	482085	727.6	500.0	280.5	447.1	23.0	325.0	402.6	348.0	379.6	361.2	366.4	26.0	0.0	26.0	-5.0	370.0	357.6
100/05-27-082-09W400	05-27-082-09W4	6221274	479183	737.8	507.0	285.8	452.0	21.0	329.0	408.8	350.0	387.8	365.2	372.6	24.0	0.0	24.0	-5.0	377.0	360.8
1AA/15-28-082-09W400	15-28-082-09W4	6222003	478427	742.7	526.0	291.2	451.5	19.0	336.0	406.7	355.0	387.7	371.8	370.9	24.0	0.0	24.0	-5.0	383.0	359.7
100/08-29-082-09W400	08-29-082-09W4	6221363	477273	732.7	501.0	277.5	455.2	22.0	322.0	410.7	344.0	388.7	358.0	374.7	21.0	0.0	21.0	-5.0	373.0	359.7
100/08-30-082-09W400	08-30-082-09W4	6221389	475427	730.2	494.0	277.3	452.9						358.3	371.9						
100/06-31-082-09W400	06-31-082-09W4	6222817	474894	730.5	501.0	275.8	454.7	24.0	321.0	409.5	345.0	385.5	356.8	373.7	22.0	0.0	22.0	-5.0	369.0	361.5
1AA/12-31-082-09W400	12-31-082-09W4	6223224	474435	719.4	502.4	266.3	453.2	23.0	313.0	406.4	336.0	383.4	348.3	371.1	23.0	0.0	23.0	-5.0	359.0	360.4
100/08-32-082-09W400	08-32-082-09W4	6222806	477219	728.1	505.0	277.5	450.6	21.0	323.0	405.1	344.0	384.1	359.0	369.1	21.0	0.0	21.0	-5.0	369.0	359.1
100/02-33-082-09W400	02-33-082-09W4	6222584	478466	730.8	496.0	278.1	452.7	22.0	323.0	407.8	345.0	385.8	359.1	371.7	24.0	0.0	24.0	-5.0	369.0	361.8
100/10-33-082-09W400	10-33-082-09W4	6223107	478473	726.9	514.2	276.5	450.5	21.0	322.0	404.9	343.0	383.9	359.7	367.2	24.0	0.0	24.0	-5.0	369.0	357.9
100/03-34-082-09W400	03-34-082-09W4	6222398	479742	729.7	495.6	282.1	447.6	21.0	323.0	406.7	344.0	385.7	357.6	372.1	26.0	0.0	26.0	-5.0	367.0	362.7
100/06-35-082-09W400	06-35-082-09W4	6222794	481186	727.6	501.1	276.8	450.8						356.0	371.7						
100/01-36-082-09W400	01-36-082-09W4	6222373	483695	728.8	498.0	272.9	455.9	31.0	317.0	411.8	348.0	380.8	353.7	375.2	26.0	0.0	26.0	-5.0	362.0	366.8
100/12-07-082-10W400	12-07-082-10W4	6216647	464754	706.6	488.0	261.1	445.5	32.0	306.0	400.6	338.0	368.6	349.9	356.7	13.0	0.0	13.0	-5.0	362.0	344.6
100/10-09-082-10W400	10-09-082-10W4	6216739	468892	704.0	486.0	257.2	446.8	32.0	301.0	403.0	333.0	371.0	344.6	359.4	6.0	0.0	6.0	-5.0	365.0	339.0
100/07-10-082-10W400	07-10-082-10W4	6216548	470521	708.9	482.0	261.2	447.7	29.0	305.0	403.9	334.0	374.9	348.0	360.9	0.0	0.0	-5.0	-5.0		
100/12-13-082-10W400	12-13-082-10W4	6218256	472850	713.4	493.0	264.6	448.8	25.0	309.0	404.4	334.0	379.4	349.7	363.7	9.0	0.0	9.0	-5.0	371.0	342.4
100/13-14-082-10W400	13-14-082-10W4	6218728	471347	711.1	486.0	263.2	447.9	26.0	308.0	403.1	334.0	377.1	348.0	363.1	11.0	0.0	11.0	-5.0	368.0	343.1
100/06-15-082-10W400	06-15-082-10W4	6217906	470110	708.0	482.0	260.0	448.0	27.0	305.0	403.0	332.0	376.0	346.9	361.1	8.0	0.0	8.0	-5.0	368.0	340.0
1AA/08-16-082-10W400	08-16-082-10W4	6218206	469169	707.1	486.0	259.1	448.0	29.0	304.0	403.1	333.0	374.1	344.6	362.5	15.0	0.0	15.0	-5.0	360.0	347.1
100/07-17-082-10W400	07-17-082-10W4	6218153	467057	705.5	478.0	258.0	447.5	31.0	302.0	403.5	333.0	372.5	344.8	360.7	17.0	0.0	17.0	-5.0	357.0	348.5

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Upper Clearwater Watersand Base (m bKB)	Upper Clearwater Watersand Base (m asl)	Middle Clearwater Watersand Top (m bKB)	Middle Clearwater Watersand Top (m asl)	Middle Clearwater Watersand Base (m bKB)	Middle Clearwater Watersand Base (m asl)	Top Wabiskaw (m bKB)	Top Wabiskaw (m asl)	Top McMurray (m bKB)	Top McMurray (m asl)	Paleo Surface (m bKB)	Paleo Surface (m asl)	Watersand Thickness (m)	Watersand Thickness (Surfer) (m)	Watersand Surface Elevation (m asl)	Log Analysis Notes:
100/15-17-082-08 W4/00	15-17-082-08 W4	410.0	330.0					443.0	297.0	453.0	287.0	510.0	230.0	9.0	9.0	239.0	
100/13-19-082-08 W4/00	13-19-082-08 W4	411.0	335.2					444.0	302.2	458.0	288.2	503.0	243.2	0.0	-5.0	243.2	
100/07-21-082-08 W4/00	07-21-082-08 W4	409.0	332.7					442.0	299.7	453.0	288.7	490.0	251.7	0.0	-5.0	251.7	
1AA/06-25-082-08 W4/00	06-25-082-08 W4	401.0	335.1					434.0	302.1	444.0	292.1	495.0	241.1	0.0	-5.0	241.1	
100/06-27-082-08 W4/00	06-27-082-08 W4	404.0	335.3					437.0	302.3	449.0	290.3	492.0	247.3	0.0	-5.0	247.3	
1AA/05-28-082-08 W4/00	05-28-082-08 W4	404.0	334.7					437.0	301.7	448.0	290.7	501.0	237.7	2.0	2.0	239.7	
1AA/12-31-082-08 W4/00	12-31-082-08 W4	388.0	339.6					426.0	301.6	436.0	291.6	490.0	237.6	0.0	-5.0	237.6	
1AA/03-33-082-08 W4/00	03-33-082-08 W4	410.0	337.2					445.0	302.2	455.0	292.2	505.0	242.2	0.0	-5.0	242.2	
100/01-01-082-09W400	01-01-082-09W4							423.1	292.2	435.0	280.3	484.0	231.3	4.0	4.0	235.3	
100/02-04-082-09W400	02-04-082-09W4							414.6	295.2	424.3	285.5						
100/13-06-082-09W400	13-06-082-09W4							413.0	294.6	423.1	284.5						
1AA/06-08-082-09W400	06-08-082-09W4	382.0	329.7					416.7	295.0	427.3	284.4	484.1	227.6	0.0	-5.0	227.6	
100/15-08-082-09W400	15-08-082-09W4	385.0	328.6					418.5	295.2	429.7	283.9						
100/10-09-082-09W400	10-09-082-09W4	395.0	328.6					428.0	295.6	439.4	284.3	500.3	223.3	2.0	2.0	225.3	
100/10-10-082-09W400	10-10-082-09W4	403.0	329.7					436.7	296.0	447.2	285.5	502.9	229.9	0.0	-5.0	229.9	
100/10-11-082-09W400	10-11-082-09W4	404.0	332.9					435.9	301.0	447.0	289.9						
1AA/15-11-082-09W400	15-11-082-09W4	404.0	337.0					445.3	295.8	456.4	284.6	509.0	232.0				
100/06-12-082-09W400	06-12-082-09W4							444.4	294.1	455.7	282.8	509.3	229.3	0.0	-5.0	229.3	gamma ran high
102/06-12-082-09W400	06-12-082-09W4	407.0	330.3					440.0	297.3	451.4	285.9						
1AA/13-14-082-09W400	13-14-082-09W4	417.0	327.1					449.1	295.0	459.7	284.4	523.8	220.3	10.0	10.0	230.3	
100/07-15-082-09W400	07-15-082-09W4	411.0	328.7					443.2	296.5	453.9	285.8	508.0	231.7	0.0	-5.0	231.7	
1AA/13-15-082-09W400	13-15-082-09W4	411.0	327.8					442.2	296.6	452.9	285.9	515.7	223.1	0.0	-5.0	223.1	
100/15-15-082-09W400	15-15-082-09W4	407.0	330.4					439.6	297.8	448.9	288.5	515.2	222.2	0.0	-5.0	222.2	
100/15-16-082-09W400	15-16-082-09W4	402.0	333.1					433.6	301.5	443.4	291.8						
100/02-17-082-09W400	02-17-082-09W4	394.0	330.3					427.4	296.9	436.8	287.5	496.0	228.3	0.0	-5.0	228.3	
1AA/10-17-082-09W400	10-17-082-09W4	390.0	332.4					425.2	297.2	435.1	287.3	488.1	234.3	0.0	-5.0	234.3	
100/05-18-082-09W400	05-18-082-09W4	382.0	331.3					416.0	297.3	426.6	286.7						
1AA/16-18-082-09W400	16-18-082-09W4	382.0	333.9					416.0	299.9	425.8	290.2	486.2	229.7	0.0	-5.0	229.7	
100/06-19-082-09W400	06-19-082-09W4	386.0	331.4					419.5	297.9	430.2	287.2	493.8	223.6	4.0	4.0	227.6	
1AA/10-20-082-09W400	10-20-082-09W4	406.0	331.3					440.0	297.3	450.0	287.3	510.8	226.5	4.0	4.0	230.5	
1AA/15-21-082-09W400	15-21-082-09W4	404.0	330.4					438.7	295.7	449.5	284.9	504.8	229.6	3.0	3.0	232.6	
100/07-22-082-09W400	07-22-082-09W4	411.0	334.9					441.9	304.0	453.0	292.9	506.3	239.6	0.0	-5.0	239.6	
100/11-23-082-09W400	11-23-082-09W4	409.0	334.3					441.2	302.2	451.7	291.6	508.8	234.6	0.0	-5.0	234.6	
100/10-24-082-09W400	10-24-082-09W4	418.0	333.8														
100/06-25-082-09W400	06-25-082-09W4	408.0	333.6					442.3	299.3	453.2	288.4	505.4	236.2	0.0	-5.0	236.2	
100/08-26-082-09W400	08-26-082-09W4	396.0	331.6					431.2	296.4	443.0	284.6	499.5	228.1	0.0	-5.0	228.1	
100/05-27-082-09W400	05-27-082-09W4	401.0	336.8					434.9	302.9	445.2	292.6						
1AA/15-28-082-09W400	15-28-082-09W4	407.0	335.7					442.1	300.6	453.1	289.6	509.2	233.5	0.0	-5.0	233.5	
100/08-29-082-09W400	08-29-082-09W4	394.0	338.7					427.7	305.0	438.4	294.3	498.6	234.1	0.0	-5.0	234.1	
100/08-30-082-09W400	08-30-082-09W4							427.1	303.1	437.5	292.7	492.7	237.5	0.0	-5.0	237.5	gamma high
100/06-31-082-09W400	06-31-082-09W4	391.0	339.5					425.0	305.5	436.4	294.1	499.4	231.1	0.0	-5.0	231.1	
1AA/12-31-082-09W400	12-31-082-09W4	382.0	337.4					416.7	302.7	427.3	292.1	486.0	233.4	0.0	-5.0	233.4	
100/08-32-082-09W400	08-32-082-09W4	390.0	338.1					429.5	298.6	441.0	287.1						
100/02-33-082-09W400	02-33-082-09W4	393.0	337.8					429.0	301.8	439.0	291.8						
100/10-33-082-09W400	10-33-082-09W4	393.0	333.9					430.0	296.9	440.8	286.1	505.3	221.6	0.0	-5.0	221.6	
100/03-34-082-09W400	03-34-082-09W4	393.0	336.7					426.4	303.3	438.1	291.7	493.0	236.8	0.0	-5.0	236.8	
100/06-35-082-09W400	06-35-082-09W4							426.6	301.0	436.7	290.9	492.4	235.2	0.0	-5.0	235.2	
100/01-36-082-09W400	01-36-082-09W4	388.0	340.8					421.8	307.0	432.3	296.5						
100/12-07-082-10W400	12-07-082-10W4	375.0	331.6					414.7	291.9	424.8	281.8	476.1	230.5	0.0	-5.0	230.5	
100/10-09-082-10W400	10-09-082-10W4	371.0	333.0					409.0	295.0	418.5	285.5	475.7	228.3	0.0	-5.0	228.3	
100/07-10-082-10W400	07-10-082-10W4							410.0	298.9	420.5	288.4	477.0	231.9	6.0	6.0	237.9	
100/12-13-082-10W400	12-13-082-10W4	380.0	333.4					415.3	298.1	426.6	286.8	485.6	227.8	3.0	3.0	230.8	
100/13-14-082-10W400	13-14-082-10W4	379.0	332.1					413.8	297.3	423.8	287.3						
100/06-15-082-10W400	06-15-082-10W4	376.0	332.0					411.7	296.3	421.8	286.2	476.6	231.4	5.0	5.0	236.4	
1AA/08-16-082-10W400	08-16-082-10W4	375.0	332.1					409.1	297.9	419.2	287.9	475.0	232.1	0.0	-5.0	232.1	
100/07-17-082-10W400	07-17-082-10W4	374.0	331.5					409.9	295.6	420.5	285.1	472.2	233.4	0.0	-5.0	233.4	

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Northing (m) NAD 27	Easting (m) NAD 27	KB (m asl)	TD (m)	Top Grand Rapids (m bKB)	Top Grand Rapids (m asl)	Grand Rapids Watersand Thickness (m)	Grand Rapids Watersand Top (m bKB)	Grand Rapids Watersand Top (m asl)	Grand Rapids Watersand Base (m bKB)	Grand Rapids Watersand Base (m asl)	Top Clearwater (m bKB)	Top Clearwater (m asl)	Upper Clearwater Watersand Thickness (m)	Middle Clearwater Watersand Thickness (m)	Upper Clearwater Watersand Thickness (Surfer) (m)	Middle Clearwater Watersand Thickness (Surfer) (m)	Upper Clearwater Watersand Top (m bKB)	Upper Clearwater Watersand Top (m asl)
100/10-19-082-10W400	10-19-082-10W4	6219905	465444	707.6	491.0	258.1	449.6	25.0	303.0	404.6	328.0	379.6	347.2	360.4	16.0	0.0	16.0	-5.0	358.0	349.6
100/12-20-082-10W400	12-20-082-10W4	6219911	466451	709.6	494.0	259.7	449.9	28.0	305.0	404.6	333.0	376.6	346.2	363.4	17.0	0.0	17.0	-5.0	360.0	349.6
100/15-24-082-10W400	15-24-082-10W4	6220399	473595	717.5	509.0	266.5	451.0	24.0	312.0	405.5	336.0	381.5	348.8	368.7	25.0	0.0	25.0	-5.0	360.0	357.5
100/10-25-082-10W400	10-25-082-10W4	6221585	473510	719.4	495.0	263.4	456.0	24.0	308.0	411.4	332.0	387.4	344.7	374.7	21.0	0.0	21.0	-5.0	359.0	360.4
100/12-27-082-10W400	12-27-082-10W4	6221661	469376	713.0	487.0	259.3	453.7	22.0	305.0	408.0	327.0	386.0	343.6	369.4	24.0	0.0	24.0	-5.0	355.0	358.0
1AA/14-27-082-10W400	14-27-082-10W4	6221958	469861	713.9	505.8	262.7	451.2	21.0	308.0	405.9	329.0	384.9	346.2	367.7	28.0	0.0	28.0	-5.0	355.0	358.9
1AA/10-28-082-10W400	10-28-082-10W4	6221663	468735	713.0	494.6	262.9	450.1	24.0	308.0	405.0	332.0	381.0	346.5	366.5	26.0	0.0	26.0	-5.0	357.0	356.0
100/03-30-082-10W400	03-30-082-10W4	6220760	465044	708.4	493.0	258.6	449.8	26.0	304.0	404.4	330.0	378.4	345.6	362.8	14.0	0.0	14.0	-5.0	360.0	348.4
1AA/02-36-082-10W400	02-36-082-10W4	6222341	473632	719.9	506.0	265.1	454.8	21.0	311.0	408.9	332.0	387.9	346.0	373.9	20.0	0.0	20.0	-5.0	359.0	360.9
100/06-04-082-11 W4/00	06-04-082-11 W4	6214645	458590	721.9	510.0	281.0	440.9	24.0	329.0	392.9	353.0	368.9	376.0	345.9	0.0	0.0	-5.0	-5.0		
100/12-12-082-11 W4/00	12-12-082-11 W4	6216615	463081	708.2	496.0	264.0	444.2	31.0	310.0	398.2	341.0	367.2	353.0	355.2	14.0	0.0	14.0	-5.0	365.0	343.2
100/06-13-082-11 W4/00	06-13-082-11 W4	6217838	463492	711.3	485.0	265.0	446.3	29.0	310.0	401.3	339.0	372.3	350.0	361.3	16.0	0.0	16.0	-5.0	364.0	347.3
100/11-16-082-11 W4/00	11-16-082-11 W4	6218285	458625	733.0	516.0	287.0	446.0	24.0	334.0	399.0	358.0	375.0	379.0	354.0	12.0	0.0	12.0	-5.0	390.0	343.0
100/12-23-082-11 W4/00	12-23-082-11 W4	6219867	461486	720.8	497.0	275.0	445.8	28.0	322.0	398.8	350.0	370.8	369.0	351.8	20.0	0.0	20.0	-5.0	374.0	346.8
100/11-25-082-11 W4/00	11-25-082-11 W4	6221478	463523	719.2	492.0	268.0	451.2	21.0	315.0	404.2	336.0	383.2	348.0	371.2	23.0	0.0	23.0	-5.0	362.0	357.2
100/11-32-082-11 W4/00	11-32-082-11 W4	6223147	457050	738.9	513.0	288.0	450.9	21.0	337.0	401.9	358.0	380.9	374.0	364.9	12.0	0.0	12.0	-5.0	392.0	346.9
100/08-02-082-12 W4/00	08-02-082-12 W4	6214702	452894	760.1	540.0	319.0	441.1	26.0	365.0	395.1	391.0	369.1	414.0	346.1	0.0	0.0	-5.0	-5.0		
100/07-03-082-12 W4/00	07-03-082-12 W4	6214725	450868	742.2	529.0	297.0	445.2	21.0	346.0	396.2	367.0	375.2	394.0	348.2	0.0	0.0	-5.0	-5.0		
100/08-04-082-12 W4/00	08-04-082-12 W4	6214739	449644	749.1	545.0	307.0	442.1	33.0	357.0	392.1	390.0	359.1	405.0	344.1	0.0	0.0	-5.0	-5.0		
100/14-05-082-12 W4/00	14-05-082-12 W4	6215573	447227	739.3	536.0	300.0	439.3	18.0	351.0	388.3	369.0	370.3	395.0	344.3	0.0	0.0	-5.0	-5.0		
100/08-06-082-12 W4/00	08-06-082-12 W4	6214778	446395	732.5	530.0	292.0	440.5	35.0	340.0	392.5	375.0	357.5	387.0	345.5	0.0	0.0	-5.0	-5.0		
100/07-08-082-12 W4/00	07-08-082-12 W4	6216372	447638	738.4	535.0	294.0	444.4	28.0	343.0	395.4	371.0	367.4	388.0	350.4	0.0	0.0	-5.0	-5.0		
100/07-09-082-12 W4/00	07-09-082-12 W4	6216352	449262	743.0	533.0	306.0	437.0	15.0	351.0	392.0	366.0	377.0	393.0	350.0	0.0	0.0	-5.0	-5.0		
100/08-11-082-12 W4/00	08-11-082-12 W4	6216311	452912	756.2	545.0	314.0	442.2	32.0	361.0	395.2	393.0	363.2	409.0	347.2	0.0	0.0	-5.0	-5.0		
100/06-13-082-12 W4/00	06-13-082-12 W4	6217931	453751	754.0	535.0	309.0	445.0	22.0	356.0	398.0	378.0	376.0	401.0	353.0	0.0	0.0	-5.0	-5.0		
100/10-14-082-12 W4/00	10-14-082-12 W4	6218346	452533	753.1	530.5	306.0	447.1	35.0	355.0	398.1	390.0	363.1	401.0	352.1	11.0	0.0	11.0	-5.0	410.0	343.1
100/05-16-082-12 W4/00	05-16-082-12 W4	6217991	448480	724.4	521.0	276.0	448.4	21.0	324.0	400.4	345.0	379.4	370.0	354.4	0.0	0.0	-5.0	-5.0		
100/03-18-082-12 W4/00	03-18-082-12 W4	6217624	445628	680.8	472.5	239.0	441.8	30.0	287.0	393.8	317.0	363.8	334.0	346.8	0.0	0.0	-5.0	-5.0		
100/02-19-082-12 W4/00	02-19-082-12 W4	6219227	446049	667.3	451.0	223.0	444.3	28.0	272.0	395.3	300.0	367.3	317.0	350.3	0.0	0.0	-5.0	-5.0		
102/05-21-082-12 W4/00	05-21-082-12 W4	6219599	448499	697.9	479.0	250.0	447.9	27.0	298.0	399.9	325.0	372.9	344.0	353.9	0.0	0.0	-5.0	-5.0		
100/06-22-082-12 W4/00	06-22-082-12 W4	6219576	450523	744.4	528.0	297.0	447.4	26.0	344.0	400.4	370.0	374.4	390.0	354.4	10.0	0.0	10.0	-5.0	398.0	346.4
100/11-27-082-12 W4/00	11-27-082-12 W4	6221607	450546	714.4	500.0	269.0	445.4						355.0	359.4						
100/10-29-082-12 W4/00	10-29-082-12 W4	6221640	447702	663.5	965.0	221.0	442.5	34.0	269.0	394.5	303.0	360.5	314.0	349.5	11.0	0.0	11.0	-5.0	322.0	341.5
100/06-36-082-12 W4/00	06-36-082-12 W4	6222777	453804	747.4	1080.5	297.0	450.4						387.0	360.4						
100/11-01-082-13 W4/00	11-01-082-13 W4	6215212	443974	698.2	500.0	260.0	438.2	31.0	309.0	389.2	340.0	358.2	354.0	344.2	0.0	0.0	-5.0	-5.0		
100/10-03-082-13 W4/00	10-03-082-13 W4	6215250	441125	669.8	460.0	237.0	432.8	30.0	282.0	387.8	312.0	357.8	330.0	339.8	0.0	0.0	-5.0	-5.0		
100/06-06-082-13 W4/00	06-06-082-13 W4	6214923	435844	601.1	386.5	166.0	435.1	29.0	214.0	387.1	243.0	358.1	261.0	340.1	0.0	0.0	-5.0	-5.0		
100/06-10-082-13 W4/00	06-10-082-13 W4	6216462	440741	634.0	426.7	198.0	436.0	33.0	247.0	387.0	280.0	354.0	294.0	340.0	0.0	0.0	-5.0	-5.0		
1AA/09-11-082-13 W4/00	09-11-082-13 W4	6216831	443173	663.5	465.7	222.0	441.5	20.0	272.0	391.5	292.0	371.5	317.0	346.5	0.0	0.0	-5.0	-5.0		
100/04-12-082-13 W4/00	04-12-082-13 W4	6216021	443583	674.6	472.0	234.0	440.6	30.0	284.0	390.6	314.0	360.6	331.0	343.6	0.0	0.0	-5.0	-5.0		
100/15-13-082-13 W4/00	15-13-082-13 W4	6218846	444422	657.0	442.0	216.0	441.0	22.0	265.0	392.0	287.0	370.0	311.0	346.0	0.0	0.0	-5.0	-5.0		
100/05-16-082-13 W4/00	05-16-082-13 W4	6218119	438739	604.4	382.0	165.0	439.4	19.0	214.0	390.4	233.0	371.4	260.0	344.4	0.0	0.0	-5.0	-5.0		
1AA/01-18-082-13 W4/00	01-18-082-13 W4	6217746	436688	597.0	391.0	158.0	439.0	17.0	211.0	386.0	228.0	369.0	254.0	343.0	0.0	0.0	-5.0	-5.0		

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Upper Clearwater Watersand Base (m bKB)	Upper Clearwater Watersand Base (m asl)	Middle Clearwater Watersand Top (m bKB)	Middle Clearwater Watersand Top (m asl)	Middle Clearwater Watersand Base (m bKB)	Middle Clearwater Watersand Base (m asl)	Top Wabiskaw (m bKB)	Top Wabiskaw (m asl)	Top McMurray (m bKB)	Top McMurray (m asl)	Paleo Surface (m bKB)	Paleo Surface (m asl)	Watersand Thickness (m)	Watersand Thickness (Surfer) (m)	Watersand Surface Elevation (m asl)	Log Analysis Notes:
100/10-19-082-10W400	10-19-082-10W4	374.0	333.6					409.0	298.6	419.8	287.8	474.6	233.0	0.0	-5.0	233.0	
100/12-20-082-10W400	12-20-082-10W4	377.0	332.6					412.0	297.6	422.0	287.6	479.6	230.0	0.0	-5.0	230.0	
100/15-24-082-10W400	15-24-082-10W4	385.0	332.5					418.0	299.5	428.2	289.3	493.3	224.2	0.0	-5.0	224.2	
100/10-25-082-10W400	10-25-082-10W4	380.0	339.4					413.6	305.8	425.3	294.1	488.0	231.4	0.0	-5.0	231.4	
100/12-27-082-10W400	12-27-082-10W4	379.0	334.0					414.4	298.6	424.7	288.3	480.4	232.6	0.0	-5.0	232.6	
1AA/14-27-082-10W400	14-27-082-10W4	383.0	330.9					417.4	296.5	428.1	285.8	485.5	228.4	0.0	-5.0	228.4	
1AA/10-28-082-10W400	10-28-082-10W4	383.0	330.0					418.8	294.1	429.0	283.9	479.9	233.0	0.0	-5.0	233.0	
100/03-30-082-10W400	03-30-082-10W4	374.0	334.4					409.0	299.4	419.2	289.2	479.0	229.4	0.0	-5.0	229.4	
1AA/02-36-082-10W400	02-36-082-10W4	379.0	340.9					413.1	306.8	423.2	296.7	485.6	234.3	0.0	-5.0	234.3	
100/06-04-082-11 W4/00	06-04-082-11 W4							437.0	284.9	446.0	275.9	498.0	223.9	0.0	-5.0	223.9	
100/12-12-082-11 W4/00	12-12-082-11 W4	379.0	329.2					417.0	291.2	427.0	281.2	480.0	228.2	0.0	-5.0	228.2	
100/06-13-082-11 W4/00	06-13-082-11 W4	380.0	331.3					416.0	295.3	427.0	284.3	481.0	230.3	0.0	-5.0	230.3	
100/11-16-082-11 W4/00	11-16-082-11 W4	402.0	331.0					443.0	290.0	453.0	280.0	505.0	228.0	0.0	-5.0	228.0	
100/12-23-082-11 W4/00	12-23-082-11 W4	394.0	326.8					432.0	288.8	443.0	277.8	492.0	228.8	0.0	-5.0	228.8	
100/11-25-082-11 W4/00	11-25-082-11 W4	385.0	334.2					419.0	300.2	429.0	290.2	486.0	233.2	0.0	-5.0	233.2	
100/11-32-082-11 W4/00	11-32-082-11 W4	404.0	334.9					442.0	296.9	452.0	286.9	501.0	237.9	0.0	-5.0	237.9	
100/08-02-082-12 W4/00	08-02-082-12 W4							475.0	285.1	485.0	275.1	536.0	224.1	2.0	2.0	226.1	
100/07-03-082-12 W4/00	07-03-082-12 W4							454.0	288.2	464.0	278.2	520.0	222.2	0.0	-5.0	222.2	
100/08-04-082-12 W4/00	08-04-082-12 W4							468.0	281.1	478.0	271.1	531.0	218.1	0.0	-5.0	218.1	
100/14-05-082-12 W4/00	14-05-082-12 W4							458.0	281.3	467.0	272.3	520.0	219.3	6.0	6.0	225.3	
100/08-06-082-12 W4/00	08-06-082-12 W4							451.0	281.5	460.0	272.5	513.0	219.5	3.0	3.0	222.5	
100/07-08-082-12 W4/00	07-08-082-12 W4							451.0	287.4	460.0	278.4	514.0	224.4	3.0	3.0	227.4	
100/07-09-082-12 W4/00	07-09-082-12 W4							456.0	287.0	465.0	278.0	519.0	224.0	3.0	3.0	227.0	
100/08-11-082-12 W4/00	08-11-082-12 W4							472.0	284.2	482.0	274.2	531.0	225.2	0.0	-5.0	225.2	
100/06-13-082-12 W4/00	06-13-082-12 W4							464.0	290.0	474.0	280.0	525.0	229.0	1.0	1.0	230.0	
100/10-14-082-12 W4/00	10-14-082-12 W4	421.0	332.1					465.0	288.1	474.0	279.1	520.0	233.1	0.0	-5.0	233.1	
100/05-16-082-12 W4/00	05-16-082-12 W4							432.0	292.4	441.0	283.4	497.0	227.4	0.0	-5.0	227.4	
100/03-18-082-12 W4/00	03-18-082-12 W4							397.0	283.8	406.0	274.8	459.0	221.8	0.0	-5.0	221.8	
100/02-19-082-12 W4/00	02-19-082-12 W4							380.0	287.3	389.0	278.3	442.0	225.3	0.0	-5.0	225.3	
102/05-21-082-12 W4/00	05-21-082-12 W4							407.0	290.9	416.0	281.9	471.0	226.9	0.0	-5.0	226.9	
100/06-22-082-12 W4/00	06-22-082-12 W4	408.0	336.4					454.0	290.4	463.0	281.4	514.0	230.4	0.0	-5.0	230.4	
100/11-27-082-12 W4/00	11-27-082-12 W4							426.0	288.4	436.0	278.4	487.0	227.4	0.0	-5.0	227.4	no gamma or porosity logs through GDRD or CLWT
100/10-29-082-12 W4/00	10-29-082-12 W4	333.0	330.5					379.0	284.5	388.0	275.5	439.0	224.5	0.0	-5.0	224.5	
100/06-36-082-12 W4/00	06-36-082-12 W4							454.0	293.4	465.0	282.4	516.0	231.4	0.0	-5.0	231.4	gamma ran high
100/11-01-082-13 W4/00	11-01-082-13 W4							417.0	281.2	426.0	272.2	485.0	213.2	0.0	-5.0	213.2	
100/10-03-082-13 W4/00	10-03-082-13 W4							393.0	276.8	402.0	267.8	456.0	213.8	4.0	4.0	217.8	
100/06-06-082-13 W4/00	06-06-082-13 W4							325.0	276.1	333.0	268.1	381.0	220.1	0.0	-5.0	220.1	
100/06-10-082-13 W4/00	06-10-082-13 W4							358.0	276.0	367.0	267.0	419.0	215.0	0.0	-5.0	215.0	
1AA/09-11-082-13 W4/00	09-11-082-13 W4							380.0	283.5	388.0	275.5	449.0	214.5	6.0	6.0	220.5	
100/04-12-082-13 W4/00	04-12-082-13 W4							395.0	279.6	404.0	270.6	463.0	211.6	0.0	-5.0	211.6	
100/15-13-082-13 W4/00	15-13-082-13 W4							375.0	282.0	384.0	273.0	437.0	220.0	2.0	2.0	222.0	
100/05-16-082-13 W4/00	05-16-082-13 W4							323.0	281.4	332.0	272.4	374.0	230.4	0.0	-5.0	230.4	
1AA/01-18-082-13 W4/00	01-18-082-13 W4							318.0	279.0	327.0	270.0	373.0	224.0	0.0	-5.0	224.0	

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Northing (m) NAD 27	Easting (m) NAD 27	KB (m asl)	TD (m)	Top Grand Rapids (m bKB)	Top Grand Rapids (m asl)	Grand Rapids Watersand Thickness (m)	Grand Rapids Watersand Top (m bKB)	Grand Rapids Watersand Top (m asl)	Grand Rapids Watersand Base (m bKB)	Grand Rapids Watersand Base (m asl)	Top Clearwater (m bKB)	Top Clearwater (m asl)	Upper Clearwater Watersand Thickness (m)	Middle Clearwater Watersand Thickness (m)	Upper Clearwater Watersand Thickness (Surfer) (m)	Middle Clearwater Watersand Thickness (Surfer) (m)	Upper Clearwater Watersand Top (m bKB)	Upper Clearwater Watersand Top (m asl)
100/10-21-082-13 W4/00	10-21-082-13 W4	6220118	439569	596.8	381.0	157.0	439.8	22.0	205.0	391.8	227.0	369.8	253.0	343.8	0.0	0.0	-5.0	-5.0		
100/05-23-082-13 W4/00	05-23-082-13 W4	6219682	442008	599.0	396.0	159.0	440.0	32.0	208.0	391.0	240.0	359.0	256.0	343.0	0.0	0.0	-5.0	-5.0		
100/06-24-082-13 W4/00	06-24-082-13 W4	6219655	444032	629.3	416.4	188.0	441.3	27.0	237.0	392.3	264.0	365.3	283.0	346.3	0.0	0.0	-5.0	-5.0		
100/10-26-082-13 W4/00	10-26-082-13 W4	6221702	442836	595.0	387.0	151.0	444.0	23.0	201.0	394.0	224.0	371.0	248.0	347.0	0.0	0.0	-5.0	-5.0		
100/10-29-082-13 W4/00	10-29-082-13 W4	6221770	437970	596.5	418.0	159.0	437.5	26.0	205.0	391.5	231.0	365.5	252.0	344.5	0.0	0.0	-5.0	-5.0		
100/10-06-082-14 W4/00	10-06-082-14 W4	6215474	426504	581.4	350.0	140.0	441.4	24.0	190.0	391.4	214.0	367.4	242.0	339.4	0.0	0.0	-5.0	-5.0		
100/12-08-082-14 W4/00	12-08-082-14 W4	6217069	427354	580.1	360.0	137.0	443.1	23.0	188.0	392.1	211.0	369.1	240.0	340.1	0.0	0.0	-5.0	-5.0		
100/10-15-082-14 W4/00	10-15-082-14 W4	6218631	431430	589.1	353.0	145.0	444.1	25.0	193.0	396.1	218.0	371.1	247.0	342.1	0.0	0.0	-5.0	-5.0		
100/10-16-082-14 W4/00	10-16-082-14 W4	6218657	429806	584.0	351.0	144.0	440.0	25.0	188.0	396.0	213.0	371.0	242.0	342.0	0.0	0.0	-5.0	-5.0		
100/06-27-082-14 W4/00	06-27-082-14 W4	6221472	431074	584.9	371.9	146.0	438.9						245.0	339.9						
100/12-30-082-14 W4/00	12-30-082-14 W4	6221963	425814	573.9	360.0	131.0	442.9	22.0	178.0	395.9	200.0	373.9	231.0	342.9	0.0	0.0	-5.0	-5.0		
100/08-02-083-06 W4/00	08-02-083-06 W4	6224180	510876	497.7	294.0			38.0	98.0	399.7	136.0	361.7	136.0	361.7	21.0	0.0	21.0	-5.0	139.0	358.7
100/08-03-083-06 W4/00	08-03-083-06 W4	6224176	509240	552.9	375.0	103.0	449.9	38.0	157.0	395.9	195.0	357.9	195.0	357.9	23.0	0.0	23.0	-5.0	201.0	351.9
100/12-04-083-06 W4/00	12-04-083-06 W4	6224573	506391	590.4	373.0	132.0	458.4	33.0	189.0	401.4	222.0	368.4	223.0	367.4	29.0	0.0	29.0	-5.0	226.0	364.4
1AA/05-05-083-06 W4/00	05-05-083-06 W4	6224169	504756	621.1	402.0	164.0	457.1	29.0	223.0	398.1	252.0	369.1	252.0	369.1	28.0	0.0	28.0	-5.0	258.0	363.1
1AA/07-06-083-06 W4/00	07-06-083-06 W4	6224168	503928	630.5	451.6	181.0	449.5	26.0	237.0	393.5	263.0	367.5	264.0	366.5	27.0	0.0	27.0	-5.0	273.0	357.5
1AA/06-07-083-06 W4/00	06-07-083-06 W4	6225776	503522	654.1	462.6	202.0	452.1						297.0	357.1						
100/10-09-083-06 W4/00	10-09-083-06 W4	6226183	507196	590.2	415.0	144.0	446.2	36.0	198.0	392.2	234.0	356.2	234.0	356.2	35.0	0.0	35.0	-5.0	239.0	351.2
100/01-10-083-06 W4/00	01-10-083-06 W4	6225383	509237	574.4	374.0	123.0	451.4	33.0	170.0	404.4	203.0	371.4	203.0	371.4	25.0	0.0	25.0	-5.0	210.0	364.4
100/02-11-083-06 W4/00	02-11-083-06 W4	6225386	510469	557.4	361.0			35.0	150.0	407.4	185.0	372.4	185.0	372.4	20.0	0.0	20.0	-5.0	191.0	366.4
100/11-12-083-06 W4/00	11-12-083-06 W4	6226193	511698	507.3	294.0			33.0	100.0	407.3	133.0	374.3	133.0	374.3	19.0	0.0	19.0	-5.0	140.0	367.3
100/12-13-083-06 W4/00	12-13-083-06 W4	6227821	511290	533.6	320.0			32.0	128.0	405.6	160.0	373.6	160.0	373.6	21.0	0.0	21.0	-5.0	167.0	366.6
100/11-14-083-06 W4/00	11-14-083-06 W4	6227818	510059	563.8	360.0			32.0	160.0	403.8	192.0	371.8	192.0	371.8	11.0	0.0	11.0	-5.0	204.0	359.8
1AA/05-17-083-06 W4/00	05-17-083-06 W4	6227406	504752	591.4	365.0	139.0	452.4	35.0	196.0	395.4	231.0	360.4	231.0	360.4	18.0	0.0	18.0	-5.0	236.0	355.4
1AA/02-18-083-06 W4/00	02-18-083-06 W4	6227003	503925	630.9	443.0	178.0	452.9	38.0	239.0	391.9	277.0	353.9	277.0	353.9	23.0	0.0	23.0	-5.0	279.0	351.9
1AA/06-19-083-06 W4/00	06-19-083-06 W4	6229014	503520	601.2	401.0	150.0	451.2	38.0	200.0	401.2	238.0	363.2	238.0	363.2	13.0	0.0	13.0	-5.0	245.0	356.2
100/11-20-083-06 W4/00	11-20-083-06 W4	6229418	505153	555.1	420.0			40.0	155.0	400.1	195.0	360.1	195.0	360.1	25.0	0.0	25.0	-5.0	199.0	356.1
100/07-21-083-06 W4/00	07-21-083-06 W4	6229018	507192	575.8	415.0			36.0	174.0	401.8	210.0	365.8	210.0	365.8	20.0	0.0	20.0	-5.0	216.0	359.8
100/06-22-083-06 W4/00	06-22-083-06 W4	6229021	508422	593.0	380.0	131.0	462.0	36.0	184.0	409.0	220.0	373.0	220.0	373.0	16.0	0.0	16.0	-5.0	225.0	368.0
1AA/09-23-083-06 W4/00	09-23-083-06 W4	6229428	510862	558.9	354.0			35.0	149.0	409.9	184.0	374.9	184.0	374.9	10.0	0.0	10.0	-5.0	190.0	368.9
100/10-24-083-06 W4/00	10-24-083-06 W4	6229432	512093	547.8	364.0	111.0	436.8	27.0	159.0	388.8	186.0	361.8	186.0	361.8	15.0	0.0	15.0	-5.0	197.0	350.8
1AA/11-25-083-06 W4/00	11-25-083-06 W4	6231059	511685	553.4	360.0	119.0	434.4	34.0	169.0	384.4	203.0	350.4	203.0	350.4	12.0	0.0	12.0	-5.0	211.0	342.4
100/06-26-083-06 W4/00	06-26-083-06 W4	6230653	510053	556.4	350.0								194.0	362.4						
1AA/05-27-083-06 W4/00	05-27-083-06 W4	6230649	508016	582.2	382.0	138.0	444.2	38.0	184.0	398.2	222.0	360.2	222.0	360.2	26.0	0.0	26.0	-5.0	226.0	356.2
100/10-28-083-06 W4/00	10-28-083-06 W4	6231049	507188	573.0	365.0			31.0	178.0	395.0	209.0	364.0	209.0	364.0	13.0	0.0	13.0	-5.0	215.0	358.0
1AA/07-29-083-06 W4/00	07-29-083-06 W4	6230645	505555	540.1	341.0			42.0	138.0	402.1	180.0	360.1	180.0	360.1	20.0	0.0	20.0	-5.0	183.0	357.1
104/10-31-083-06 W4/00	10-31-083-06 W4	6232654	503920	551.0	381.0	105.0	446.0	37.0	156.0	395.0	193.0	358.0	193.0	358.0	25.0	0.0	25.0	-5.0	201.0	350.0
100/07-32-083-06 W4/00	07-32-083-06 W4	6232253	505553	530.3	703.0			37.0	127.0	403.3	164.0	366.3	164.0	366.3	12.0	0.0	12.0	-5.0	171.0	359.3
100/06-33-083-06 W4/00	06-33-083-06 W4	6232255	506783	523.4	298.0			34.0	120.0	403.4	154.0	369.4	154.0	369.4	18.0	0.0	18.0	-5.0	161.0	362.4
1AA/11-34-083-06 W4/00	11-34-083-06 W4	6232660	508415	557.0	374.0	110.0	447.0	38.0	159.0	398.0	197.0	360.0	197.0	360.0	13.0	0.0	13.0	-5.0	200.0	357.0
1AA/06-35-083-06 W4/00	06-35-083-06 W4	6232262	510049	545.2	367.0			35.0	152.0	393.2	187.0	358.2	188.0	357.2	16.0	0.0	16.0	-5.0	193.0	352.2
100/15-36-083-06 W4/00	15-36-083-06 W4	6233071	512083	529.3	320.0			26.0	147.0	382.3	173.0	356.3	173.0	356.3	25.0	0.0	25.0	-5.0	175.0	354.3
1AA/06-01-083-07 W4/00	06-01-083-07 W4	6224165	501892	664.0	451.0	212.0	452.0	17.0	268.0	396.0	285.0	379.0	292.0	372.0	21.0	0.0	21.0	-5.0	303.0	361.0
100/08-02-083-07 W4/00	08-02-083-07 W4	6224165	501064	662.6	445.0	211.0	451.6	18.0	262.0	400.6	280.0	382.6	289.0	373.6	27.0	0.0	27.0	-5.0	301.0	361.6
100/07-03-083-07 W4/00	07-03-083-07 W4	6224165	499024	659.8	439.0	206.0	453.8	20.0	259.0	400.8	279.0	380.8	286.0	373.8	28.0	0.0	28.0	-5.0	297.0	362.8
100/07-08-083-07 W4/00	07-08-083-07 W4	6225775	495753	717.2	491.3	266.0	451.2	16.0	318.0	399.2	334.0	383.2	335.0	382.2	28.0	0.0	28.0	-5.0	358.0	359.2
1AA/01-10-083-07 W4/00	01-10-083-07 W4	6225371	499428	688.5	474.0	235.0	453.5	21.0	293.0	395.5	314.0	374.5	321.0	367.5	27.0	0.0	27.0	-5.0	334.0	354.5
1AA/11-11-083-07 W4/00	11-11-083-07 W4	6226175	500256	694.7	484.0	240.0	454.7	20.0	295.0	399.7	315.0	379.7	321.0	373.7	29.0	0.0	29.0	-5.0	335.0	359.7
1AA/08-12-083-07 W4/00	08-12-083-07 W4	6225774	502699	629.1	420.0	173.0	456.1	25.0	237.0	392.1	262.0	367.1	264.0	365.1	25.0	0.0	25.0	-5.0	265.0	364.1
1AA/09-13-083-07 W4/00	09-13-083-07 W4	6227805	502697	612.0	407.0	154.0	458.0	37.0	207.0	405.0	244.0	368.0	244.0	368.0	28.0	0.0	28.0	-5.0	248.0	364.0
1AA/09-14-083-07 W4/00	09-14-083-07 W4	6227804	501063	662.3	470.0	208.0	454.3	39.0	261.0	401.3	300.0	362.3	300.0	362.3	20.0	0.0	20.0	-5.0	302.0	360.3
100/07-15-083-07 W4/00	07-15-083-07 W4	6227402	499024	705.9	490.0	252.0	453.9	20.0	308.0	397.9	328.0	377.9	335.0	370.9	24.0	0.0	24.0	-5.0	345.0	360.9
100/07-16-083-07 W4/00	07-16-083-07 W4	6227403	497390	715.6	545.0	265.0	450.6	15.0	317.0	398.6	332.0	383.6	332.0	383.6	20.0	0.0	20.0	-5.0	354.0	361.6

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Upper Clearwater Watersand Base (m bKB)	Upper Clearwater Watersand Base (m asl)	Middle Clearwater Watersand Top (m bKB)	Middle Clearwater Watersand Top (m asl)	Middle Clearwater Watersand Base (m bKB)	Middle Clearwater Watersand Base (m asl)	Top Wabiskaw (m bKB)	Top Wabiskaw (m asl)	Top McMurray (m bKB)	Top McMurray (m asl)	Paleo Surface (m bKB)	Paleo Surface (m asl)	Watersand Thickness (m)	Watersand Thickness (Surfer) (m)	Watersand Surface Elevation (m asl)	Log Analysis Notes:
100/10-21-082-13 W4/00	10-21-082-13 W4							317.0	279.8	325.0	271.8	374.0	222.8	0.0	-5.0	222.8	
100/05-23-082-13 W4/00	05-23-082-13 W4							321.0	278.0	329.0	270.0	387.0	212.0	0.0	-5.0	212.0	
100/06-24-082-13 W4/00	06-24-082-13 W4							347.0	282.3	355.0	274.3	407.0	222.3	0.0	-5.0	222.3	
100/10-26-082-13 W4/00	10-26-082-13 W4							313.0	282.0	322.0	273.0	376.0	219.0	0.0	-5.0	219.0	
100/10-29-082-13 W4/00	10-29-082-13 W4							318.0	278.5	327.0	269.5	374.0	222.5	0.0	-5.0	222.5	
100/10-06-082-14 W4/00	10-06-082-14 W4							304.0	277.4	312.0	269.4	345.0	236.4	0.0	-5.0	236.4	
100/12-08-082-14 W4/00	12-08-082-14 W4							300.0	280.1	309.0	271.1	342.0	238.1	0.0	-5.0	238.1	
100/10-15-082-14 W4/00	10-15-082-14 W4							306.0	283.1	315.0	274.1	353.0	236.1	0.0	-5.0	236.1	
100/10-16-082-14 W4/00	10-16-082-14 W4							303.0	281.0	311.0	273.0	347.0	237.0	0.0	-5.0	237.0	
100/06-27-082-14 W4/00	06-27-082-14 W4							305.0	279.9	314.0	270.9	358.0	226.9	0.0	-5.0	226.9	gamma ran high
100/12-30-082-14 W4/00	12-30-082-14 W4							291.0	282.9	299.0	274.9	328.0	245.9	0.0	-5.0	245.9	
100/08-02-083-06 W4/00	08-02-083-06 W4	160.0	337.7					202.0	295.7	215.0	282.7	289.0	208.7	0.0	-5.0	208.7	
100/08-03-083-06 W4/00	08-03-083-06 W4	224.0	328.9					259.0	293.9	273.0	279.9	355.0	197.9	0.0	-5.0	197.9	
100/12-04-083-06 W4/00	12-04-083-06 W4	255.0	335.4					288.0	302.4	297.0	293.4	355.0	235.4	0.0	-5.0	235.4	
1AA/05-05-083-06 W4/00	05-05-083-06 W4	286.0	335.1					321.0	300.1	330.0	291.1	386.0	235.1	0.0	-5.0	235.1	
1AA/07-06-083-06 W4/00	07-06-083-06 W4	300.0	330.5					336.0	294.5	350.0	280.5	435.0	195.5	1.0	1.0	196.5	
1AA/06-07-083-06 W4/00	06-07-083-06 W4							362.0	292.1	375.0	279.1	436.0	218.1	0.0	-5.0	218.1	gamma ran high
100/10-09-083-06 W4/00	10-09-083-06 W4	274.0	316.2					310.0	280.2	323.0	267.2	393.0	197.2	0.0	-5.0	197.2	
100/01-10-083-06 W4/00	01-10-083-06 W4	235.0	339.4					274.0	300.4	288.0	286.4	370.0	204.4	0.0	-5.0	204.4	
100/02-11-083-06 W4/00	02-11-083-06 W4	211.0	346.4					254.0	303.4	268.0	289.4	356.0	201.4	0.0	-5.0	201.4	
100/11-12-083-06 W4/00	11-12-083-06 W4	159.0	348.3					201.0	306.3	210.0	297.3	288.0	219.3	1.0	1.0	220.3	
100/12-13-083-06 W4/00	12-13-083-06 W4	188.0	345.6					229.0	304.6	243.0	290.6	314.0	219.6	0.0	-5.0	219.6	
100/11-14-083-06 W4/00	11-14-083-06 W4	215.0	348.8					261.0	302.8	274.0	289.8	351.0	212.8	0.0	-5.0	212.8	
1AA/05-17-083-06 W4/00	05-17-083-06 W4	254.0	337.4					302.0	289.4	315.0	276.4	346.0	245.4	0.0	-5.0	245.4	
1AA/02-18-083-06 W4/00	02-18-083-06 W4	302.0	328.9					347.0	283.9	355.0	275.9	437.0	193.9	0.0	-5.0	193.9	
1AA/06-19-083-06 W4/00	06-19-083-06 W4	258.0	343.2					306.0	295.2	319.0	282.2	381.0	220.2	0.0	-5.0	220.2	
100/11-20-083-06 W4/00	11-20-083-06 W4	224.0	331.1					258.0	297.1	266.0	289.1	327.0	228.1	0.0	-5.0	228.1	
100/07-21-083-06 W4/00	07-21-083-06 W4	236.0	339.8					278.0	297.8	288.0	287.8	352.0	223.8	0.0	-5.0	223.8	
100/06-22-083-06 W4/00	06-22-083-06 W4	241.0	352.0					285.0	308.0	293.0	300.0	370.0	223.0	0.0	-5.0	223.0	
1AA/09-23-083-06 W4/00	09-23-083-06 W4	200.0	358.9					250.0	308.9	265.0	293.9	339.0	219.9	0.0	-5.0	219.9	
100/10-24-083-06 W4/00	10-24-083-06 W4	212.0	335.8					258.0	289.8	271.0	276.8	348.0	199.8	7.0	7.0	206.8	
1AA/11-25-083-06 W4/00	11-25-083-06 W4	223.0	330.4					271.0	282.4	280.0	273.4	349.0	204.4	9.0	9.0	213.4	
100/06-26-083-06 W4/00	06-26-083-06 W4							259.0	297.4	269.0	287.4	340.0	216.4	0.0	-5.0	216.4	gamma ran high
1AA/05-27-083-06 W4/00	05-27-083-06 W4	252.0	330.2					290.0	292.2	305.0	277.2	369.0	213.2	0.0	-5.0	213.2	
100/10-28-083-06 W4/00	10-28-083-06 W4	228.0	345.0					278.0	295.0	287.0	286.0	356.0	217.0	0.0	-5.0	217.0	
1AA/07-29-083-06 W4/00	07-29-083-06 W4	203.0	337.1					244.0	296.1	256.0	284.1	327.0	213.1	0.0	-5.0	213.1	
104/10-31-083-06 W4/00	10-31-083-06 W4	226.0	325.0					260.0	291.0	273.0	278.0	362.0	189.0	24.0	24.0	213.0	
100/07-32-083-06 W4/00	07-32-083-06 W4	183.0	347.3					230.0	300.3	243.0	287.3	315.0	215.3				
100/06-33-083-06 W4/00	06-33-083-06 W4	179.0	344.4					220.0	303.4	233.0	290.4	291.0	232.4	0.0	-5.0	232.4	
1AA/11-34-083-06 W4/00	11-34-083-06 W4	213.0	344.0					258.0	299.0	272.0	285.0	359.0	198.0	0.0	-5.0	198.0	
1AA/06-35-083-06 W4/00	06-35-083-06 W4	209.0	336.2					254.0	291.2	266.0	279.2	351.0	194.2	4.0	4.0	198.2	
100/15-36-083-06 W4/00	15-36-083-06 W4	200.0	329.3					235.0	294.3	248.0	281.3	316.0	213.3	12.0	12.0	225.3	
1AA/06-01-083-07 W4/00	06-01-083-07 W4	324.0	340.0					366.0	298.0	381.0	283.0	438.0	226.0	0.0	-5.0	226.0	
100/08-02-083-07 W4/00	08-02-083-07 W4	328.0	334.6					361.0	301.6	374.0	288.6	433.0	229.6	0.0	-5.0	229.6	
100/07-03-083-07 W4/00	07-03-083-07 W4	325.0	334.8					358.0	301.8	367.0	292.8	433.0	226.8	0.0	-5.0	226.8	
100/07-08-083-07 W4/00	07-08-083-07 W4	386.0	331.2					421.0	296.2	431.0	286.2	489.0	228.2	0.0	-5.0	228.2	
1AA/01-10-083-07 W4/00	01-10-083-07 W4	361.0	327.5					396.0	292.5	409.0	279.5	467.0	221.5	3.0	3.0	224.5	
1AA/11-11-083-07 W4/00	11-11-083-07 W4	364.0	330.7					397.0	297.7	405.0	289.7	469.0	225.7	0.0	-5.0	225.7	
1AA/08-12-083-07 W4/00	08-12-083-07 W4	290.0	339.1					325.0	304.1	337.0	292.1	405.0	224.1	0.0	-5.0	224.1	
1AA/09-13-083-07 W4/00	09-13-083-07 W4	276.0	336.0					309.0	303.0	319.0	293.0	387.0	225.0	0.0	-5.0	225.0	
1AA/09-14-083-07 W4/00	09-14-083-07 W4	322.0	340.3					364.0	298.3	374.0	288.3	455.0	207.3	0.0	-5.0	207.3	
100/07-15-083-07 W4/00	07-15-083-07 W4	369.0	336.9					410.0	295.9	419.0	286.9	479.0	226.9	0.0	-5.0	226.9	
100/07-16-083-07 W4/00	07-16-083-07 W4	374.0	341.6					418.0	297.6	431.0	284.6	500.0	215.6	0.0	-5.0	215.6	

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Northing (m) NAD 27	Easting (m) NAD 27	KB (m asl)	TD (m)	Top Grand Rapids (m bKB)	Top Grand Rapids (m asl)	Grand Rapids Watersand Thickness (m)	Grand Rapids Watersand Top (m bKB)	Grand Rapids Watersand Top (m asl)	Grand Rapids Watersand Base (m bKB)	Grand Rapids Watersand Base (m asl)	Top Clearwater (m bKB)	Top Clearwater (m asl)	Upper Clearwater Watersand Thickness (m)	Middle Clearwater Watersand Thickness (m)	Upper Clearwater Watersand Thickness (Surfer) (m)	Middle Clearwater Watersand Thickness (Surfer) (m)	Upper Clearwater Watersand Top (m bKB)	Upper Clearwater Watersand Top (m asl)
100/07-19-083-07 W4/00	07-19-083-07 W4	6229015	494122	712.0	510.0	259.0	453.0	25.0	309.0	403.0	334.0	378.0	335.0	377.0	23.0	0.0	23.0	-5.0	350.0	362.0
100/05-20-083-07 W4/00	05-20-083-07 W4	6229014	494949	709.3	505.0	256.0	453.3	24.0	307.0	402.3	331.0	378.3	331.0	378.3	22.0	0.0	22.0	-5.0	347.0	362.3
100/07-21-083-07 W4/00	07-21-083-07 W4	6229012	497391	678.7	525.0	224.0	454.7	17.0	275.0	403.7	292.0	386.7	301.0	377.7	18.0	0.0	18.0	-5.0	314.0	364.7
1AA/14-22-083-07 W4/00	14-22-083-07 W4	6229815	498622	638.6	458.0	185.0	453.6	35.0	242.0	396.6	277.0	361.6	278.0	360.6	20.0	0.0	20.0	-5.0	284.0	354.6
1AA/11-23-083-07 W4/00	11-23-083-07 W4	6229413	500255	642.2	452.6	188.0	454.2	36.0	239.0	403.2	275.0	367.2	275.0	367.2	13.0	0.0	13.0	-5.0	282.0	360.2
102/11-24-083-07 W4/00	11-24-083-07 W4	6229413	501889	613.8	418.0	161.0	452.8	37.0	210.0	403.8	247.0	366.8	248.0	365.8	13.0	0.0	13.0	-5.0	254.0	359.8
1AA/06-25-083-07 W4/00	06-25-083-07 W4	6230640	501889	596.1	408.0	147.0	449.1	36.0	200.0	396.1	236.0	360.1	236.0	360.1	20.0	0.0	20.0	-5.0	243.0	353.1
1AA/06-26-083-07 W4/00	06-26-083-07 W4	6230640	500255	605.5	420.0	151.0	454.5	29.0	212.0	393.5	241.0	364.5	241.0	364.5	23.0	0.0	23.0	-5.0	250.0	355.5
1AA/13-27-083-07 W4/00	13-27-083-07 W4	6231444	498219	654.2	441.0	205.0	449.2	27.0	257.0	397.2	284.0	370.2	287.0	367.2	22.0	0.0	22.0	-5.0	295.0	359.2
1AA/06-28-083-07 W4/00	06-28-083-07 W4	6230641	496988	693.7	500.0	240.0	453.7	21.0	294.0	399.7	315.0	378.7	325.0	368.7	12.0	0.0	12.0	-5.0	338.0	355.7
1AA/10-29-083-07 W4/00	10-29-083-07 W4	6231044	495758	700.0	505.0	250.0	450.0	23.0	301.0	399.0	324.0	376.0	332.0	368.0	9.0	0.0	9.0	-5.0	344.0	356.0
1AA/01-32-083-07 W4/00	01-32-083-07 W4	6231848	496162	637.2	444.0	190.0	447.2	24.0	244.0	393.2	268.0	369.2	275.0	362.2	10.0	0.0	10.0	-5.0	287.0	350.2
100/07-33-083-07 W4/00	07-33-083-07 W4	6232249	497393	617.3	406.0	166.0	451.3	23.0	218.0	399.3	241.0	376.3	248.0	369.3	10.0	0.0	10.0	-5.0	258.0	359.3
100/05-35-083-07 W4/00	05-35-083-07 W4	6232248	499852	593.4	382.0			31.0	198.0	395.4	229.0	364.4	229.0	364.4	22.0	0.0	22.0	-5.0	239.0	354.4
1AA/13-06-083-08 W4/00	13-06-083-08 W4	6225006	483494	726.0	514.0	273.0	453.0						352.0	374.0						
1AA/16-14-083-08 W4/00	16-14-083-08 W4	6228220	491255	727.0	543.0	276.0	451.0	27.0	326.0	401.0	353.0	374.0	353.0	374.0	23.0	0.0	23.0	-5.0	368.0	359.0
100/06-01-083-08 W4/00	06-01-083-08 W4	6224177	492075	733.2	503.0	275.0	458.2	25.0	326.0	407.2	351.0	382.2	361.0	372.2	26.0	0.0	26.0	-5.0	370.0	363.2
100/06-03-083-08 W4/00	06-03-083-08 W4	6224184	488803	732.8	507.0	278.0	454.8	28.0	325.0	407.8	353.0	379.8	353.0	379.8	25.0	0.0	25.0	-5.0	370.0	362.8
100/07-05-083-08 W4/00	07-05-083-08 W4	6224193	485935	727.3	496.0	273.0	454.3	29.0	319.0	408.3	348.0	379.3	351.0	376.3	24.0	0.0	24.0	-5.0	365.0	362.3
1AA/11-10-083-08 W4/00	11-10-083-08 W4	6226195	488808	731.9	522.0	278.0	453.9	28.0	327.0	404.9	355.0	376.9	355.0	376.9	28.0	0.0	28.0	-5.0	368.0	363.9
100/11-11-083-08 W4/00	11-11-083-08 W4	6226191	490443	734.6	517.0	282.0	452.6						364.0	370.6						
100/02-18-083-08 W4/00	02-18-083-08 W4	6227034	484309	727.5	490.0	274.0	453.5	20.0	322.0	405.5	342.0	385.5	346.0	381.5	27.0	0.0	27.0	-5.0	365.0	362.5
1AA/06-23-083-08 W4/00	06-23-083-08 W4	6229026	490450	733.2	538.0	280.0	453.2	28.0	331.0	402.2	359.0	374.2	359.0	374.2	24.0	0.0	24.0	-5.0	372.0	361.2
1AA/10-26-083-08 W4/00	10-26-083-08 W4	6231056	490858	728.0	513.0	272.0	456.0	27.0	320.0	408.0	347.0	381.0	347.0	381.0	25.0	0.0	25.0	-5.0	363.0	365.0
100/13-30-083-08 W4/00	13-30-083-08 W4	6231481	483519	731.8	495.0	276.0	455.8	16.0	324.0	407.8	340.0	391.8	352.0	379.8	19.0	0.0	19.0	-5.0	366.0	365.8
1AA/14-36-083-08 W4/00	14-36-083-08 W4	6233065	492091	731.3	513.5	278.0	453.3	25.0	329.0	402.3	354.0	377.3	355.0	376.3	24.0	0.0	24.0	-5.0	368.0	363.3
100/10-01-083-09W400	10-01-083-09W4	6224708	482798	728.5	445.0	273.7	454.8	19.0	320.0	408.5	339.0	389.5	356.2	372.3	23.0	0.0	23.0	-5.0	363.0	365.5
100/10-03-083-09W400	10-03-083-09W4	6224952	479443	728.2	417.6	274.2	454.0	23.0	320.0	408.2	343.0	385.2	355.6	372.6	27.0	0.0	27.0	-5.0	363.0	365.2
100/11-04-083-09W400	11-04-083-09W4	6224974	477108	729.5	496.0	274.9	454.6	19.0	320.0	409.5	339.0	390.5	355.0	374.5	20.0	0.0	20.0	-5.0	364.0	365.5
1AA/10-05-083-09W400	10-05-083-09W4	6224904	476125	730.7	501.1	277.8	452.9	23.0	324.0	406.7	347.0	383.7	358.9	371.8	29.0	0.0	29.0	-5.0	366.0	364.7
100/09-07-083-09W400	09-07-083-09W4	6226344	474963	732.4	495.0	276.4	456.1	21.0	322.0	410.4	343.0	389.4	356.3	376.1	22.0	0.0	22.0	-5.0	367.0	365.4
1AA/13-07-083-09W400	13-07-083-09W4	6227032	473502	721.1	501.5	264.7	456.4	23.0	311.0	410.1	334.0	387.1	346.2	374.9	24.0	0.0	24.0	-5.0	355.0	366.1
102/12-10-083-09W400	12-10-083-09W4	6226559	478666	726.8	377.0	273.3	453.5	18.0	319.0	407.8	337.0	389.8	354.3	372.6						
100/06-15-083-09W400	06-15-083-09W4	6227679	478941	729.1	489.8	272.2	456.9	20.0	316.0	413.1	336.0	393.1	351.0	378.1	19.0	0.0	19.0	-5.0	363.0	366.1
100/07-16-083-09W400	07-16-083-09W4	6227695	477722	736.7	466.3	280.4	456.3	19.0	327.0	409.7	346.0	390.7	359.4	377.3	21.0	0.0	21.0	-5.0	371.0	365.7
100/11-17-083-09W400	11-17-083-09W4	6228209	475582	733.0	502.9	276.5	456.5						354.9	378.1						
100/10-19-083-09W400	10-19-083-09W4	6229622	474281	717.5	447.0	259.3	458.2	19.0	307.0	410.5	326.0	391.5	339.3	378.2	17.0	0.0	17.0	-5.0	352.0	365.5
100/03-20-083-09W400	03-20-083-09W4	6228889	475619	738.1	462.0	278.9	459.2	21.0	326.0	412.1	347.0	391.1	356.4	381.7	20.0	0.0	20.0	-5.0	371.0	367.1
100/11-21-083-09W400	11-21-083-09W4	6229637	477128	725.5	376.0	269.5	456.0						349.0	376.5						
100/06-23-083-09W400	06-23-083-09W4	6229278	480703	737.1	511.0	282.8	454.3	17.0	330.0	407.1	347.0	390.1	360.0	377.1	26.0	0.0	26.0	-5.0	371.0	366.1
100/07-25-083-09W400	07-25-083-09W4	6230852	482688	730.9	448.1	278.5	452.4	19.0	326.0	404.9	345.0	385.9	356.7	374.2	22.0	0.0	22.0	-5.0	366.0	364.9
100/15-25-083-09W400	15-25-083-09W4	6231799	482732	734.8	498.0	279.3	455.5	19.0	328.0	406.8	347.0	387.8	357.0	377.8	23.0	0.0	23.0	-5.0	370.0	364.8
100/06-27-083-09W400	06-27-083-09W4	6230873	478863	750.7	516.6	292.8	457.9						374.4	376.3						
100/09-28-083-09W400	09-28-083-09W4	6231476	478123	750.0	474.0	288.4	461.6	19.0	337.0	413.0	356.0	394.0	369.0	381.1	18.0	0.0	18.0	-5.0	381.0	369.0
100/06-29-083-09W400	06-29-083-09W4	6230966	475536	714.5	408.7	256.1	458.4	22.0	304.0	410.5	326.0	388.5	337.0	377.5	19.0	0.0	19.0	-5.0	349.0	365.5
100/11-31-083-09W400	11-31-083-09W4	6233158	473915	716.3	485.9	255.2	461.1	20.0	304.0	412.3	324.0	392.3	339.2	377.1	15.0	0.0	15.0	-5.0	351.0	365.3
100/12-34-083-09W400	12-34-083-09W4	6232953	478658	732.7	382.7	274.2	458.5	18.0	323.0	409.7	341.0	391.7	356.9	375.8						
100/06-10-083-10W400	06-10-083-10W4	6226034	468990	720.2	463.3	268.7	451.5	21.0	316.0	404.2	337.0	383.2	350.3	369.9	22.0	0.0	22.0	-5.0	359.0	361.2
100/03-13-083-10W400	03-13-083-10W4	6227376	472281	717.6	483.0	261.2	456.4	21.0	307.0	410.6	328.0	389.6	341.2	376.4	22.0	0.0	22.0	-5.0	352.0	365.6
1AA/08-13-083-10W400	08-13-083-10W4	6227593	473225	722.6	495.6	266.3	456.3						346.1	376.5						
100/14-16-083-10W400	14-16-083-10W4	6228604	467343	732.3	512.0	280.3	452.1						364.9	367.4						
100/02-17-083-10W400	02-17-083-10W4	6227474	466121	727.9	495.0	273.4	454.5	27.0	321.0	406.9	348.0	379.9	358.1	369.8	26.0	0.0	26.0	-5.0	366.0	361.9
100/09-26-083-10W400	09-26-083-10W4	6231253	471805	713.4	479.0	255.9	457.5	21.0	304.0	409.4	325.0	388.4			24.0	0.0	24.0	-5.0	349.0	364.4
100/10-28-083-10W400	10-28-083-10W4	6231355	468036	738.0	505.0	278.1	459.9	19.0	327.0	411.0	346.0	392.0			9.0	0.0	9.0	-5.0	372.0	366.0
100/14-31-083-10W400	14-31-083-10W4	6233308	464095	703.2	397.8	243.2	460.0						327.0	376.2						
100/02-02-083-11 W4/00	02-02-083-11 W4	6223944	461406	736.5	507.0	291.0	445.5	22.0	336.0	400.5	358.0	378.5	369.0	367.5	25.0	0.0	25.0	-5.0	382.0	354.5

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Upper Clearwater Watersand Base (m bKB)	Upper Clearwater Watersand Base (m asl)	Middle Clearwater Watersand Top (m bKB)	Middle Clearwater Watersand Top (m asl)	Middle Clearwater Watersand Base (m bKB)	Middle Clearwater Watersand Base (m asl)	Top Wabiskaw (m bKB)	Top Wabiskaw (m asl)	Top McMurray (m bKB)	Top McMurray (m asl)	Paleo Surface (m bKB)	Paleo Surface (m asl)	Watersand Thickness (m)	Watersand Thickness (Surfer) (m)	Watersand Surface Elevation (m asl)	Log Analysis Notes:
100/07-19-083-07 W4/00	07-19-083-07 W4	373.0	339.0					415.0	297.0	427.0	285.0	501.0	211.0	0.0	-5.0	211.0	
100/05-20-083-07 W4/00	05-20-083-07 W4	369.0	340.3					410.0	299.3	423.0	286.3	500.0	209.3	4.0	4.0	213.3	
100/07-21-083-07 W4/00	07-21-083-07 W4	332.0	346.7					373.0	305.7	386.0	292.7	469.0	209.7	0.0	-5.0	209.7	
1AA/14-22-083-07 W4/00	14-22-083-07 W4	304.0	334.6					346.0	292.6	359.0	279.6	432.0	206.6	3.0	3.0	209.6	
1AA/11-23-083-07 W4/00	11-23-083-07 W4	295.0	347.2					344.0	298.2	357.0	285.2	426.0	216.2	0.0	-5.0	216.2	
102/11-24-083-07 W4/00	11-24-083-07 W4	267.0	346.8					314.0	299.8	328.0	285.8	414.0	199.8	0.0	-5.0	199.8	
1AA/06-25-083-07 W4/00	06-25-083-07 W4	263.0	333.1					306.0	290.1	319.0	277.1	386.0	210.1	5.0	5.0	215.1	
1AA/06-26-083-07 W4/00	06-26-083-07 W4	273.0	332.5					312.0	293.5	322.0	283.5	406.0	199.5	6.0	6.0	205.5	
1AA/13-27-083-07 W4/00	13-27-083-07 W4	317.0	337.2					358.0	296.2	370.0	284.2	425.0	229.2	0.0	-5.0	229.2	
1AA/06-28-083-07 W4/00	06-28-083-07 W4	350.0	343.7					397.0	296.7	410.0	283.7	487.0	206.7	8.0	8.0	214.7	
1AA/10-29-083-07 W4/00	10-29-083-07 W4	353.0	347.0					403.0	297.0	416.0	284.0	487.0	213.0	0.0	-5.0	213.0	
1AA/01-32-083-07 W4/00	01-32-083-07 W4	297.0	340.2					347.0	290.2	359.0	278.2	431.0	206.2	0.0	-5.0	206.2	
100/07-33-083-07 W4/00	07-33-083-07 W4	268.0	349.3					320.0	297.3	332.0	285.3	395.0	222.3	0.0	-5.0	222.3	
100/05-35-083-07 W4/00	05-35-083-07 W4	261.0	332.4					304.0	289.4	314.0	279.4	377.0	216.4				
1AA/13-06-083-08 W4/00	13-06-083-08 W4							426.0	300.0	437.0	289.0	497.0	229.0	9.0	9.0	238.0	gamma high
1AA/16-14-083-08 W4/00	16-14-083-08 W4	391.0	336.0					432.0	295.0	444.0	283.0	527.0	200.0	15.0	15.0	215.0	
100/06-01-083-08 W4/00	06-01-083-08 W4	396.0	337.2					429.0	304.2	446.0	287.2	494.0	239.2	0.0	-5.0	239.2	
100/06-03-083-08 W4/00	06-03-083-08 W4	395.0	337.8					431.0	301.8	445.0	287.8	490.0	242.8	0.0	-5.0	242.8	
100/07-05-083-08 W4/00	07-05-083-08 W4	389.0	338.3					423.0	304.3	435.0	292.3	490.0	237.3	0.0	-5.0	237.3	
1AA/11-10-083-08 W4/00	11-10-083-08 W4	396.0	335.9					433.0	298.9			504.0	227.9	0.0	-5.0	227.9	
100/11-11-083-08 W4/00	11-11-083-08 W4							436.0	298.6	450.0	284.6	507.0	227.6	0.0	-5.0	227.6	gamma high
100/02-18-083-08 W4/00	02-18-083-08 W4	392.0	335.5					427.0	300.5	439.0	288.5						
1AA/06-23-083-08 W4/00	06-23-083-08 W4	396.0	337.2					436.0	297.2			522.0	211.2	0.0	-5.0	211.2	
1AA/10-26-083-08 W4/00	10-26-083-08 W4	388.0	340.0					424.0	304.0	434.0	294.0	496.0	232.0	0.0	-5.0	232.0	
100/13-30-083-08 W4/00	13-30-083-08 W4	385.0	346.8					428.0	303.8	437.0	294.8	490.0	241.8	0.0	-5.0	241.8	
1AA/14-36-083-08 W4/00	14-36-083-08 W4	392.0	339.3					428.0	303.3	440.0	291.3	500.0	231.3	0.0	-5.0	231.3	
100/10-01-083-09W400	10-01-083-09W4	386.0	342.5					425.8	302.7	437.1	291.4						
100/10-03-083-09W400	10-03-083-09W4	390.0	338.2														
100/11-04-083-09W400	11-04-083-09W4	384.0	345.5					425.0	304.5	435.4	294.1						
1AA/10-05-083-09W400	10-05-083-09W4	395.0	335.7					430.7	300.0	441.1	289.6	491.0	239.6	0.0	-5.0	239.6	
100/09-07-083-09W400	09-07-083-09W4	389.0	343.4					424.9	307.5	435.0	297.4						
1AA/13-07-083-09W400	13-07-083-09W4	379.0	342.1					416.0	305.1	425.7	295.4	481.8	239.3	0.0	-5.0	239.3	
102/12-10-083-09W400	12-10-083-09W4																no clwt on log
100/06-15-083-09W400	06-15-083-09W4	382.0	347.1					422.2	306.9	432.9	296.2	472.7	256.4	0.0	-5.0	256.4	
100/07-16-083-09W400	07-16-083-09W4	392.0	344.7					430.6	306.1	441.6	295.1						
100/11-17-083-09W400	11-17-083-09W4							426.6	306.4	437.3	295.7	488.9	244.1	0.0	-5.0	244.1	gamma high
100/10-19-083-09W400	10-19-083-09W4	369.0	348.5					407.8	309.7	418.5	299.0						
100/03-20-083-09W400	03-20-083-09W4	391.0	347.1					426.9	311.2	437.3	300.8						
100/11-21-083-09W400	11-21-083-09W4																gamma high
100/06-23-083-09W400	06-23-083-09W4	397.0	340.1					432.8	304.3	445.0	292.1	496.2	240.9	0.0	-5.0	240.9	
100/07-25-083-09W400	07-25-083-09W4	388.0	342.9					428.9	302.0	440.7	290.2						
100/15-25-083-09W400	15-25-083-09W4	393.0	341.8					429.7	305.1	441.8	293.0	496.0	238.8	0.0	-5.0	238.8	
100/06-27-083-09W400	06-27-083-09W4							442.0	308.7	455.0	295.7	500.3	250.4	0.0	-5.0	250.4	gamma high
100/09-28-083-09W400	09-28-083-09W4	399.0	351.0					436.1	313.9	447.5	302.5						
100/06-29-083-09W400	06-29-083-09W4	368.0	346.5														
100/11-31-083-09W400	11-31-083-09W4	366.0	350.3					408.3	308.0	418.2	298.1	477.6	238.7	0.0	-5.0	238.7	
100/12-34-083-09W400	12-34-083-09W4																no clwt on log
100/06-10-083-10W400	06-10-083-10W4	381.0	339.2					422.8	297.4	432.9	287.3						
100/03-13-083-10W400	03-13-083-10W4	374.0	343.6					410.1	307.5	420.3	297.3	474.4	243.2	0.0	-5.0	243.2	
1AA/08-13-083-10W400	08-13-083-10W4							417.8	304.8	428.0	294.6	482.0	240.6	0.0	-5.0	240.6	gamma runs high
100/14-16-083-10W400	14-16-083-10W4							435.0	297.3	445.5	286.8	496.1	236.2	0.0	-5.0	236.2	
100/02-17-083-10W400	02-17-083-10W4	392.0	335.9					431.0	296.9	441.6	286.4	486.0	241.9	0.0	-5.0	241.9	
100/09-26-083-10W400	09-26-083-10W4	373.0	340.4					410.2	303.2	420.4	293.0						
100/10-28-083-10W400	10-28-083-10W4	381.0	357.0					428.5	309.5	439.1	298.9						
100/14-31-083-10W400	14-31-083-10W4																
100/02-02-083-11 W4/00	02-02-083-11 W4	407.0	329.5					440.0	296.5	454.0	282.5	505.0	231.5	0.0	-5.0	231.5	

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Northing (m) NAD 27	Easting (m) NAD 27	KB (m asl)	TD (m)	Top Grand Rapids (m bKB)	Top Grand Rapids (m asl)	Grand Rapids Watersand Thickness (m)	Grand Rapids Watersand Top (m bKB)	Grand Rapids Watersand Top (m asl)	Grand Rapids Watersand Base (m bKB)	Grand Rapids Watersand Base (m asl)	Top Clearwater (m bKB)	Top Clearwater (m asl)	Upper Clearwater Watersand Thickness (m)	Middle Clearwater Watersand Thickness (m)	Upper Clearwater Watersand Thickness (Surfer) (m)	Middle Clearwater Watersand Thickness (Surfer) (m)	Upper Clearwater Watersand Top (m bKB)	Upper Clearwater Watersand Top (m asl)
100/04-03-083-11 W4/00	04-03-083-11 W4	6223967	458962	739.5	517.3	288.0	451.5	21.0	335.0	404.5	356.0	383.5	371.0	368.5	24.0	0.0	24.0	-5.0	382.0	357.5
100/02-04-083-11 W4/00	02-04-083-11 W4	6223975	458134	743.9	512.0	292.0	451.9	26.0	339.0	404.9	365.0	378.9	377.0	366.9	24.0	0.0	24.0	-5.0	387.0	356.9
100/09-25-083-11 W4/00	09-25-083-11 W4	6231205	463508	715.2	478.0	254.0	461.2	24.0	302.0	413.2	326.0	389.2	338.0	377.2	12.0	0.0	12.0	-5.0	349.0	366.2
100/01-29-083-11 W4/00	01-29-083-11 W4	6230462	456967	646.5	408.0	187.0	459.5	23.0	236.0	410.5	259.0	387.5	270.0	376.5	20.0	0.0	20.0	-5.0	280.0	366.5
100/11-34-083-11 W4/00	11-34-083-11 W4	6232851	459450	652.6	414.5	190.0	462.6	18.0	247.0	405.6	265.0	387.6	275.0	377.6	18.0	0.0	18.0	-5.0	285.0	367.6
100/16-35-083-11 W4/00	16-35-083-11 W4	6233230	461893	669.4	436.0	209.0	460.4	21.0	263.0	406.4	284.0	385.4	293.0	376.4	14.0	0.0	14.0	-5.0	303.0	366.4
100/09-25-083-11W400	09-25-083-11W4	6231619	463353	715.2	478.0	254.2	461.0	26.0	302.0	413.2	328.0	387.2			12.0	0.0	12.0	-5.0	349.0	366.2
100/02-04-083-12 W4/00	02-04-083-12 W4	6224080	448320	634.8	420.0	187.0	447.8	23.0	234.0	400.8	257.0	377.8	280.0	354.8	0.0	0.0	-5.0	-5.0		
100/06-16-083-13 W4/00	06-16-083-13 W4	6227855	438157	574.2	365.8	126.0	448.2						220.0	354.2						
100/10-22-083-13 W4/00	10-22-083-13 W4	6229837	440223	565.7	352.0	118.0	447.7	4.0	168.0	397.7	172.0	393.7	202.0	363.7	16.0	0.0	16.0	-5.0	214.0	351.7
100/07-23-083-13 W4/00	07-23-083-13 W4	6229412	441851	563.9	354.2	112.0	451.9						192.0	371.9						
100/02-06-083-14 W4/00	02-06-083-14 W4	6224417	425423	565.3	316.0	118.0	447.3	5.0	169.0	396.3	174.0	391.3	199.0	366.3	0.0	0.0	-5.0	-5.0		
100/11-20-083-14 W4/00	11-20-083-14 W4	6230046	426751	554.1	310.9										8.0	0.0	8.0	-5.0	205.0	349.1
100/10-21-083-14 W4/00	10-21-083-14 W4	6230011	428789	557.6	320.5	107.0	450.6	12.0	157.0	400.6	169.0	388.6	192.0	365.6	8.0	0.0	8.0	-5.0	210.0	347.6
100/08-22-083-14 W4/00	08-22-083-14 W4	6229576	430820	560.4	330.0	113.0	447.4						198.0	362.4						
100/01-29-083-14 W4/00	01-29-083-14 W4	6230856	427572	553.1	390.0	98.0	455.1	10.0	149.0	404.1	159.0	394.1	180.0	373.1	12.0	0.0	12.0	-5.0	199.0	354.1

Table 5A-1 LSA Geologic Picks

UWI	Legal Location	Upper Clearwater Watersand Base (m bKB)	Upper Clearwater Watersand Base (m asl)	Middle Clearwater Watersand Top (m bKB)	Middle Clearwater Watersand Top (m asl)	Middle Clearwater Watersand Base (m bKB)	Middle Clearwater Watersand Base (m asl)	Top Wabiskaw (m bKB)	Top Wabiskaw (m asl)	Top McMurray (m bKB)	Top McMurray (m asl)	Paleo Surface (m bKB)	Paleo Surface (m asl)	Watersand Thickness (m)	Watersand Thickness (Surfer) (m)	Watersand Surface Elevation (m asl)	Log Analysis Notes:
100/04-03-083-11 W4/00	04-03-083-11 W4	406.0	333.5					444.0	295.5	454.0	285.5	502.0	237.5	0.0	-5.0	237.5	
100/02-04-083-11 W4/00	02-04-083-11 W4	411.0	332.9					450.0	293.9	460.0	283.9	507.0	236.9	0.0	-5.0	236.9	
100/09-25-083-11 W4/00	09-25-083-11 W4	361.0	354.2					409.0	306.2	419.0	296.2						
100/01-29-083-11 W4/00	01-29-083-11 W4	300.0	346.5					343.0	303.5	353.0	293.5	402.0	244.5	0.0	-5.0	244.5	
100/11-34-083-11 W4/00	11-34-083-11 W4	303.0	349.6					345.0	307.6	356.0	296.6	402.0	250.6	0.0	-5.0	250.6	
100/16-35-083-11 W4/00	16-35-083-11 W4	317.0	352.4					363.0	306.4	374.0	295.4	420.0	249.4	0.0	-5.0	249.4	
100/09-25-083-11W400	09-25-083-11W4	361.0	354.2					408.7	306.5	418.9	296.3						
100/02-04-083-12 W4/00	02-04-083-12 W4							345.0	289.8	354.0	280.8	405.0	229.8	0.0	-5.0	229.8	
100/06-16-083-13 W4/00	06-16-083-13 W4							285.0	289.2	295.0	279.2	336.0	238.2	0.0	-5.0	238.2	gamma ran high
100/10-22-083-13 W4/00	10-22-083-13 W4	230.0	335.7					275.0	290.7	283.0	282.7	340.0	225.7	0.0	-5.0	225.7	top of GDRD picked as top zone was picked in adjacent logs 83-14
100/07-23-083-13 W4/00	07-23-083-13 W4							269.0	294.9	279.0	284.9	329.0	234.9	0.0	-5.0	234.9	gamma ran high
100/02-06-083-14 W4/00	02-06-083-14 W4							276.0	289.3	284.0	281.3	311.0	254.3	0.0	-5.0	254.3	
100/11-20-083-14 W4/00	11-20-083-14 W4	213.0	341.1					255.0	299.1	270.0	284.1	302.0	252.1	0.0	-5.0	252.1	
100/10-21-083-14 W4/00	10-21-083-14 W4	218.0	339.6					268.0	289.6	277.0	280.6	311.0	246.6	0.0	-5.0	246.6	
100/08-22-083-14 W4/00	08-22-083-14 W4							265.0	295.4	279.0	281.4	323.0	237.4	0.0	-5.0	237.4	gamma ran high
100/01-29-083-14 W4/00	01-29-083-14 W4	211.0	342.1					258.0	295.1	267.0	286.1	297.0	256.1	0.0	-5.0	256.1	

Table 5A-2 Wireline Log Analysis Cut-offs Watersand Mapping

Formation	Basal McMurray Aquifer	Gross Clearwater B Aquifer	Gross Clearwater A Aquifer	Gross Lower Grand Rapids Aquifer
Maximum Gamma (API)	60	60	60	60
Minimum Porosity (%)	30	30	30	30
Maximum Resistivity (ohm)	10	-	-	-
Spontaneous Potential Development	good	good	good	good

Notes: Clearwater aquifers picked at the gas/water interface where gas present.
Lower Grand Rapids Aquifer srtucture top below the oil/water interface where oil present.
All information considered together to pick aquifer top and bottom.

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Wightman, D., Attalla, M., Wynne, D., Strobl, R., Berhane, H., Cotterill, D. and T. Berezniuk. 1995. Resource Characterization of the McMurry/Wabiskaw Deposit in the Athabasca Oil Sands Area: A Synthesis. AOSTRA Technical Publication Series #10, Alberta Department of

Table 5A-3 RSA Geologic Picks

UWI	Easting Nad27 Z12	Northing SF Nad 27 Z12	KB (masl)	Empress Channel Deposits (TVD/MD)	Terrace Sand (TVD/MD)	Bedrock (TVD/MD)	Base of Fish Scales (TVD/MD)	Viking (TVD/MD)	Joli Fou (TVD/MD)	Grand Rapids 'A' (TVD/MD)	Grand Rapids 'B' (TVD/MD)	Grand Rapids 'C' (TVD/MD)	Clearwater Shale (TVD/MD)	Clearwater 'A' (TVD/MD)	Clearwater 'B' (TVD/MD)	Clearwater 'C' (TVD/MD)	Wabiskaw (TVD/MD)	Sub-Cretaceous Unconformity (TVD/MD)
00/01-15-079-07-W4/04	500006.58	6188112.90	564.4			74		102	108	133.7	161.9	191.3	219.2	229.6	251.4	267.3	283	355
00/01-15-080-08-W4/00	490160.29	6197873.02	655.9			138.1		187.7	199	218.8	254.8	274	294.6	310.5	334.9	351.2	364.2	430
00/01-16-081-05-W4/00	517795.50	6207722.65	483.1			96.8						106.3	133.1	143.2	178.5	191.1	203.3	297
00/01-22-070-13-W4/00	443079.80	6102771.49	586.7			134.6	201.6	237.5	249	276.8	291	329	360.3	372	379.7	404.7	421.7	
00/01-25-083-02-W4/00	551702.41	6230685.91	480.5			88.4							133.3	139.8	173.7	193.3	203.8	301.3
00/02-17-078-08-W4/00	487240.57	6178571.15	578.7			68.5		123.5	134.7	161.1	181.4	205.1	239	255.2	272.4	295.3	308	364.7
00/02-18-079-03-W4/00	534106.07	6188247.81	572.8			100.2		144	153	170.3	189.2	224.2	248.2	260.6	279.2	296.8	308.5	
00/02-22-071-05-W4/03	520367.04	6112193.20	665.4	218.3		250		258	266	297.4	315.3	338.8	383.2	386.5	396.7	412.7	427.5	502.5
00/03-10-088-03-W4/00	537067.27	6274186.03	475.5			26.7						58.6	94.1	103.8	116.3	132	140.5	201.2
00/03-14-073-03-W4/00	541011.66	6130264.29	718.7	279.3		306.6		322.7	331.7	358.9	379.1	406.3	436.5	443.9	461.7	476.3	497	586
00/03-21-074-07-W4/00	498749.25	6141367.35	693		207.5	214.4	229.2	270	277.3	306.1	325	358.9	387.1	397.9	410.5	426.5	440.5	519.6
00/03-26-068-17-W4/02	404860.95	6085687.15	554.8			95.3	212.6	251.6	271	293	306.3	323.9	358.8	366	397.2	422.8	439	
00/03-27-079-17-W4/00	401105.53	6192561.98	558.6			136.6			143	171.2	199.7	220.8	264.1	283.1	307.1	329.3	340.7	
00/03-34-080-07-W4/00	499149.09	6202733.18	606.4			108.1		139.1	149	173.1	207.6	228.9	259.4	269.1	286.5	310.3	322.7	406.8
00/04-25-074-06-W4/00	512951.96	6143000.57	666.2		185.7	190.9		245.2	255.6	281.2	304.2	327.4	351.3	356.1	373.6	393.4	410	
00/05-08-071-06-W4/00	506425.98	6109143.23	659.8			186.1	228.5	264.5	272.5	304	320.9	344.9	388.5	391.8	404.7	423.3	445.5	510.5
00/05-10-086-17-W4/00	400794.72	6255885.23	509.5			35.4				50.8	78.1	109.5	144.5	167.3	185.1	201.2	213	
00/05-12-074-15-W4/03	424998.79	6139198.44	700.3			189.5	287.2	325	335	372.6	390.2	405.5	435.4	443.8	477.8	493.7	512	
00/05-15-068-03-W4/00	539460.95	6082021.35	737.6			128.8	295	342	350	377.1	389.5	429.7	468.6	472.5	490.9	507.6	516.1	592
00/05-19-079-02-W4/00	543088.90	6190447.11	526.2			101.7				111.9	137	163.9	199.2	210.4	221.7	238.4	250.6	329
00/05-23-070-08-W4/00	492419.10	6102808.41	634.8			99.9	219	261	268.5	296.2	315.1	353.8	392.6	400	407.3	415.7	432	506.5
00/05-23-075-10-W4/00	471698.63	6151375.79	686.3		173.9	188.3	226.5	262	270.5	301	315.5	345	370.2	376.3	409.8	446.7	455	
00/05-27-075-07-W4/00	499150.84	6152894.57	666.9		170.6	193.6		229.7	234.8	266.3	285.9	316.4	338.2	350.4	368.8	402.5	413.9	478.2
00/06-03-074-18-W4/00	392970.56	6137962.14	594.4			194.9	197.5	229.2	254.3	275.5	294.9	314.6	351.5	360.6	402.6	428.3	446	
00/06-11-072-13-W4/00	443150.37	6119124.48	646.7			150.7	247.2	282.8	294	321.5	346.5	374	417.2	427.3	436.2	453.3	468.6	544.6
00/06-12-085-17-W4/00	404418.85	6246409.53	513.4			54.7				62.3	91.6	107.2	149.9	174.6	193.5	209.8	225	
Cotterill. 1993. Regional-Scale	422483.85	6189239.28	647.7			189		205.8	214.3	242.2	270.5	289.9	330.6	348.9	374.7	394.8	405.8	
00/06-15-074-03-W4/00	539087.39	6140312.46	657.7		172.1	194.2	220.3	289	301	325.7	351.8	371.8	408.5	414.9	438.1	449.8	465	561.3
American). 2006. Application fo	538110.45	6091709.62	721.9			148.3	295	336	345	378.5	399.2	436.5	471.2	482.8	499.9	516.1	527	602.6
00/06-16-074-04-W4/00	527748.90	6139999.33	619.3		140.4	157.3		200	210	236.4	255.5	281.1	322.4	327.6	334.6	351	368.1	419
rhane, H., Cotterill, D. and T. Be	438098.28	6227772.63	574.2			52.1		85.4	94.7	125.8	158.4	190.2	219	226.3	246.3	266	285.3	361.4
s Area: A Synthesis. AOSTRA	429080.77	6190580.82	714			217.5		280	288.7	307.2	337.4	356.7	397.2	418.7	437.5	458.5	470.3	
00/06-23-079-13-W4/00	442004.17	6190468.61	685.9			135.4	205	239	248	273.4	298.6	316.2	363.3	380.7	404.8	423.7	435	495
00/06-26-076-06-W4/00	511002.17	6162551.23	570	136.5		144.4				160.8	184.1	208	234.9	241	274.4	292.4	310.1	391.4
00/06-28-076-17-W4/02	400282.22	6163797.30	695.7			193.1	260	294	307.1	331.9	357.4	374.1	420.1	434.5	460.5	490.7	504	
00/06-30-083-05-W4/00	513285.39	6230837.66	535.1			71.5				116.6	136.3	149.2	182.5	188.4	221.4	237.5	248.1	
00/06-35-068-13-W4/00	443753.83	6086702.87	601.7			190.5	230.4	267	278.9	304.4	325.5	356.3	387	396.6	407.8	433.9	450.5	
00/07-08-068-10-W4/00	468659.25	6080191.89	713.2			189.3		370.6	381.2	410.2	457.3	469.6	c	512.7	535.2	549.4	557.5	629.5
00/07-10-073-13-W4/00	442256.16	6129143.60	668.8			190.7	250	288.5	299.5	326.5	357.8	377.5	419.5	431.4	439.4	458.7	474.5	531.2
00/07-11-075-17-W4/00	403715.20	6149210.51	643.5			109.7	227	263	276.5	301.2	323.3	339	386.2	398.3	431.2	452.5	470.2	
00/07-12-079-05-W4/00	522695.29	6187169.50	532			75.1		92.3	100.2	121.5	144.7	168.9	201.5	212.7	236.6	255.1	266.6	363.6
00/07-13-078-01-W4/00	562036.36	6179116.78	582.5			201.2						213.5	248.4	251.7	274.3	291	301.8	389.5
00/07-14-070-17-W4/00	405311.25	6102239.28	581			186.6	227	264.3	277.5	306.7	323.9	337	370.4	373.8	417.2	438.6	453.5	
00/07-14-074-12-W4/00	453682.72	6140201.67	664.1	199.8		216.1		264.8	276.5	305	331.8	353.5	370	377.9	415.2	438	455	520
00/07-15-068-06-W4/00	511088.55	6081749.59	697.3			153.3	276.8	322.4	329.9	361.1	378.8	403.6	447.7	459.9	482	492.6	504.4	576
00/07-15-082-13-W4/00	441047.65	6218221.08	615.9			95.9		144	153.6	177.5	209.9	227.7	274.4	283.5	312.4	330.7	338.9	398.8
00/07-16-077-17-W4/00	400965.62	6170094.63	616.7			190.7		204	218	248.4	276.8	298.3	330.5	346.7	368.2	403.1	417	
00/07-17-075-03-W4/00	536166.32	6149992.71	626.7		146.2	160.3	172.7	241.7	250.2	270	292.9	314.6	370.2	377.5	391.9	407.4	415.5	505
00/07-20-072-01-W4/00	556198.78	6122655.69	696	265.3		298.6		319.8	330.2	358.6	377.5	418.6	449.9		458.2	471	494.7	611.3
00/07-21-070-06-W4/00	509429.72	6102806.26	641.1			133.8	209.7	255.3	263.7	291	308.2	334.9	364.9	373.1	389.4	405.3	423.9	496.8
00/07-21-071-01-W4/00	558053.27	6112845.50	734.5	314.5		336.6		360	369	401.9	423	467.6	493.3		502.6	515.8	539.8	646.7
00/07-21-084-10-W4/00	468056.48	6238855.72	636.7			62.9	111.9	139	144	173.3	202.7	225.7	254.9	268.8	296.5	320.8	328.2	386.3
00/07-22-074-17-W4/00	403414.09	6142590.19	589.8			189.5		210.3	223.7	248.3	267.2	286.9	321	334	370.5	389.8	406.3	
00/07-22-078-10-W4/00	470766.20	6180715.02	636.3			173.4		181.6	190.8	219.7	238.3	262.7	302.1	316.8	330.6	355.1	370	438.2
00/07-24-086-03-W4/00	541220.08	6258519.02	476.7			32.8						54.9	85.8	93.8	113.8	128.7	139.6	189.9
00/07-25-080-03-W4/00	541982.79	6201507.51	486.2			71.2				75.1	97.3	126.2	170	177	200.5	214.5	227	326.7
00/07-26-069-01-W4/00	561573.74	6095102.83	693.8			136.8	260	294.7	305	335.1	362.3	392.7	422.9		431.4	457.2	474.5	588
00/07-29-074-09-W4/00	478026.01	6143344.30	664.4	201.9		223.2		246	255	284.6	304.8	333.7	361	372.5	385	407.6	422.8	486.2
00/07-29-078-03-W4/00	535830.37	6182145.62	555			87.3		120	128.3	148.2	165.3	197.1	228.3	244.1	259.5	277.9	290.6	
00/07-32-079-06-W4/00	506179.00	6193340.56	550.4			63.7		88.2	98.5	121	151.4	176.9	210.8	222.1	246.1	260.3	274.9	354
00/07-33-079-01-W4/00	556853.91	6193890.29	533.5			101.3				108.4	129.7	158.7	177.9	182.8	220.9	233.9	248	331.5
00/08-12-082-17-W4/00	405937.06	6216970.62	538.3			39.4		69.2	86.5	113.7	144.6	164.7	200	219.3	247.1	261.3	274	
00/08-15-069-06-W4/00	511236.91	6091559.02	700.7			149.9	263.8	310.6	318.7	350.1	376.3	401.7	435.6	443.1	457.6	475.6	495	
00/08-15-071-13-W4/00	442070.90	6111420.06	636.4			149.8	246	282.1	292	321.2	345.4	382.4	406.6	417.1	434.8	450.4	468.7	538
00/08-15-079-10-W4/00	470595.17	6188468.59	672.4			168.1		210	216	246.1	269.9	289.9	337.2	354.6	365.8	386.5	400	465.6
00/08-16-069-07-W4/00	500076.82	6091515.33	627.1			113.7	208	254.5	261.6	289.8	306.2	343.4	376.1	380.1	390	408.6		503
00/08-16-072-06-W4/00	509087.23	6120484.48	715.4	263.3		295.4		308.2	316.8	343.1	362.2	383.8	428.1	431.7	441.9	460.6	473.6	550.1

Table 5A-3 RSA Geologic Picks

UWI	Easting Nad27 Z12	Northing SF Nad 27 Z12	KB (masl)	Empress Channel Deposits (TVD/MD)	Terrace Sand (TVD/MD)	Bedrock (TVD/MD)	Base of Fish Scales (TVD/MD)	Viking (TVD/MD)	Joli Fou (TVD/MD)	Grand Rapids 'A' (TVD/MD)	Grand Rapids 'B' (TVD/MD)	Grand Rapids 'C' (TVD/MD)	Clearwater Shale (TVD/MD)	Clearwater 'A' (TVD/MD)	Clearwater 'B' (TVD/MD)	Clearwater 'C' (TVD/MD)	Wabiskaw (TVD/MD)	Sub-Cretaceous Unconformity (TVD/MD)
00/08-16-075-05-W4/04	518410.97	6149785.58	621.1			163.8		182	193	219.3	239.4	262.1	295.5	301.1	321.5	341.1	360	415
00/08-16-080-10-W4/00	469157.54	6198512.01	694.3			173.8		228	235	262	287.2	313.4	348.3	359.7	369.5	396.4	408.6	475.2
00/08-16-081-13-W4/00	439631.21	6208577.55	688.4			119.9	199	227	236.5	262	292.1	309.5	358.3	374.9	397.6	411.9	421.3	
00/08-21-074-05-W4/00	519000.25	6141661.11	656.8		177.1	187.6		231	243.8	269.9	288	313.2	343.3	352.7	370.4	387.8	404.5	521.5
00/08-22-074-10-W4/00	471674.65	6141877.92	670.3	209		242.9		269	280	305.9	325	350.1	388.3	393.4	407	428.7	444.7	502.7
00/08-24-076-02-W4/00	552716.68	6161338.03	634		159.8	170.4		207.3	218.5	244.1	274.3	296.3	325.6	334.2	362.9	375.9	392.3	517.6
00/08-33-081-01-W4/00	556897.96	6213305.65	484.7			150.2							154	169.5	198.3	213.8	225	343.6
00/09-06-085-13-W4/00	435858.30	6244562.90	541.2			51.3				79.2	107.5	119.6	164.4	171.9	193.6	212.5	230.1	
00/09-07-080-01-W4/00	554030.42	6197346.47	565			109.9				128	150.4	177.4	200.8	211.3	246.5	258	270	358
00/09-09-085-05-W4/00	517235.75	6245628.66	478.6			73.8						89.1	115.6	123.5	150.6	166.4	176.6	321
00/09-11-071-17-W4/00	404533.61	6110652.27	563			157.9	198	235	256.5	271.8	286.4	315.3	343.3	355.4	381	402.1	415.2	
00/09-11-074-14-W4/00	434368.80	6139243.78	734.4			124.8	313.5	347	358	385.4	408	431.7	460.6	470.5	503.7	523.5	542.6	615.8
00/09-12-073-01-W4/00	563124.08	6129543.67	669.5	226.2		260		262.5	278.4	312.4	351.3	378.2	403.2		415.8	428.6	454	604
00/09-16-083-03-W4/02	536866.99	6228043.47	463.8			82.9							98.4	101.2	137.1	152.3	162	282
00/09-17-084-06-W4/00	506141.74	6237469.03	497.8			41.8				52.7	83.3	111.2	129.6	140.5	175.3	191.1	201.1	273
00/09-21-081-10-W4/00	469308.36	6209909.54	708.9			154.1		233.7	240	267.5	295.3	313.6	352.3	364.5	382.8	407.6	417.7	483
00/10-01-079-16-W4/00	414593.56	6186649.02	606.6			188.8				208.2	234.6	253.6	291.6	310.8	340.7	363.1	375.5	
00/10-09-074-08-W4/00	489321.68	6138831.72	703.2	239		264.1		284.5	292.5	319.9	340.2	374.2	400.8	410.8	426.9	436.2	454.7	530
00/10-09-080-17-W4/02	399955.62	6198172.22	558.1			136.6				163.5	191.2	211	250.2	272.1	302.2	322.1	333	
00/10-11-076-08-W4/00	492089.97	6158328.04	640.4			177.1		197.5	205.3	235.7	252.9	276	310.4	321.4	339.6	378.9	390.1	456
00/10-14-073-10-W4/00	473084.77	6130783.35	663.9	203.7		238.3		267.5	275	305.6	324	358.2	386	388.9	406.3	430.4	442	564.3
00/10-14-074-08-W4/00	492559.58	6140514.65	702.3		212.2	225.3		286	293	320.9	339.6	373.1	403.1	413.7	426.1	443.5	456.9	532.6
00/10-14-078-17-W4/00	404348.75	6180383.80	563			119.2		134	148	176.5	201.7	219.4	259	279.1	296.9	313.7	325	
00/10-15-071-07-W4/00	500755.46	6111376.89	650.4			162.6		254	260	296	314.4	340.2	384.5	387.8	397	415.3	428.2	503.5
00/10-15-071-08-W4/00	491011.97	6111381.01	668.6			158.1	237	275.5	285	317.1	332.6	372.7	414.3	421.7	430.1	440.5	452	530.4
00/10-15-072-03-W4/00	540012.82	6121053.72	693.6	253		292		298.9	310.6	338.5	360.2	384.6	414.7	419.9	441.5	455.8	474	551.6
00/10-15-072-08-W4/00	490936.27	6121153.59	686.9	234		263.1		288	295.7	324.6	343.4	378.9	401.1	411.4	428.7	448.9	461.8	534.9
00/10-15-073-08-W4/00	491026.25	6130776.85	714.3	255		321.1				343.9	363.7	398	418.6	430.9	443.3	463.3	478.1	550
00/10-16-072-07-W4/00	499166.83	6121123.48	702.2	254		283.5		307	312.3	341.1	360.9	388	427.5	430.7	442.1	462.4	475.3	548
00/10-16-078-13-W4/00	440219.17	6179798.91	668.6	191.5		215.5		228	235	264.4	287.9	301.7	349.5	365.1	383.9	411.1	424	485
00/10-16-084-03-W4/00	536489.78	6237589.77	458.1			86.9							107.5	114.3	152.9	169.3	181.4	295.7
00/10-20-077-03-W4/00	535789.94	6171106.17	568.8			106.9		153	160	187.4	213.2	237	262.8	276.5	298.9	317.3	328.7	440
00/10-21-083-17-W4/00	399544.69	6230411.42	542.9			23.5	37	67.5	82	108.5	137.5	157.6	184.7	204.3	232.3	256	270	
00/10-22-078-05-W4/02	519659.03	6180937.86	591.8			123.6		148	154	175	196.8	231.9	248.7	265	290	308.7	320.2	415
00/10-23-072-10-W4/00	473055.70	6122779.09	672.1			101.8	248.7	282.5	290.7	321.7	337.9	373.6	411.3	424.6	435.1	443.9	459.7	
00/10-28-075-06-W4/00	508281.63	6153350.25	618.4		123.1	141.6		182	189.8	217.3	238.1	272.4	300.1	304.6	327.8	350.9	364.2	441.4
00/10-32-076-03-W4/00	535839.46	6164716.29	579.5	138.2		148.7		174	182	206.5	231.7	255	276.9	292	319.4	334.3	347.6	434.2
00/11-04-074-13-W4/00	440112.23	6137563.26	700.1			122.3	275	309	319	348	373.5	401.1	431	436	465.7	485.3	503	557
00/11-08-068-01-W4/00	556130.18	6081004.85	669.7			135.4	310	353.1	364	393.9	413.2	453.9	510.7		516.4	528.1	538.7	630
00/11-11-081-03-W4/00	539714.90	6206753.79	467.9			105.2						117.9	139.7	156.4	182	196.9	209.3	309.1
00/11-11-083-08-W4/00	490444.74	6226192.59	734.6			62.9	205	246	254	281.3	303.9	327.5	356.6	371.3	410.6	427.5	436.3	506.7
00/11-15-068-07-W4/00	500972.27	6081992.96	639.8			173.7	228	273.7	279.5	313.2	329	354.9	397.3	402	412.7	435.3	455.3	527
00/11-15-073-05-W4/00	519965.50	6130604.27	686.2	234.8		265.1		266.5	271.8	302.8	322.1	347.9	385.5	391.1	400	416.8	433.8	518.3
00/11-15-073-06-W4/02	510068.10	6130729.68	682.8	229.8		259.2		261.3	270.7	297.9	316.4	350.3	386.1	389.4	398.3	415.7	429.1	
00/11-15-077-07-W4/00	499652.20	6169619.92	571.2			127.5				148.6	171.9	194.7	223.1	238.2	256.5	292.2	304.9	368.4
00/11-15-079-09-W4/02	479781.21	6188861.99	678.9			209.5		218	227.2	253.8	285.6	305.5	326.8	343.1	365.7	384.2	398	456
00/11-15-080-13-W4/00	440322.80	6199252.16	688			107.3	204.7	235	244.4	273.4	300.8	321.8	365.3	381.6	405	422.5	432.5	493.7
00/11-16-079-04-W4/00	527043.20	6188848.88	531.7			79.6		88	99	119.9	138.7	162.3	201.7	214.3	236.3	254.4	266	386
00/11-16-080-06-W4/00	507254.94	6198674.04	584.2			62		126	134	158	190	218	248.5	258.1	283.8	297.4	311	387.5
00/11-18-081-06-W4/00	504082.18	6208374.98	559.6			52.7		91.4	99.5	120.5	158.3	181.1	207.3	213.9	245.5	257.7	273.4	
00/11-20-072-17-W4/00	399222.39	6123820.82	582.7			130.2	190	223	240	266.9	284	310.8	337.9	343.5	384.2	405.5	423	
00/11-21-069-17-W4/00	401463.09	6094467.99	560			109.8	222.5	258	271	298.6	311.3	331	368	370.6	405.5	431.9	448.9	
00/11-22-074-16-W4/00	412611.66	6142959.23	648.6			187.3	232	266.7	280.1	304.2	326.7	345.8	383.3	392.1	432.1	448.1	465.4	
00/11-22-077-10-W4/00	470354.39	6171287.23	645.6			158.5	162.8	199.5	207.6	235.9	261.7	277.5	322.5	331.3	343	379.1	395	457.6
00/11-29-074-01-W4/00	555278.38	6144047.79	697		215.2	229.4	250	293.7	302.8	331.9	355.4	388.7	423.6		430.5	442.2	468.6	568
00/11-34-070-01-W4/00	559141.14	6106582.44	706.6	268.3		302.5		326	334	366.4	386.5	425.2	455.5		463	478.9	503	610.7
00/12-11-076-10-W4/00	471690.77	6158331.92	672	213.9		239				272.9	296.7	312.1	352.6	363.6	381.6	420.6	429	539.5
00/12-14-072-05-W4/00	521048.53	6120871.43	717.6	272.5		303.4		309.5	315.5	342.9	361.2	386.8	430.8	434.7	444.3	459.8	474	549.5
00/12-15-075-08-W4/00	489649.49	6150172.30	652.5		167.8	181.3		223.7	230	259.9	279.3	309.9	348	351.7	364.3	396.4	408.7	477
00/12-16-070-07-W4/00	498933.97	6101475.17	651.4			110.2	228	268.4	277.7	307.6	324.3	349.3	398.9	407.4	414.5	423.8	439	513.5
00/12-21-077-08-W4/00	488016.60	6171153.41	567.3			106		110.6	123	156.3	166.6	190.2	222.7	238.3	252.6	289.5	302	361
00/12-22-068-05-W4/00	520163.67	6083749.47	693.4			105.3	257	309	319	345.7	359.1	384.1	441.2	451.5	471.9	484.9	495	566.2
00/12-27-082-10-W4/00	469433.28	6221435.23	713			183.3	191.8	226.5	233.3	259.4	285.3	304.7	340	352	382.3	405.9	415.1	480
00/12-29-082-03-W4/00	534533.87	6221513.65	478.2			71.1						86.7	116	125.3	159.3	173.6	184.6	254.6
00/13-03-081-17-W4/00	401201.08	6206574.49	549			60		92.6	109	135.3	166	184.9	221.1	237.7	252.9	291.4	300.7	
00/13-09-078-07-W4/02	497886.20	6177893.31	553.4		70.5	79.7		88	95	123.6	144.7	170.5	204	220.4	240.7	265	276.8	
00/13-15-070-05-W4/00	519936.29	6101954.79	671.7			152.5	222	268	275.6	305.8	320.6	345.2	390.3	393.3	404.6	414	418.8	541

Table 5A-3 RSA Geologic Picks

UWI	Easting Nad27 Z12	Northing SF Nad 27 Z12	KB (masl)	Empress Channel Deposits (TVD/MD)	Terrace Sand (TVD/MD)	Bedrock (TVD/MD)	Base of Fish Scales (TVD/MD)	Viking (TVD/MD)	Joli Fou (TVD/MD)	Grand Rapids 'A' (TVD/MD)	Grand Rapids 'B' (TVD/MD)	Grand Rapids 'C' (TVD/MD)	Clearwater Shale (TVD/MD)	Clearwater 'A' (TVD/MD)	Clearwater 'B' (TVD/MD)	Clearwater 'C' (TVD/MD)	Wabiskaw (TVD/MD)	Sub-Cretaceous Unconformity (TVD/MD)
00/13-15-079-08-W4/00	488904.94	6189523.98	614.6			81		143.3	154	177.3	201.4	230.2	253.5	271.7	296.6	313.9	327	389
00/13-15-079-11-W4/02	459732.47	6189494.70	690.9			175.2		227.2	237.5	263.5	288.8	307.7	353.7	372.2	391.5	408.3	420	487
00/13-16-079-12-W4/00	448293.93	6189688.19	685			154.4	190	226.6	237	266.6	287.2	305.5	351.9	369.5	393.5	410.1	422	
00/13-21-073-17-W4/00	400822.64	6133769.76	581.5			181.3		208.7	225	248.6	265	281	321.8	327.9	366.7	390.9	407	
00/14-14-074-11-W4/02	462857.81	6140887.39	674.2	219		244.3		267	276	311.9	341	366.7	401.1	405.8	423.3	446.2	462.2	
00/14-15-081-07-W4/00	499188.27	6208602.07	627.8			108.7		157.8	166.5	189	229.7	252.1	276.2	286.9	313.1	329.7	339.6	416
00/14-22-070-10-W4/00	471595.10	6103417.31	648.8			183	239.5	277	288	315.1	338.8	370.9	409.6	421.7	429.8	443.4	460.5	
00/14-27-072-06-W4/00	510111.80	6124652.11	713.5	263.1		319.9				337.8	353.1	393.5	435.8	438.8	448.9	467.2	480.5	595.2
00/15-05-068-08-W4/00	488312.45	6079383.77	672			173.1	279	324	333.2	367.2	385.8	420.2	452.5	458.3	478.5	488.1	502.9	566.7
00/15-08-076-05-W4/00	516273.28	6158713.38	576.9	127.5		154.3				173.5	197.4	220.8	252.4	261.6	288.2	308.4	322	395.2
00/15-16-071-03-W4/00	538143.17	6111667.19	683	245.3		278		307.6	318	345.9	372.9	395.2	430.5	435.2	457	470.8	490	545.3
00/16-15-076-13-W4/00	441706.19	6160489.94	717.5	231.3		276.7		300	310.3	338.7	359.3	379.2	420	428.9	452.4	491	500	557.5
00/16-15-080-05-W4/00	519421.75	6198989.95	468.7			84.1						117.1	137	153.6	180.3	195	209.8	288
00/16-16-077-13-W4/00	440525.54	6170220.49	684.9	192.5		242		248.7	259.3	285.4	309.3	324.4	373.2	384.9	402.7	440.3	452.5	508
00/16-16-081-08-W4/00	488510.24	6208611.20	737.2			160.3		264.8	271.6	296.7	326.3	340.2	373.7	392.6	416.2	432.1	442.6	507
02/01-15-075-13-W4/00	441579.52	6149720.78	708.4			153.6	263	299	310	337.3	358.5	383.9	418	424.1	453.6	478.9	500	556
02/04-22-070-03-W4/00	539416.11	6102687.05	707.4			143.4	254.6	305.5	311.5	339.3	354.6	378.2	409.7	414.5	451.7	463	472.3	538
02/07-33-079-01-W4/00	556861.91	6193890.40	533.5			101				107.5	129	158.6	177.6	188.1	220.9	234.2	247.5	331.5
03/10-14-076-07-W4/00	501817.03	6159851.30	594.5	140.2		168.5				182.8	197.7	222.5	250.3	259	280.3	315.3	327	396
AA/02-20-088-05-W4/00	514785.55	6277188.74	466.3			62.4						67.7	84.4	95.3	111	120.9	128.9	
AA/03-16-077-05-W4/00	517818.32	6168675.68	588.3			128.1		153.5	162.5	183.7	208.9	232.8	259.2	275.7	303.3	322.4	335.5	435
AA/04-22-087-07-W4/00	497769.95	6267559.11	440.3			22.4							55.2	67.4	93.1	104.1	112.2	
AA/05-23-077-06-W4/00	510868.10	6170804.58	566.8			107.9		124	132.1	155.4	183	212.3	229.8	243	272.2	289.2	307.5	394.5
AA/06-10-087-06-W4/00	508046.94	6264798.16	447.5			21.6						35.2	57.9	61.9	85.8	97.6	106.6	184.5
AA/06-18-084-07-W4/00	493648.49	6237257.86	734.6			27.1	194.6	242.3	253	278.5	308	333.3	360.3	375	412.6	425.6	433.6	503.2
AA/08-21-073-07-W4/00	499513.19	6131901.66	734.3	291.3		324.6				354.8	373.5	412.1	442.7	447.7	457.6	474.9	488.8	566
AA/09-14-078-06-W4/00	511710.79	6179141.70	589.9			90.2		140	150	172.7	199.8	226.8	255.9	267.3	292.2	309.4	324.8	414
AA/10-02-087-06-W4/00	509956.44	6263513.38	453.4			23.5						36.3	55.6	71.6	101	113.9	120.9	201
AA/10-27-086-07-W4/00	499000.34	6260200.05	489.4			24.1						83.2	116.4	131	158.3	173.4	181.7	251
AA/11-15-083-06-W4/00	508515.80	6227937.29	587.4			84		103.5	113.2	138.3	167.1	187.2	220.4	226.9	267.7	277.5	292.5	384
AA/11-15-083-07-W4/00	498554.27	6227712.80	700.9			66.6		218.3	226	251.5	288.2	303.8	330.4	338.5	379.5	393.4	404	489
AA/16-16-082-07-W4/00	498436.56	6218349.93	746.2			124.4		268.4	279	296.3	333.8	352.9	380.2	391.8	428.3	443.9	455.1	525.5
AC/07-28-085-10-W4/00	468071.28	6250166.00	523.1			83.3					87.7	113.1	127.8	140.8	179.5	204.2	211.4	274.5

Notes:
TVD - True Vertical Depth
MD - Measurement Depth

Table 5A-4 Summary of Hydrostratigraphic Unit Data Sources

Hydrostartigraphic Unit	LSA Data Source	RSA Data Source (Excluding LSA)
Undifferentiated Overburden aquifer/Aquitard	North American (2006)	Andriashek (2003)
Terrace Sand Aquifer	North American (2006)	Andriashek (2003)
Empress Channel Aquifer	North American (2006)	Andriashek (2003)
LaBiche aquitard	North American (2006)	Wireline Logs
Viking Aquifer	North American (2006)	Wireline Logs
Joli Fou Aquitard	North American (2006)	Wireline Logs
Upper Grand Rapids Aquifer (Grand Rapids 'A' and 'B' Units)	North American (2006)	Wireline Logs
Lower Grand Rapids Aquifer (Grand Rapids 'C' Unit)	Wireline Logs	Wireline Logs
Clearwater Shale Aquitard	Wireline Logs	Wireline Logs
Clearwater Aquitard	Wireline Logs	Wireline Logs
Clearwater 'A' Aquifer	Wireline Logs	Wireline Logs
Clearwater 'B' Aquifer	Wireline Logs	Wireline Logs
Clearwater 'C' Aquifer	Wireline Logs	Wireline Logs
Wabiskaw Aquifer	Wireline Logs	Wireline Logs
Wabiskaw Bitumen Aquitard	Wireline Logs	Wightman et al. 1995
McMurray Aquifer	Wireline Logs	Wightman et al., 1995
McMurray Bitumen Aquitard	Wireline Logs	Wightman et al., 1995
Basal McMurray Aquifer	Wireline Logs	Wightman et al., 1995
Sub-Cretaceous Unconformity (Top of Devonian)	Wireline Logs	Wireline Logs and Wightman et al. (1995)
Winterburn Aquifer	Wireline Logs and Bachu et al. (1993)	Bachu et al. (1993) and Wightman et al. (1995)
Grosmont Aquifer	Wireline Logs and Bachu et al. (1993)	Bachu et al. (1993) and Wightman et al. (1995)
Ireton Aquitard	Wireline Logs and Bachu et al. (1993)	Bachu et al. (1993) and Wightman et al. (1995)
Cooking Lake/Beaverhill Lake Aquifer	Wireline Logs and Bachu et al. (1993)	Bachu et al. (1993) and Wightman et al. (1995)
Watt Mountain Aquitard	Wireline Logs and Bachu et al. (1993)	Bachu et al. (1993)
Prairie/Muskeg Aquiclude	Wireline Logs and Bachu et al. (1993)	Bachu et al. (1993)
Keg River/Winnipegosis Aquifer	Wireline Logs and Bachu et al. (1993)	Bachu et al. (1993)

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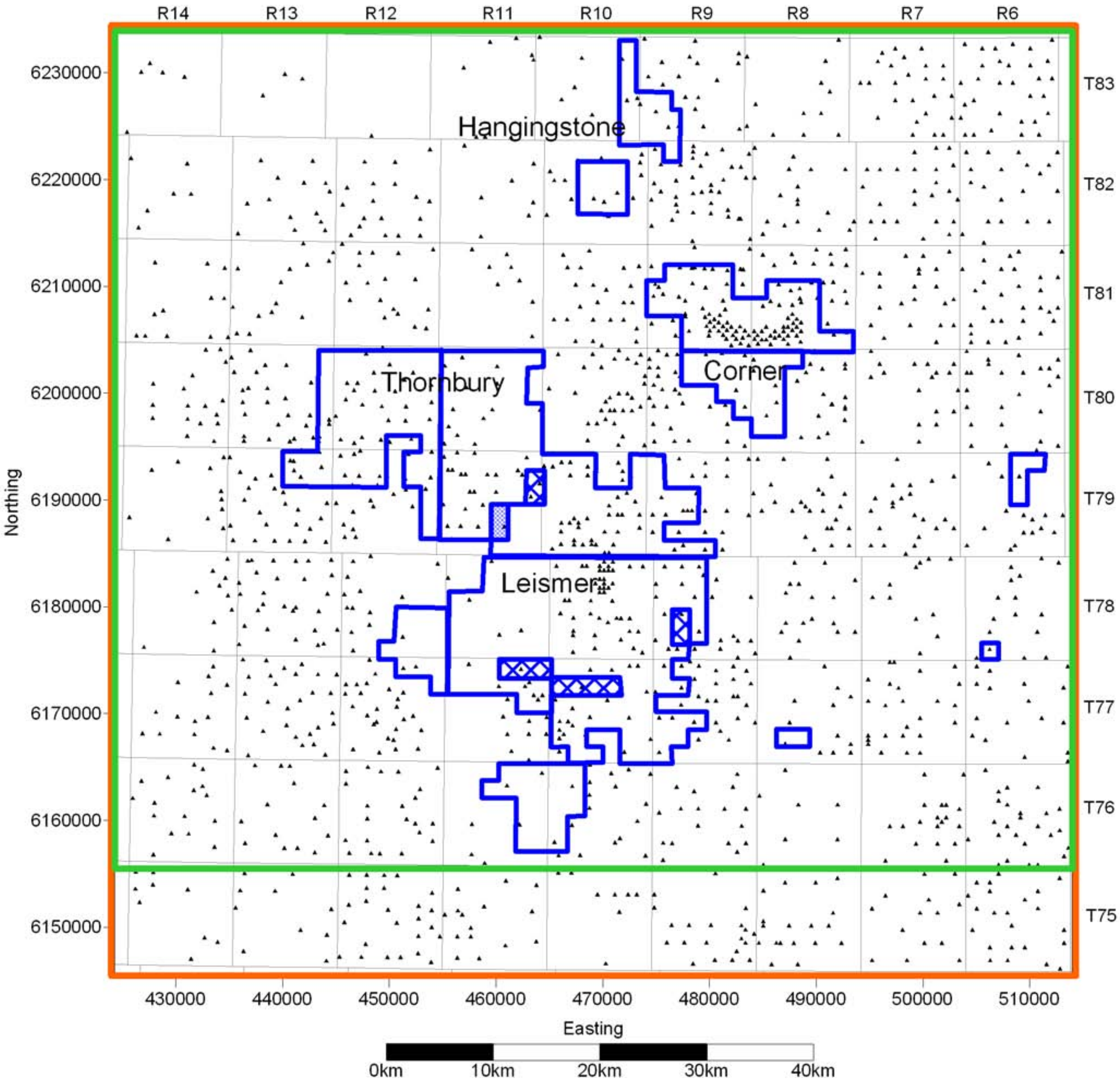


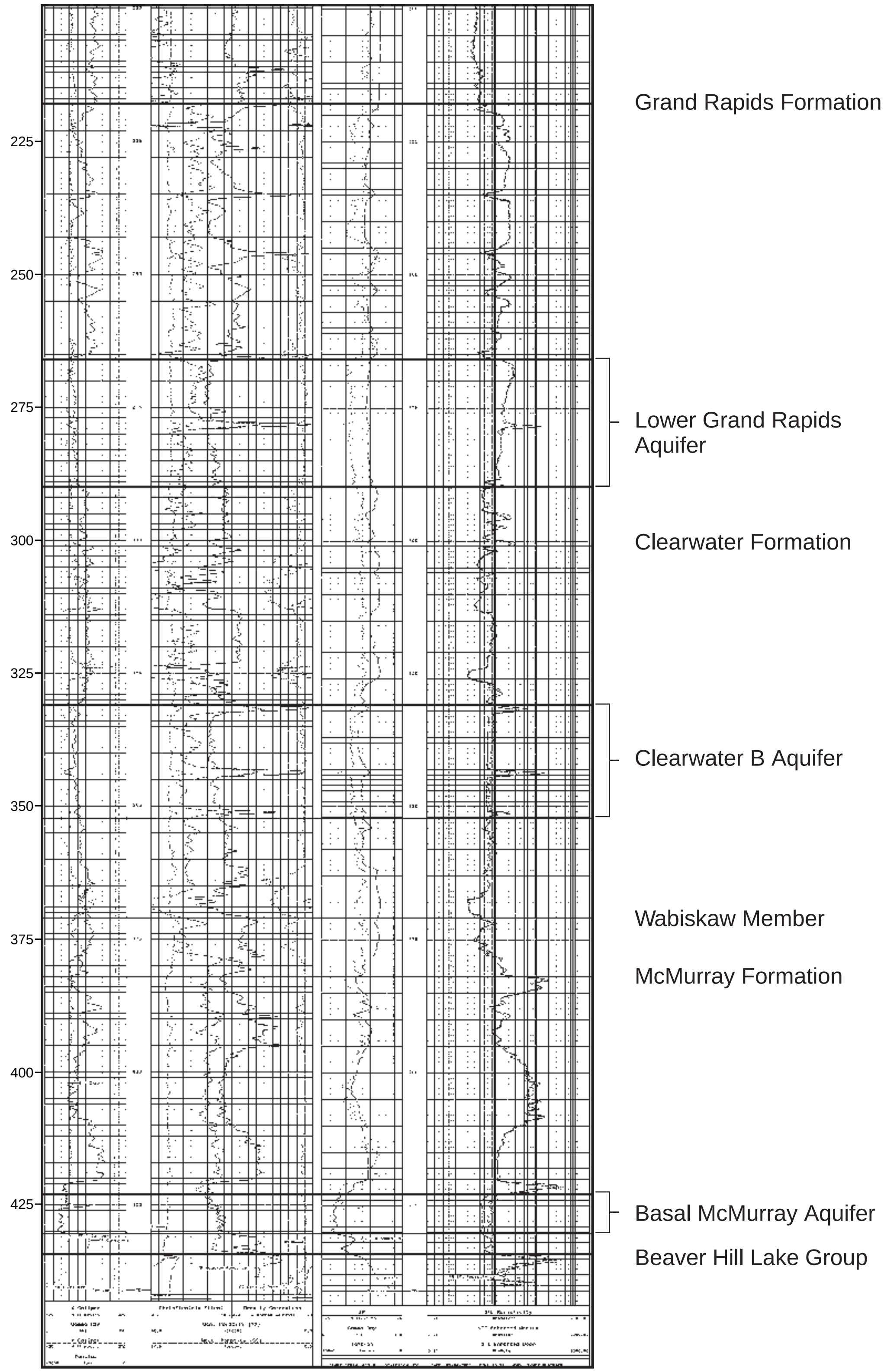
LEGEND
- NAOSC LEASE AREAS
- ▲ WELL LOCATIONS (LOG REVIEWED)
- GRAND RAPIDS AND CLEARWATER MAPPING AREA
- WABISKAW TO DEVONIAN MAPPING AREA

Title:

REGIONAL STUDY AREA HYDROGEOLOGICAL INVESTIGATION

NORTH AMERICAN OIL SANDS CORPORATION

Approved: LP	Revision Date: 07/05/15	
File: 4455-Area-07.cdr		
Drawn by: JW	Checked: BW	Fig. No.: **5A-1**



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TYPE LOG
MANNVILLE GROUP
1AA/03-15-078-10 W4/100

NORTH AMERICAN OIL SANDS CORPORATION

Approved: LP		Revision Date: 07/05/22
File: 4455-Strat-07.cdr		
Drawn by: GDE	Checked: BW	Fig. No.: **5A-2**

APPENDIX 5B
Hydraulic Head Mapping

5B1 INTRODUCTION

Hydraulic head mapping was completed using topography, geologic subcrop and outcrop locations, and several types of subsurface data sets including:

- Onsite measurements;
- Published EIAs;
- Published heads from regional hydrogeologic studies; and
- Drill stem test (DST) data.

The data points were divided according to hydrostratigraphic units, screened for quality control and interpreted with respect to topography and geology. Tables 5B-1 through 5B-4 summarise measured water levels in the region and are divided according to hydrostratigraphic units. Tables 5B-5 through 5B-8 summarise pressure data obtained from industry (DST data) and are also divided into hydrostratigraphic units.

The following sections provide further background as to the data sources and describes the QA/QC process employed in screening the data.

5B1.1 Regional Water Well Data

Regional water well data was obtained by reviewing the following data sources:

- Alberta Research Council reports;
- Alberta Geological Survey reports;
- AENV's Groundwater Information Centre water well database; and
- Published EIAs and hydrogeological assessments for projects in the study area.

The specific data source for each of the water level measurements is included in the presented tables. These data were considered "hard" and therefore no data points were eliminated.

5B1.2 Pressure Data Use for Hydrogeologic Investigations

Pressure measurements obtained by the oil and gas industry are a valuable data source for hydrogeologic investigations due to the regional distribution and large number of available pressures. For the purposes of this investigation, equivalent hydraulic heads (h_{equiv}) were obtained from the drill stem tests according to the following equation:

$$h_{equiv} = h_Z + h_P \qquad \text{(Equation 5B-1)}$$

where:

h_Z = elevation of Kelly bushing (KB) less depth of pressure recorder [masl]
h_P = recorded extrapolated pressure [m of freshwater head]

It is common practice for industry to conduct more than one test on the same production zone. When this occurs multiple extrapolated pressures for the same zone are available. The duplicate pressures are referred to as first extrapolated pressure, second extrapolated pressure, etc. For the purposes of this investigation the first extrapolated pressure was used to calculate the equivalent hydraulic head values. If the first extrapolated pressure was unavailable but a second extrapolated pressure was obtained the second extrapolated pressure was used to determine the equivalent hydraulic heads.

Errors in the extrapolated hydraulic head data set can arise for several reasons including:

- Assigned hydrostratigraphic unit
- Elevation of pressure recorder
- Inaccurate fluid pressures

These sources of error are discussed in the following sections.

5B1.2.1 Assigned Hydrostratigraphic Unit

Included in the DST data held by the EUB is the reported formation that the test was completed in. In order to facilitate interpretations of hydraulic head the pressure data was separated into four groups according to regional hydrostratigraphy and the reported formation on the test. The four hydrostratigraphic units were Grand Rapids, Clearwater, McMurray and Grosmont. With respect to characterizing horizontal groundwater flow, two sources of error are associated with this data.

The first source of error occurs when the perforated and tested interval does not correlate to the reported formation and therefore the assigned hydrostratigraphic formation. Due to the large number of DSTs included in this investigation the validity of the reported formation was not confirmed. If an anomalous pressure is assigned to a given hydrostratigraphic unit because the wrong formation was reported this pressure may still get removed from the data set as per the process described in Section 3.3.

A second source of data uncertainty occurs when a vertical gradient is present in the formation. This can complicate the interpretations of horizontal flow because pressure measurements from different depths cannot easily be compared. For instance in Township 78 Range 10 the Grand Rapids Formation can be divided into three hydrostratigraphic units (A, B, and C) separated by shale. Since the hydraulic head values in these units decrease with depth, posting pressures from the Grand Rapids A and Grand Rapids C on the same map of horizontal groundwater flow is a source of data uncertainty with respect to mapping horizontal groundwater flow.

5B1.2.2 Elevation of Pressure Recorder

Implicit in the above described method of converting pressures to hydraulic heads is the assumption that well bore is filled with freshwater. If the fluid in the well bore is of a different density (gas or drilling mud) then the accuracy of the calculated equivalent hydraulic head is dependant on the depth of the pressure recorder. For instance if the well bore is filled with drilling mud (greater density than water) and the recorder is placed above the perforated interval, then the equivalent hydraulic head of the formation would be underestimated by Equation 5B-1.

Fortunately, the recorder is most commonly placed within the perforated interval and this source of error is not an issue. Occasionally the recorder is placed above or below the perforated interval and therefore introduces a potential source of error.

The DST data set was therefore screened to confirm whether the pressure recorder was located within the perforated interval. For well tests where the pressure recorder was located above or below the perforated interval the magnitude of the separation was recorded in the tables in a column labelled “QC Recorder Elevation” (Tables 5B-5 through 5B-8). For the purposes of this investigation if the pressure recorder was installed more than 10 m above or below the perforated interval those data pressures were discounted.

5B1.2.3 Inaccurate Fluid Pressures

Fluid pressures measured by DSTs may not reflect true undisturbed formation pressures for a variety of reasons including:

- Mechanical error/failure during the test;
- Inaccurate or incomplete recording of test data;
- Formation pressure modification during drilling (eg., supercharge);
- Improper extrapolation of the pressure test data; and
- Pressure induced drawdown (PID)

In order to reduce these sources of error in the data set the pressures were screened for a QC code and anomalous pressure data was eliminated. A set of DST pressure quality codes has been developed for use in the Western Canadian Sedimentary Basin by the Canadian Institute of Formation Evaluation (CIFE, 1980). These codes are summarised in Table 5B-9 and were developed based on a review of the reported mechanical operations during the test and the pressure build-up curve. For the purposes of this study, only DSTs of A, B, C and D quality were used. When interpreting the results a higher weighting was given to test measurements of A and B quality.

The next stage of data culling was “bust elimination”. Initial contour maps of hydraulic head were scrutinized for anomalous high and low pressures. If there was no hydrogeological reason for the closures, the anomalous data point in the centre of the closure was not used as a control point for the hydraulic head mapping.

5B1.2.4 Summary of DST Data

The initial pressure data set consisted of 1,304 DST pressures from across the region. Approximately 8% of the initial DST pressure data points were eliminated, leaving 1,206 DST pressure values. Table 5B-10 summarizes the number of data points in the initial data set and screened data set for the Grand Rapids, Clearwater, McMurray and Grosmont units.

5B1.3 Interpretation of Hydraulic Heads

Thirty-one hydraulic head measurements and 1,206 interpreted DST pressures were obtained for five hydrostratigraphic units as summarised in Table 5B-11. Hydraulic head values were then posted in plan view for each of the hydrostratigraphic units. Hydraulic head contours were then hand drawn based on: hydraulic head values, known geology and physiographic conditions, and hydraulic gradients in the overlying and underlying aquifers.

5B1.4 Literature Cited

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TABLE 5B-1 REGIONAL HYDRAULIC HEADS: EMPRESS FORMATION

UWI	Well Location	Unit	Ground Surface	Casing Elevation	Perforated Interval (m bgs) Top	Perforated Interval (m bgs) Bottom	Mid Point Perforated Interval Depth (m bgs)	Mid Point Perforated Interval Elevation (masl)	Pressure Head (m)	Hydraulic Head (masl)	East_utm27z12	North_utm27z12	Reference
PW1	12-28-75-6 W4M	Terrace Sand	605.1	606.3	123.4	129.6	126.5	478.6	149.5	628.1	507473.8	6153435.2	Matrix, 2005
PW2	12-28-75-6 W4M	Terrace Sand	604.4	605.1	123.1	129.2	126.2	478.3	150.0	628.3	507445.7	6153440.2	Matrix, 2005
WEPA 00-3-158	16-4-75-5 W4M	Terrace Sand	648.2	648.9	155.4	158.8	157.1	491.1	117.2	608.3	518557.2	6147238.6	Lemay, 2002
1420120	NW-14-78-9 W4M	Terrace Sand	608.0	---	90.5	96.6	93.6	514.4	90.0	604.4	481660.5	6179485.3	GIC, 2006
100/15-27-084-09W4	15-27-84-9 W4M	Empress Channel Deposits	716.8	717.8	172.5	210.8	191.6	525.2	79.5	604.7	479481.3	6241219.3	Petro Canada, 2001
WSW 9-17	9-17-76-6 W4M	Empress Channel Deposits	563.6	563.9	127.4	139.6	133.5	430.1	130.2	560.3	507059.7	6159816.9	CH2M Gore & Storrie, 1998
OBS 9-17	9-17-76-6 W4M	Empress Channel Deposits	563.6	564.4	121.9	139.0	130.5	433.2	127.0	560.2	507059.7	6159816.9	CH2M Gore & Storrie, 1998
PW04	7-12-71-4 W4M	Empress Channel Deposits	669.2	---	191.7	199.3	195.5	473.7	191.3	665.0	533338.6	6109554.2	CH2M Gore & Storrie, 1999
WSW 11-21	11-21-73-7 W4M	Empress Channel Deposits	728.0	728.6	284.1	293.5	288.8	439.2	213.4	652.6	498614.1	6132303.1	Golder, 2000
278986	14-31-76-7 W4M	Empress Channel Deposits	566.0	---	---	---	131.0	435.0	119.9	554.9	494840.4	6165077.0	GIC, 2006
1420099	15-12-77-9 W4M	Empress Channel Deposits	609.0	---	116.1	120.7	118.5	490.5	94.9	585.4	483852.0	6168342.7	GIC, 2006
WSW 6-19	6-19-77-5 W4M	Empress Channel Deposits	563.0	---	101.8	112.8	107.3	455.7	119.3	575.0	514374.1	6170766.3	MEG, 2005
WR99-1-230	7-36-77-15 W4M	Empress Channel Deposits	663.1	663.8	227.5	230.6	229.1	434.0	159.5	593.5	425426.3	6174704.0	Lemay, 2002

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TABLE 5B-2 REGIONAL HYDRAULIC HEADS: GRAND RAPIDS

UWI	Well Location	Formation	Ground Surface	Casing or KB Elevation	Perforated Interval (m bgs) Top	Perforated Interval (m bgs) Bottom	Mid Point Perforated Interval Depth (m bgs)	Mid Point Perforated Interval Elevation (masl)	Pressure Head (m)	Hydraulic Head (masl)	East_utm27z12	North_utm27z12	Reference
1-23 deviated well	1-23-70-3 W4M	Lower Grand Rapids	729.9	734.4	477	518	498	232	256	489	542339	6102435	Matrix, 2005
1-23 vertical well	1-23-70-3 W4M	Lower Grand Rapids	730.3	733.6	444	516	480	251	235	486	542168	6102332	Matrix, 2005
13-14 observation well	13-14-70-3 W4M	Lower Grand Rapids	736.2	740.8	466	505	486	251	244	495	541141	6101941	Matrix, 2005
1F1/2-26-083-06W4	2-26-83-6 W4M	Lower Grand Rapids	551.5	---	173	188	180	371	75	446	510452	6230236	Matrix, 2003a
1F1/2-21-083-07W4	2-21-83-7 W4M	Lower Grand Rapids	690.6	---	290	305.7	298	393	62	454	497381	6228602	Matrix, 2003b
Obs Site 10d	9-24-85-9 W4M	Lower Grand Rapids	764	---	354	363	359	406	65	470	483164	6248877	Hackbarth and Nastasa, 1979
Obs Site 11b	16-2-87-9 W4M	Lower Grand Rapids	420	---	29	34	32	388	29	418	480897	6263858	Hackbarth and Nastasa, 1979
9-17 test well	9-17-82-12 W4M	Lower Grand Rapids	709	712.16	326	329	328	382	80	462	448071	6218398	Connacher, 2005
105/15-27-084-09 W4M	15-27-84-9 W4M	Lower Grand Rapids	718.8	719.8	308	328	318	401	58	459	479481.3	6241219.3	Petro Canada, 2001
1AA/13-22-078-10W4/0	13-22-78-10 W4M	Lower Grand Rapids	637.2	641.4	280	294	287	350	119	469	470060	6181369	North American, 2006
00/07-32-075-06W4M	7-32-75-6 W4M	Lower Grand Rapids	600	604	na	na	257	347	157	504	506573	6154413	Devon, 2005
00/12-15-075-06W4M	12-15-75-6 W4M	Lower Grand Rapids	629.6	632.6	292	316	304	326	168	493	509113	6150159	Westwater, 2004
03/12-15-075-06W4M	12-15-75-6 W4M	Lower Grand Rapids	629.4	630.8	298	315	306	323	169	493	509163	6150159	Westwater, 2004

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Westwater Environmental, 2004. Grand Rapids Formation Unit C Pumping Test Analysis Source Well 12C and Observation Well 12D2 Kirby, 12-15-75-6 W4M, Prepared for Devon Canada, September 2004, Calgary Alberta.

TABLE 5B-3 REGIONAL HYDRAULIC HEADS: CLEARWATER

UWI	Well Location	Formation	Ground Surface	Casing Elevation	Perforated Interval (m bgs)		Mid Point Perforated Interval		Pressure Head (m)	Hydraulic Head (masl)	East_utm27z12	North_utm27z12	Reference
					Top	Bottom	Depth (m BKb)	Elevation (masl)					
Obs Site 12b	8-27-88-9 W4M		372	---	68	81	74	298	dry	dry	479337.816	6279236.557	Hackbarth and Nastasa, 1979

Reference:

Hackbarth, D.A. and N. Nastasa. 1979. The Hydrogeology of the Athabasca Oil Sands Area, Alberta. Alberta Research Council, Bulletin 38, Edmonton, Alberta.

TABLE 5B-4 REGIONAL HYDRAULIC HEADS: McMURRAY

UWI	Well Location	Formation	Ground Surface	KB/Casing Elevation	Perforated Interval (m bgs)		Mid Point Perforated Interval		Pressure Head (m)	Hydraulic Head (masl)	East_utm27z12	North_utm27z12	Reference
					Top	Bottom	Depth (m bgs)	Elevation (masl)					
Obs Site 10e	9-24-85-9 W4M	Upper McMurray	764	---	460	463	462	302	63	365	483164	6248877	Hackbarth and Nastasa, 1979
Obs Site 10f	9-24-85-9 W4M	Lower McMurray	764	---	515	517	516	248	117	365	483164	6248877	Hackbarth and Nastasa, 1979
Obs Site 11c	16-2-87-9 W4M	Upper McMurray	420	---	128	139	134	287	12	298	480897	6263858	Hackbarth and Nastasa, 1979
Obs Site 11d	16-2-87-9 W4M	Upper McMurray	420	---	177	179	178	242	41	283	480897	6263858	Hackbarth and Nastasa, 1979
Obs Site 12c	8-27-88-9 W4M		372	---	134	139	137	235	22	257	479338	6279237	Hackbarth and Nastasa, 1979
MEG Hardy 10-29	10-29-77-5 W4M	Lower McMurray	574	577	364	397	380	193	191	384	516391	6172789	Westwater Environmental, 2005
1AA/01-28-078-10W4/00	1-28-78-10 W4M	Lower McMurray	639	643	439	449	444	195	241	436	469596	6181780	North American, 2006
102/12-15-075-06W4M	12-15-75-6 W4M	Lower McMurray	627	631	442	485	463	164	285	449	509138	6150135	Devon, 2005

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Westwater Environmental, 2005. Christina Lake Regional Project Hydrogeology Environmental Setting Report. Prepared for MEG Energy Corporation. Calgary, Alberta. February 2005.

TABLE 5B-5 GRAND RAPIDS FORMATION REGIONAL HYDRAULIC HEADS FROM DSTs

UWI	Formation	UTM Coordinates (Zone 12; Nad 27)		KB Elevation (masl)	Perforated Interval (m bKB)		Mid Point Perforated Interval (m bKB)	Recorder Depth (m bKB)	Pressure Head (m)	Freshwater Hydraulic Head (masl)	Hydro-Fax QC	QC Recorder Elevation	
		Easting	Northing		Top	Bottom						Below Perfs (m)	Above Perfs (m)
100/07-05-070-02W4/00	Kgrand_rp	546780.84	6098300.78	665.99	409.50	417.00	413.25	411.51	213.6	466.3	A	0	0
100/07-05-070-02W4/00	Kgrand_rp	546780.84	6098300.78	665.99	382.01	389.51	385.76	383.99	189.0	469.2	B	0	0
100/07-05-070-02W4/00	Kgrand_rp	546780.84	6098300.78	665.99	378.99	383.01	381.00	381.00	186.9	471.9	C	0	0
100/05-30-070-03W4/00	Kgrand_rp	534651.87	6104635.98	671.60	310.99	316.99	313.99	313.00	164.3	521.9	A	0	0
100/07-17-070-03W4/00	Kgrand_rp	537087.80	6101320.29	690.10	323.00	328.00	325.50	324.19	157.5	522.1	A	0	0
100/11-03-070-03W4/00	Kgrand_rp	539824.95	6098252.30	666.20	372.01	378.01	375.01	293.19	248.9	540.1	A	0	79
100/05-30-070-03W4/00	Kgrd_rp_L	534651.87	6104635.98	671.60	399.01	403.01	401.01	401.91	220.4	491.0	B	0	0
100/06-22-070-03W4/00	Kgrd_rp_L	539728.59	6103044.60	709.00	446.99	451.99	449.49	448.00	249.0	508.5	A	0	0
100/07-02-070-03W4/00	Kgrd_rp_L	541868.49	6098266.52	709.79	474.00	477.99	475.99	476.01	269.4	503.2	A	0	0
100/07-02-070-03W4/00	Kgrd_rp_L	541868.49	6098266.52	709.79	469.00	472.99	470.99	471.01	267.4	506.2	A	0	0
100/11-03-070-03W4/00	Kgrd_rp_L	539824.95	6098252.30	666.20	469.00	477.01	473.01	470.00	262.0	455.2	A	0	0
100/05-25-070-04W4/00	Kgrand_rp	533077.28	6104617.34	669.80	309.49	313.00	311.25	311.51	153.7	512.3	A	0	0
100/05-25-070-04W4/00	Kgrand_rp	533077.28	6104617.34	669.80	294.99	298.49	296.74	297.00	154.6	527.6	B	0	0
100/07-16-070-04W4/00	Kgrand_rp	528815.94	6101253.67	680.50	337.99	341.10	339.55	331.20	164.3	505.3	A	0	7
100/07-16-070-04W4/00	Kgrand_rp	528815.94	6101253.67	680.50	321.99	328.00	324.99	315.19	163.2	518.7	A	0	7
100/14-28-070-04W4/00	Kgrand_rp	528453.56	6105186.39	669.19	366.80	373.29	370.04	362.01	227.5	526.6	A	0	5
100/14-28-070-04W4/00	Kgrand_rp	528453.56	6105186.39	669.19	366.80	373.29	370.04	362.01	227.5	526.7	A	0	5
100/05-14-070-04W4/00	Kgrd_rp_L	531188.87	6101277.41	669.10	396.52	401.00	398.76	397.49	244.8	515.1	A	0	0
100/05-25-070-04W4/00	Kgrd_rp_L	533077.28	6104617.34	669.80	398.01	401.51	399.76	399.99	230.9	500.9	B	0	0
100/08-12-070-04W4/00	Kgrd_rp_L	533974.44	6099708.57	677.39	422.30	425.99	424.15	424.01	240.4	493.7	A	0	0
100/08-33-070-04W4/00	Kgrd_rp_L	529160.83	6106242.61	663.70	392.00	396.00	394.00	382.31	249.3	519.0	A	0	10
100/10-06-070-04W4/00	Kgrd_rp_L	525577.17	6098152.49	689.92	414.01	418.00	416.01	414.99	249.3	523.2	A	0	0
100/05-09-070-05W4/00	Kgrand_rp	518350.23	6099699.41	681.69	323.00	326.41	324.70	325.59	163.8	520.8	B	0	0
100/05-19-070-05W4/00	Kgrand_rp	515232.85	6102813.61	670.81	313.00	316.20	314.60	304.71	164.0	520.2	A	0	8
100/06-21-070-05W4/00	Kgrand_rp	518851.96	6102846.35	671.11	316.29	320.01	318.15	318.30	147.1	500.0	A	0	0
100/06-33-070-05W4/00	Kgrand_rp	518668.16	6106178.52	657.30	294.99	300.50	297.74	285.20	166.8	526.4	A	0	10
100/07-14-070-05W4/00	Kgrand_rp	522369.45	6101237.86	680.50	325.01	329.00	327.01	315.19	171.5	525.0	A	0	10
100/07-14-070-05W4/00	Kgrand_rp	522369.45	6101237.86	680.50	310.99	315.01	313.00	301.20	170.3	537.8	A	0	10
100/07-20-070-05W4/00	Kgrand_rp	517426.81	6102830.55	684.10	321.99	326.99	324.49	312.39	175.9	535.5	A	0	10
100/07-26-070-05W4/00	Kgrand_rp	522216.22	6104556.69	663.31	300.02	304.01	302.01	302.00	155.9	517.2	A	0	0
100/06-21-070-05W4/00	Kgrd_rp_L	518851.96	6102846.35	671.11	403.89	407.61	405.75	405.90	227.4	492.7	A	0	0
100/06-21-070-05W4/00	Kgrd_rp_L	518851.96	6102846.35	671.11	339.91	343.60	341.76	341.90	167.9	497.3	B	0	0
100/05-23-070-06W4/00	Kgrand_rp	511928.42	6102812.46	660.50	310.99	316.20	313.59	301.39	177.7	524.6	A	0	10
100/06-01-070-06W4/00	Kgrand_rp	513914.31	6098084.27	681.69	331.01	336.01	333.51	321.99	165.3	513.5	A	0	9
100/07-21-070-06W4/00	Kgrand_rp	509429.84	6102806.48	641.09	292.49	295.41	293.95	281.61	166.5	513.7	A	0	11
100/08-13-070-06W4/00	Kgrand_rp	514555.95	6101261.19	686.20	330.01	335.01	332.51	321.99	164.7	518.4	A	0	8
100/09-12-070-06W4/00	Kgrand_rp	514626.77	6099724.62	678.61	325.01	329.00	327.01	315.19	169.2	520.8	A	0	10
100/10-33-070-06W4/00	Kgrand_rp	509228.48	6106310.34	641.61	289.99	294.10	292.05	280.20	168.6	518.2	A	0	10
100/07-03-070-08W4/00	Kgrand_rp	491518.86	6098012.79	643.50	609.51	312.39	460.95	298.49	329.9	512.4	A	0	311
100/06-16-070-09W4/00	Kgrand_rp	479662.70	6101144.68	604.21	284.50	289.99	287.24	287.61	176.1	493.1	A	0	0
100/06-16-070-09W4/00	Kgrand_rp	479662.70	6101144.68	604.21	268.01	273.01	270.51	263.50	164.6	498.3	A	0	5
100/11-05-070-09W4/00	Kgrand_rp	477927.29	6098334.12	661.81	331.41	348.11	339.76	336.59	173.4	495.4	A	0	0
100/11-35-070-09W4/00	Kgrand_rp	483115.93	6106363.92	619.90	272.00	277.00	274.50	274.90	146.9	492.3	A	0	0
100/13-33-070-09W4/00	Kgrand_rp	479477.30	6106660.74	604.30	261.00	264.99	263.00	262.31	151.9	493.2	A	0	0
100/13-33-070-09W4/00	Kgrand_rp	479477.30	6106660.74	604.30	258.50	262.49	260.50	260.09	151.0	494.8	A	0	0
100/03-12-070-10W4/00	Kgrand_rp	474974.68	6099330.09	629.11	298.00	305.01	301.51	300.02	164.3	491.9	A	0	0
100/04-11-070-10W4/00	Kgrand_rp	472984.15	6099350.58	618.29	288.01	294.99	291.50	292.49	178.8	505.6	A	0	0

TABLE 5B-5 GRAND RAPIDS FORMATION REGIONAL HYDRAULIC HEADS FROM DSTs

UWI	Formation	UTM Coordinates (Zone 12; Nad 27)		KB Elevation (masl)	Perforated Interval (m bKB)		Mid Point Perforated Interval (m bKB)	Recorder Depth (m bKB)	Pressure Head (m)	Freshwater Hydraulic Head (masl)	Hydro-Fax QC	QC Recorder Elevation	
		Easting	Northing		Top	Bottom						Below Perfs (m)	Above Perfs (m)
100/06-28-070-10W4/00	Kgrand_rp	470120.57	6104509.08	634.02	295.99	300.02	298.00	298.49	160.2	496.3	A	0	0
100/07-17-070-10W4/00	Kgrand_rp	468624.07	6101201.93	646.21	310.01	316.99	313.50	313.00	69.5	402.2	A	0	0
100/07-20-070-10W4/00	Kgrand_rp	468816.76	6102814.22	653.49	313.00	316.99	315.00	314.19	122.1	460.6	A	0	0
100/07-30-070-10W4/00	Kgrand_rp	467316.69	6104548.78	652.70	317.69	321.41	319.55	319.00	162.8	496.0	A	0	0
100/09-21-070-10W4/00	Kgrand_rp	470703.61	6103380.12	651.30	317.51	321.99	319.75	320.01	163.2	494.8	A	0	0
100/11-01-070-10W4/00	Kgrand_rp	474668.39	6098283.52	647.21	318.00	323.00	320.50	320.01	172.2	498.9	A	0	0
100/13-18-070-10W4/00	Kgrand_rp	466492.02	6101918.53	635.81	306.29	310.01	308.15	307.79	165.8	493.5	A	0	0
100/14-20-070-10W4/00	Kgrand_rp	471595.16	6103416.64	643.31	310.01	314.49	312.25	304.50	173.5	504.5	A	0	6
100/14-22-070-10W4/00	Kgrand_rp	471595.16	6103416.64	648.80	310.01	318.00	314.01	315.50	157.7	492.5	A	0	0
100/14-22-070-10W4/00	Kgrand_rp	471595.16	6103416.64	648.80	314.01	319.00	316.51	316.69	163.3	495.6	A	0	0
100/05-25-070-11W4/00	Kgrand_rp	464882.53	6104601.78	631.52	295.29	299.01	297.15	297.61	90.1	424.5	C	0	0
100/07-35-070-11W4/00	Kgrand_rp	463817.95	6106035.89	625.39	293.49	297.00	295.25	295.50	181.2	511.4	A	0	0
100/07-35-070-11W4/00	Kgrand_rp	463817.95	6106035.89	625.39	311.99	315.50	313.75	314.01	200.0	511.6	C	0	0
100/08-34-070-11W4/00	Kgrand_rp	462758.51	6106016.79	626.40	321.90	327.69	324.80	322.51	189.9	491.5	C	0	0
100/08-34-070-11W4/00	Kgrand_rp	462758.51	6106016.79	626.40	292.61	299.89	296.25	293.19	172.7	502.8	B	0	0
100/10-19-070-11W4/00	Kgrand_rp	457575.92	6103167.35	616.61	288.01	292.40	290.20	290.90	148.8	475.2	C	0	0
100/10-19-070-11W4/00	Kgrand_rp	457575.92	6103167.35	616.61	288.01	292.40	290.20	277.19	176.0	502.4	B	0	11
100/14-14-070-11W4/00	Kgrand_rp	463508.76	6101936.35	632.19	305.01	313.00	309.01	311.29	177.1	500.3	B	0	0
100/07-08-070-12W4/00	Kgrand_rp	449434.54	6099925.68	595.00	280.39	284.10	282.25	283.50	185.7	498.5	A	0	0
100/05-22-070-13W4/00	Kgrand_rp	442123.35	6103250.90	584.79	273.50	277.49	275.49	275.51	182.9	492.2	A	0	0
100/09-14-070-13W4/00	Kgrand_rp	444836.07	6101904.37	590.89	273.01	281.00	277.00	275.91	174.9	488.8	A	0	0
100/11-21-070-14W4/00	Kgrand_rp	430966.04	6103798.02	626.09	330.01	334.00	332.00	333.00	195.0	489.1	C	0	0
100/06-16-070-15W4/00	Kgrand_rp	421082.46	6101675.68	568.91	305.01	326.99	316.00	307.00	239.7	492.6	A	0	0
100/06-16-070-15W4/00	Kgrand_rp	421082.46	6101675.68	568.91	284.99	294.01	289.50	287.00	219.0	498.5	D	0	0
100/06-30-070-15W4/00	Kgrand_rp	418013.25	6104960.08	576.41	282.22	288.31	285.26	299.31	190.0	481.1	A	-11	0
100/07-17-070-15W4/00	Kgrand_rp	420055.38	6101801.92	572.29	294.99	305.01	300.00	303.31	219.2	491.5	A	0	0
100/10-05-070-15W4/00	Kgrand_rp	420185.39	6098922.29	596.59	303.00	315.01	309.01	304.01	205.0	492.6	A	0	0
100/05-11-070-16W4/00	Kgrand_rp	414497.91	6100438.94	561.20	274.99	282.00	278.50	277.89	205.9	488.6	B	0	0
100/05-11-070-16W4/00	Kgrand_rp	414497.91	6100438.94	561.20	284.50	288.01	286.25	286.51	219.5	494.5	B	0	0
100/07-27-070-16W4/00	Kgrand_rp	413668.94	6104997.54	579.70	290.81	294.10	292.46	288.62	216.0	503.2	B	0	2
100/07-35-070-16W4/00	Kgrand_rp	415327.09	6106775.68	590.09	301.51	307.51	304.51	304.01	213.3	498.9	A	0	0
100/07-35-070-16W4/00	Kgrand_rp	415327.09	6106775.68	590.09	298.00	300.99	299.50	292.79	219.7	510.3	A	0	5
100/11-23-070-16W4/00	Kgrand_rp	414758.60	6103813.37	568.61	271.00	282.49	276.74	264.99	218.0	509.8	A	0	6
100/12-01-070-16W4/00	Kgrand_rp	416137.57	6098850.62	563.52	279.01	285.99	282.50	281.00	189.8	470.8	A	0	0
100/02-24-070-17W4/00	Kgrand_rp	406914.10	6103387.98	580.31	295.99	300.02	298.00	301.81	208.4	490.8	A	-2	0
100/02-24-070-17W4/00	Kgrand_rp	406914.10	6103387.98	580.31	299.01	301.51	300.26	293.80	210.9	491.0	A	0	5
100/05-18-070-17W4/00	Kgrand_rp	398249.57	6102177.82	555.19	308.00	311.99	310.00	310.01	238.3	483.5	B	0	0
100/06-06-070-17W4/00	Kgrand_rp	398623.56	6098889.71	560.80	296.30	309.10	302.70	307.51	248.1	506.2	D	0	0
100/07-14-070-17W4/00	Kgrand_rp	405289.21	6102224.38	581.01	303.00	308.00	305.50	291.39	217.2	492.7	A	0	12
100/07-35-070-17W4/00	Kgrand_rp	405731.89	6106841.42	573.70	289.99	293.01	291.50	290.99	197.9	480.1	A	0	0
100/11-31-070-17W4/00	Kgrand_rp	398558.84	6107623.46	569.40	310.29	320.01	315.15	312.70	231.9	486.1	B	0	0
100/07-29-070-17W4/00	Kgrd_rp_L	400746.19	6105420.09	552.21	341.99	346.19	344.09	342.99	268.0	476.1	A	0	0
100/07-24-071-04W4/00	Kgrand_rp	533564.93	6112743.85	674.80	315.01	332.20	323.61	318.00	160.4	511.6	A	0	0
100/08-08-071-04W4/00	Kgrand_rp	527108.62	6109520.36	663.49	290.99	294.99	292.99	293.89	156.1	526.6	A	0	0
100/08-08-071-04W4/00	Kgrand_rp	527108.62	6109520.36	663.49	350.00	309.01	329.51	307.91	201.4	535.4	F	0	42
100/06-02-071-04W4/00	Kwaseca	531546.36	6107807.96	668.92	324.00	328.00	326.00	326.02	167.0	509.9	B	0	0
100/06-20-071-05W4/00	Kgrand_rp	516775.37	6112688.89	681.29	320.99	325.01	323.00	323.00	163.7	522.0	A	0	0

TABLE 5B-5 GRAND RAPIDS FORMATION REGIONAL HYDRAULIC HEADS FROM DSTs

UWI	Formation	UTM Coordinates (Zone 12; Nad 27)		KB Elevation (masl)	Perforated Interval (m bKB)		Mid Point Perforated Interval (m bKB)	Recorder Depth (m bKB)	Pressure Head (m)	Freshwater Hydraulic Head (masl)	Hydro-Fax QC	QC Recorder Elevation	
		Easting	Northing		Top	Bottom						Below Perfs (m)	Above Perfs (m)
100/05-28-071-06W4/00	Kgrand_rp	507984.69	6114273.58	671.90	317.51	320.50	319.00	318.00	154.6	507.5	A	0	0
100/09-14-071-06W4/00	Kgrand_rp	512660.91	6111087.25	676.11	321.99	326.02	324.00	324.00	150.7	502.8	C	0	0
100/10-23-071-07W4/00	Kgrand_rp	502394.77	6112975.06	665.41	309.01	314.01	311.51	310.99	149.5	503.4	A	0	0
100/10-28-071-07W4/00	Kgrand_rp	499071.47	6114553.62	660.81	303.00	313.00	308.00	293.71	165.4	518.2	A	0	9
100/10-30-071-07W4/00	Kgrand_rp	495833.74	6114563.26	664.89	308.00	319.00	313.50	311.20	159.7	511.1	A	0	0
100/11-13-071-07W4/00	Kgrand_rp	503378.34	6111388.79	658.00	300.99	306.51	303.75	301.81	154.1	508.4	A	0	0
100/11-13-071-07W4/00	Kgrand_rp	503378.34	6111388.79	658.00	304.01	308.00	306.00	301.81	161.6	513.6	C	0	2
100/11-17-071-07W4/00	Kgrand_rp	496859.36	6111369.70	662.70	308.00	316.99	312.50	309.01	156.3	506.5	A	0	0
100/06-27-071-08W4/00	Kgrand_rp	490347.43	6114044.31	656.51	307.00	315.01	311.00	308.00	150.7	496.2	A	0	0
100/10-13-071-08W4/00	Kgrand_rp	494254.06	6111373.42	666.51	313.00	319.00	316.00	314.49	151.6	502.1	A	0	0
100/10-15-071-08W4/00	Kgrand_rp	491011.46	6111381.01	668.61	315.99	321.99	318.99	317.60	169.9	519.5	A	0	0
100/11-26-071-08W4/00	Kgrand_rp	492004.39	6114575.18	660.90	300.02	309.01	304.51	301.51	149.9	506.3	A	0	0
100/14-06-071-08W4/00	Kgrand_rp	485724.97	6108396.85	656.91	305.50	310.71	308.11	298.49	164.7	513.5	A	0	7
100/06-30-071-09W4/00	Kgrand_rp	475790.18	6114256.66	681.81	333.00	341.99	337.49	339.61	163.0	507.4	A	0	0
100/06-30-071-09W4/00	Kgrand_rp	475790.18	6114256.66	681.81	354.00	366.00	360.00	355.21	191.4	513.2	A	0	0
100/06-36-071-09W4/00	Kgrand_rp	483826.91	6115718.05	682.91	335.01	342.99	339.00	336.01	161.1	505.0	A	0	0
100/06-36-071-09W4/00	Kgrand_rp	483826.91	6115718.05	682.91	325.50	333.51	329.51	326.50	152.8	506.2	A	0	0
100/06-36-071-09W4/00	Kgrand_rp	483826.91	6115718.05	682.91	346.01	354.00	350.00	347.02	189.2	522.1	A	0	0
100/08-03-071-09W4/00	Kgrand_rp	481313.18	6107663.12	607.80	260.00	263.50	261.75	262.89	135.9	482.0	A	0	0
100/10-06-071-09W4/00	Kgrand_rp	476140.29	6108039.48	604.82	263.01	269.99	266.50	266.00	134.6	472.9	A	0	0
100/10-08-071-09W4/00	Kgrand_rp	477873.08	6109555.14	670.29	382.19	392.00	387.10	388.01	211.8	495.0	A	0	0
100/10-08-071-09W4/00	Kgrand_rp	477873.08	6109555.14	670.29	316.99	331.59	324.29	320.01	153.2	499.2	A	0	0
100/11-17-071-09W4/00	Kgrand_rp	477330.10	6111479.76	675.32	326.02	330.01	328.01	320.50	119.8	467.1	A	0	6
100/11-27-071-09W4/00	Kgrand_rp	480630.45	6114636.90	660.29	308.00	315.01	311.51	311.20	158.7	507.4	A	0	0
100/11-28-071-09W4/00	Kgrand_rp	479075.70	6124444.93	665.29	333.00	336.01	334.50	334.49	173.6	504.4	B	0	0
100/11-28-071-09W4/00	Kgrand_rp	479039.45	6114471.63	665.29	320.01	323.00	321.50	321.50	169.1	512.9	A	0	0
100/11-28-071-09W4/00	Kgrand_rp	479075.70	6124444.93	665.29	311.99	316.99	314.49	315.50	162.5	513.3	A	0	0
100/13-31-071-09W4/00	Kgrand_rp	475475.95	6116407.32	677.91	335.01	339.00	337.00	336.59	153.3	494.3	A	0	0
100/03-23-071-10W4/00	Kgrand_rp	472571.70	6112273.31	680.32	336.99	344.00	340.49	337.99	109.3	449.2	A	0	0
100/05-12-071-10W4/00	Kgrand_rp	473877.16	6109202.87	669.31	327.51	332.51	330.01	330.59	160.5	499.8	A	0	0
100/05-13-071-10W4/00	Kgrand_rp	473865.40	6110784.31	681.50	343.51	347.50	345.51	337.99	168.0	504.0	A	0	6
100/06-04-071-10W4/00	Kgrand_rp	469182.30	6107655.96	660.02	321.99	326.02	324.00	323.61	157.8	493.8	A	0	0
100/06-08-071-10W4/00	Kgrand_rp	467552.97	6109381.35	649.59	320.99	326.50	323.74	323.00	146.4	472.3	B	0	0
100/06-08-071-10W4/00	Kgrand_rp	467552.97	6109381.35	649.59	315.50	320.99	318.24	317.51	144.0	475.4	B	0	0
100/06-15-071-10W4/00	Kgrand_rp	471025.05	6110977.73	670.99	329.00	336.99	333.00	329.00	126.5	464.5	A	0	0
100/06-19-071-10W4/00	Kgrand_rp	466118.73	6112535.91	652.00	357.01	363.99	360.50	359.70	203.9	495.4	A	0	0
100/06-19-071-10W4/00	Kgrand_rp	466118.73	6112535.91	652.00	313.00	320.01	316.51	317.30	162.8	498.3	A	0	0
100/06-22-071-10W4/00	Kgrand_rp	470935.60	6112506.28	675.80	365.00	372.50	368.75	369.81	197.4	504.5	A	0	0
100/06-22-071-10W4/00	Kgrand_rp	470935.60	6112506.28	675.80	336.01	339.00	337.51	337.51	212.0	550.3	A	0	0
100/06-33-071-10W4/00	Kgrand_rp	469081.47	6115810.66	668.40	324.00	331.01	327.51	325.01	152.2	493.1	A	0	0
100/07-08-071-10W4/00	Kgrand_rp	468136.02	6109327.06	658.89	318.00	323.00	320.50	321.29	162.1	500.5	A	0	0
100/07-10-071-10W4/00	Kgrand_rp	471103.56	6109325.73	671.99	334.00	340.01	337.00	338.51	184.9	519.9	A	0	0
100/10-18-071-10W4/00	Kgrand_rp	466342.69	6111397.96	653.80	315.80	326.11	320.96	317.30	164.1	497.0	A	0	0
100/11-05-071-10W4/00	Kgrand_rp	467635.71	6108043.08	655.20	327.51	331.99	329.75	330.50	168.8	494.2	A	0	0
100/16-34-071-10W4/00	Kgrand_rp	471560.30	6116429.56	662.00	321.99	331.99	326.99	315.41	172.7	507.7	D	0	7
100/06-03-071-11W4/00	Kgrand_rp	460933.37	6107971.06	642.00	314.49	320.01	317.25	317.91	183.6	508.4	A	0	0
100/06-05-071-11W4/00	Kgrand_rp	457742.90	6107914.49	607.50	269.69	275.69	272.69	272.61	172.9	507.7	A	0	0

TABLE 5B-5 GRAND RAPIDS FORMATION REGIONAL HYDRAULIC HEADS FROM DSTs

UWI	Formation	UTM Coordinates (Zone 12; Nad 27)		KB Elevation (masl)	Perforated Interval (m bKB)		Mid Point Perforated Interval (m bKB)	Recorder Depth (m bKB)	Pressure Head (m)	Freshwater Hydraulic Head (masl)	Hydro-Fax QC	QC Recorder Elevation	
		Easting	Northing		Top	Bottom						Below Perfs (m)	Above Perfs (m)
100/07-12-071-11W4/00	Kgrand_rp	464811.95	6109322.04	649.20	306.29	316.99	311.64	307.21	169.7	507.3	A	0	0
100/08-11-071-11W4/00	Kgrand_rp	463284.17	6109325.47	646.30	341.01	346.50	343.75	341.99	196.9	499.5	A	0	0
100/09-02-071-11W4/00	Kgrand_rp	463347.56	6108117.47	646.39	315.01	318.49	316.75	316.99	149.1	478.7	A	0	0
100/09-02-071-11W4/00	Kgrand_rp	463347.56	6108117.47	646.39	315.01	320.99	318.00	316.99	155.0	483.4	A	0	0
100/09-21-071-11W4/00	Kgrand_rp	460127.21	6113246.65	609.11	273.50	279.50	276.50	274.99	168.9	501.5	A	0	0
100/10-01-071-11W4/00	Kgrand_rp	464603.77	6108080.61	646.00	367.99	399.99	383.99	371.31	231.7	493.7	A	0	0
100/10-01-071-11W4/00	Kgrand_rp	464603.77	6108080.61	646.00	315.99	325.01	320.50	321.99	171.0	496.5	A	0	0
100/10-36-071-11W4/00	Kgrand_rp	464805.18	6116196.38	651.51	307.39	313.21	310.30	309.40	151.9	493.1	A	0	0
100/11-09-071-11W4/00	Kgrand_rp	459585.76	6109678.02	616.40	274.99	282.00	278.50	277.00	170.0	507.9	A	0	0
100/14-04-071-11W4/00	Kgrand_rp	459527.81	6108422.09	617.71	279.01	288.01	283.51	279.99	168.0	502.2	A	0	0
100/14-11-071-11W4/00	Kgrand_rp	462787.52	6110098.60	659.10	323.00	329.00	326.00	313.49	172.1	505.2	A	0	10
100/15-06-071-11W4/00	Kgrand_rp	456620.75	6108620.84	606.80	269.50	273.50	271.50	271.79	142.2	477.5	B	0	0
100/06-34-071-12W4/00	Kgrand_rp	451190.29	6115905.53	625.79	297.49	313.91	305.70	298.10	171.1	491.2	A	0	0
100/10-12-071-12W4/00	Kgrand_rp	455073.02	6109711.26	588.30	254.51	259.51	257.01	256.79	103.9	435.2	A	0	0
100/10-14-071-12W4/00	Kgrand_rp	453362.31	6111661.99	618.99	289.01	292.61	290.81	291.39	165.4	493.6	A	0	0
100/10-20-071-12W4/00	Kgrand_rp	448588.40	6113308.33	596.19	270.39	277.40	273.89	276.09	166.3	488.6	A	0	0
100/11-25-071-12W4/00	Kgrand_rp	454339.89	6114753.56	602.71	268.99	274.99	271.99	267.49	154.1	484.8	A	0	1
100/13-15-071-12W4/00	Kgrand_rp	451000.57	6111746.36	601.40	272.00	277.00	274.50	274.02	179.7	506.6	A	0	0
100/07-26-071-14W4/00	Kgrand_rp	433679.47	6114598.68	648.89	326.72	331.59	329.15	329.49	177.8	497.6	A	0	0
100/06-03-071-15W4/00	Kgrand_rp	421719.46	6108403.01	594.00	291.51	295.50	293.51	294.41	186.3	486.8	A	0	0
100/07-12-071-15W4/00	Kgrand_rp	425467.63	6110049.48	622.01	315.01	321.50	318.26	319.19	192.8	496.6	A	0	0
100/10-09-071-16W4/00	Kgrand_rp	410931.78	6110337.74	593.51	290.99	294.01	292.50	280.69	202.7	503.7	A	0	10
100/07-20-072-01W4/00	Kgrand_rp	556198.51	6122656.24	696.01	377.50	381.49	379.49	378.99	212.7	529.2	B	0	0
100/10-32-072-03W4/00	Kgrand_rp	536599.02	6125787.59	698.51	365.00	378.01	371.51	366.00	201.8	528.8	A	0	0
100/06-03-072-04W4/00	Kgrand_rp	529764.54	6117563.35	679.49	300.99	305.01	303.00	302.00	149.4	525.9	A	0	0
100/07-28-072-04W4/00	Kgrand_rp	528278.85	6124080.68	701.01	341.01	344.61	342.81	341.99	161.1	519.3	A	0	0
100/08-18-072-05W4/00	Kgrand_rp	515716.10	6120706.44	707.99	341.01	344.00	342.50	342.99	150.5	516.0	A	0	0
100/11-06-072-05W4/00	Kgrand_rp	514745.12	6117594.91	673.00	310.01	313.49	311.75	311.51	138.7	500.0	A	0	0
100/11-30-072-05W4/00	Kgrand_rp	514999.44	6124062.57	715.49	341.41	344.61	343.01	342.60	140.8	513.2	B	0	0
100/12-04-072-05W4/00	Kgrand_rp	517841.32	6117597.37	682.11	317.51	320.50	319.00	319.49	141.1	504.2	A	0	0
100/03-18-072-06W4/00	Kgrand_rp	505343.85	6120331.27	688.51	320.99	324.49	322.74	322.51	142.6	508.3	A	0	0
100/10-22-072-06W4/00	Kgrand_rp	510540.14	6122480.59	710.00	340.80	344.79	342.79	341.80	129.3	496.5	D	0	0
100/12-28-072-06W4/00	Kgrand_rp	507890.23	6124048.65	717.59	349.00	352.99	350.99	351.01	141.3	507.9	A	0	0
100/10-01-072-07W4/00	Kgrand_rp	504040.36	6117841.57	667.39	305.01	315.99	310.50	305.99	153.6	510.5	A	0	0
100/10-08-072-07W4/00	Kgrand_rp	497424.17	6119331.69	674.49	319.00	324.00	321.50	319.80	155.2	508.2	A	0	0
100/10-16-072-07W4/00	Kgrand_rp	499166.96	6121122.70	702.20	341.50	351.01	346.25	342.50	156.5	512.4	A	0	0
100/10-17-072-07W4/00	Kgrand_rp	497486.26	6121128.90	693.21	330.01	336.99	333.50	331.01	148.0	507.8	A	0	0
100/10-25-072-07W4/00	Kgrand_rp	504000.82	6124283.81	722.32	352.01	358.99	355.50	354.00	149.9	516.7	A	0	0
100/10-36-072-07W4/00	Kgrand_rp	503935.25	6125846.20	742.19	388.01	394.99	391.50	388.80	156.8	507.5	G	0	0
100/10-36-072-07W4/00	Kgrand_rp	503935.25	6125846.20	742.19	370.00	377.01	373.50	370.79	149.6	518.3	A	0	0
100/11-30-072-07W4/00	Kgrand_rp	495272.26	6124324.59	684.31	318.00	333.00	325.50	319.49	156.8	515.6	A	0	0
100/11-31-072-07W4/00	Kgrand_rp	495274.56	6125882.58	686.02	316.99	323.00	320.00	317.82	160.0	526.1	C	0	0
100/10-01-072-08W4/00	Kgrand_rp	494303.82	6117874.55	680.01	320.01	330.01	325.01	320.99	156.5	511.5	A	0	0
100/10-05-072-08W4/00	Kgrand_rp	487741.54	6117887.82	667.30	310.01	316.99	313.50	311.60	161.2	515.0	A	0	0
100/10-15-072-08W4/00	Kgrand_rp	490935.82	6121153.03	687.11	323.00	326.02	324.51	325.01	149.8	512.4	B	0	0
100/10-15-072-08W4/00	Kgrand_rp	490935.82	6121153.03	687.11	326.99	330.01	328.50	328.00	154.7	513.3	A	0	0
100/10-17-072-08W4/00	Kgrand_rp	487652.01	6121158.73	667.00	330.01	344.00	337.00	331.50	172.8	502.8	A	0	0

TABLE 5B-5 GRAND RAPIDS FORMATION REGIONAL HYDRAULIC HEADS FROM DSTs

UWI	Formation	UTM Coordinates (Zone 12; Nad 27)		KB Elevation (masl)	Perforated Interval (m bKB)		Mid Point Perforated Interval (m bKB)	Recorder Depth (m bKB)	Pressure Head (m)	Freshwater Hydraulic Head (masl)	Hydro-Fax QC	QC Recorder Elevation	
		Easting	Northing		Top	Bottom						Below Perfs (m)	Above Perfs (m)
100/10-17-072-08W4/00	Kgrand_rp	487652.01	6121158.73	667.00	311.99	326.02	319.00	313.49	156.6	504.5	A	0	0
100/10-19-072-08W4/00	Kgrand_rp	486092.62	6122735.81	677.91	320.99	324.00	322.49	321.90	161.8	517.2	A	0	0
100/11-25-072-08W4/00	Kgrand_rp	493625.19	6124332.22	685.10	320.01	330.01	325.01	320.99	168.2	528.3	A	0	0
100/11-26-072-08W4/00	Kgrand_rp	492000.36	6124342.64	683.30	320.01	331.99	326.00	320.99	168.4	525.7	D	0	0
100/02-06-072-09W4/00	Kgrand_rp	476362.29	6117159.27	681.02	337.99	341.41	339.70	340.01	131.8	473.1	A	0	0
100/03-04-072-09W4/00	Kgrand_rp	479042.36	6117114.65	670.01	323.00	326.99	324.99	324.00	163.6	508.6	A	0	0
100/03-04-072-09W4/00	Kgrand_rp	479042.36	6117114.65	670.01	315.99	320.01	318.00	316.99	157.3	509.3	B	0	0
100/03-19-072-09W4/00	Kgrand_rp	475892.65	6121861.43	663.31	310.01	315.50	312.76	313.09	151.8	502.3	C	0	0
100/03-19-072-09W4/00	Kgrand_rp	475892.65	6121861.43	663.31	330.01	336.01	333.01	333.70	172.9	503.2	A	0	0
100/03-19-072-09W4/00	Kgrand_rp	475892.65	6121861.43	663.31	319.00	323.00	321.00	320.32	161.0	503.3	A	0	0
100/06-09-072-09W4/00	Kgrand_rp	479054.37	6118849.54	681.50	339.00	349.00	344.00	346.59	174.5	512.0	C	0	0
100/06-09-072-09W4/00	Kgrand_rp	479054.37	6118849.54	681.50	325.01	331.99	328.50	329.61	159.8	512.8	A	0	0
100/06-11-072-09W4/00	Kgrand_rp	482222.29	6118860.20	679.89	328.00	334.00	331.00	328.91	149.3	498.2	A	0	0
100/06-30-072-09W4/00	Kgrand_rp	475885.86	6124000.41	665.99	313.00	325.01	319.00	314.89	163.5	510.5	A	0	0
100/07-17-072-09W4/00	Kgrand_rp	478027.58	6120543.83	668.70	318.79	324.89	321.84	310.90	171.8	518.7	A	0	8
100/07-17-072-09W4/00	Kgrand_rp	478027.58	6120543.83	668.70	309.10	316.41	312.76	301.11	169.2	525.2	B	0	8
100/10-08-072-09W4/00	Kgrand_rp	477929.60	6119514.92	674.19	316.99	324.61	320.80	320.01	159.5	512.9	A	0	0
100/10-15-072-09W4/00	Kgrand_rp	481177.82	6121165.90	685.59	325.01	333.00	329.00	326.99	158.8	515.4	A	0	0
100/10-25-072-09W4/00	Kgrand_rp	484422.76	6124386.18	685.50	323.00	326.99	324.99	325.01	148.0	508.5	A	0	0
100/11-01-072-09W4/00	Kgrand_rp	483874.48	6117945.81	660.72	310.01	318.00	314.01	310.90	164.2	510.9	A	0	0
100/11-01-072-09W4/00	Kgrand_rp	483874.48	6117945.81	660.72	333.00	341.01	337.00	333.91	188.6	512.4	A	0	0
100/11-28-072-09W4/00	Kgrand_rp	479075.70	6124444.93	668.22	334.00	350.49	342.25	338.69	176.7	502.6	A	0	0
100/11-28-072-09W4/00	Kgrand_rp	479075.70	6124444.93	668.22	310.50	313.00	311.75	311.11	156.8	513.3	C	0	0
100/11-28-072-09W4/00	Kgrand_rp	479075.70	6124444.93	668.22	310.50	318.00	314.25	315.59	162.5	516.5	A	0	0
100/11-32-072-09W4/00	Kgrand_rp	477435.69	6125957.59	663.61	331.01	336.01	333.51	333.00	181.0	511.1	A	0	0
100/03-13-072-10W4/00	Kgrand_rp	474196.42	6120357.47	668.09	320.99	326.50	323.74	324.40	144.7	489.0	A	0	0
100/04-16-072-10W4/00	Kgrand_rp	469049.07	6120477.20	657.09	315.99	319.00	317.50	317.51	157.0	496.6	A	0	0
100/06-24-072-10W4/00	Kgrand_rp	474073.42	6122164.38	673.09	345.00	366.00	355.50	354.79	200.3	517.9	A	0	0
100/06-28-072-10W4/00	Kgrand_rp	469118.73	6123809.82	663.00	313.00	315.99	314.49	314.49	159.3	507.8	A	0	0
100/06-32-072-10W4/00	Kgrand_rp	467601.66	6125550.09	665.59	315.01	320.01	317.51	310.01	131.8	479.9	A	0	5
100/07-35-072-10W4/00	Kgrand_rp	473027.22	6125450.29	672.39	344.00	352.01	348.01	349.21	225.5	549.8	B	0	0
100/09-21-072-10W4/00	Kgrand_rp	469986.53	6122722.13	665.59	315.99	320.99	318.49	317.51	160.7	507.8	A	0	0
100/11-09-072-10W4/00	Kgrand_rp	469157.88	6119568.33	661.39	309.40	324.89	317.15	310.90	148.6	492.9	A	0	0
100/11-10-072-10W4/00	Kgrand_rp	470804.82	6119553.85	666.81	358.11	376.40	367.25	360.91	184.1	483.6	A	0	0
100/14-01-072-10W4/00	Kgrand_rp	474195.58	6118133.96	668.09	318.00	321.50	319.75	320.01	154.4	502.7	A	0	0
100/07-13-072-11W4/00	Kgrand_rp	464828.22	6120790.22	653.89	310.01	315.99	313.00	302.00	162.2	503.1	A	0	8
100/07-24-072-11W4/00	Kgrand_rp	464835.51	6122190.19	658.31	326.02	331.99	329.00	327.51	163.9	493.2	A	0	0
100/07-24-072-11W4/00	Kgrand_rp	464835.51	6122190.19	658.31	309.01	319.00	314.01	310.01	213.2	557.5	D	0	0
100/08-01-072-12W4/00	Kgrand_rp	455400.17	6117717.63	628.90	299.01	307.00	303.00	300.02	155.0	480.9	B	0	0
100/11-03-072-12W4/00	Kgrand_rp	451200.49	6118107.93	624.20	352.99	364.21	358.60	355.40	236.1	501.7	A	0	0
100/06-27-072-13W4/00	Kgrand_rp	441574.78	6124146.39	660.81	333.00	336.99	334.99	336.01	161.9	487.7	A	0	0
100/06-27-072-13W4/00	Kgrand_rp	441574.78	6124146.39	660.81	323.52	327.51	325.51	326.02	153.0	488.3	A	0	0
100/06-30-072-13W4/00	Kgrand_rp	436866.14	6124105.25	652.70	318.49	325.50	321.99	319.61	160.9	491.6	A	0	0
100/08-29-072-13W4/00	Kgrand_rp	439330.96	6124093.07	655.50	324.49	330.50	327.49	326.81	155.9	484.0	B	0	0
100/10-17-072-13W4/00	Kgrand_rp	438772.24	6121515.24	645.90	321.29	333.51	327.40	331.59	167.7	486.2	A	0	0
100/10-20-072-13W4/00	Kgrand_rp	438701.56	6122842.92	647.92	311.99	329.49	320.74	314.01	152.0	479.2	A	0	0
100/10-32-072-13W4/00	Kgrand_rp	438755.33	6126316.99	659.89	279.81	331.01	305.41	283.50	268.5	623.0	A	0	0

TABLE 5B-5 GRAND RAPIDS FORMATION REGIONAL HYDRAULIC HEADS FROM DSTs

UWI	Formation	UTM Coordinates (Zone 12; Nad 27)		KB Elevation (masl)	Perforated Interval (m bKB)		Mid Point Perforated Interval (m bKB)	Recorder Depth (m bKB)	Pressure Head (m)	Freshwater Hydraulic Head (masl)	Hydro-Fax QC	QC Recorder Elevation	
		Easting	Northing		Top	Bottom						Below Perfs (m)	Above Perfs (m)
100/07-27-072-16W4/00	Kgrand_rp	412774.30	6124569.71	586.41	271.30	278.89	275.10	275.81	176.0	487.3	C	0	0
100/11-30-072-17W4/00	Kgrand_rp	397499.60	6125578.14	585.19	292.00	309.71	300.85	298.70	188.3	472.6	A	0	0
100/09-12-073-01W4/00	Kgrand_rp	563123.02	6129542.21	669.50	363.99	372.01	368.00	365.00	233.7	535.2	C	0	0
100/07-06-073-04W4/00	Kgrand_rp	525097.05	6127294.44	719.21	354.30	357.50	355.90	355.49	155.4	518.7	A	0	0
100/10-16-073-04W4/00	Kgrand_rp	528288.28	6130851.57	704.70	340.01	360.00	350.00	341.01	168.4	523.1	D	0	0
100/10-19-073-05W4/00	Kgrand_rp	515344.05	6132435.86	665.72	283.50	289.59	286.54	284.99	140.9	520.0	C	0	0
100/11-16-073-05W4/00	Kgrand_rp	518168.32	6130798.40	687.81	297.00	300.02	298.51	298.49	124.7	514.0	D	0	0
100/12-04-073-05W4/00	Kgrand_rp	517935.06	6127291.89	691.20	326.81	330.01	328.41	328.30	151.1	513.9	B	0	0
100/08-02-073-06W4/00	Kgrand_rp	512536.13	6127254.39	707.02	325.80	329.49	327.65	326.99	139.3	518.7	A	0	0
100/09-26-073-06W4/00	Kgrand_rp	512274.35	6133935.32	666.20	282.00	293.01	287.50	283.01	149.1	527.8	C	0	0
100/11-32-073-06W4/00	Kgrand_rp	506607.69	6135596.96	650.69	281.00	285.99	283.50	283.10	138.4	505.6	A	0	0
100/11-34-073-06W4/00	Kgrand_rp	509887.01	6135657.62	646.21	258.50	267.62	263.06	261.49	137.6	520.8	A	0	0
100/05-25-073-07W4/00	Kgrand_rp	503249.23	6133586.71	675.41	316.99	325.01	321.00	323.21	148.3	502.7	A	0	0
100/06-31-073-07W4/00	Kgrand_rp	495369.31	6135064.72	733.29	367.32	378.01	372.66	368.81	158.0	518.6	C	0	0
100/07-34-073-07W4/00	Kgrand_rp	500588.88	6135224.81	708.69	326.11	335.31	330.71	328.00	154.8	532.8	C	0	0
100/10-15-073-07W4/00	Kgrand_rp	500704.95	6130793.39	734.20	356.01	361.01	358.51	357.50	137.9	513.6	A	0	0
100/10-20-073-07W4/00	Kgrand_rp	497595.41	6132404.30	728.50	347.99	355.00	351.50	348.69	151.0	528.0	A	0	0
100/11-21-073-07W4/00	Kgrand_rp	498515.12	6132368.29	733.81	355.00	361.01	358.00	355.79	150.2	526.0	A	0	0
100/05-26-073-08W4/00	Kgrand_rp	491842.74	6133618.64	713.81	335.01	339.00	337.00	336.99	142.8	519.6	A	0	0
100/10-04-073-08W4/00	Kgrand_rp	489252.73	6127504.53	696.01	331.01	336.99	334.00	331.81	169.0	531.1	A	0	0
100/10-05-073-08W4/00	Kgrand_rp	487775.95	6127585.15	700.71	336.99	342.50	339.75	340.01	150.1	511.1	A	0	0
100/10-13-073-08W4/00	Kgrand_rp	494307.09	6130798.11	696.41	326.02	334.00	330.01	328.00	154.9	521.3	A	0	0
100/10-14-073-08W4/00	Kgrand_rp	492478.84	6130685.11	707.72	336.99	344.00	340.49	337.90	162.9	530.1	A	0	0
100/10-16-073-08W4/00	Kgrand_rp	489297.94	6130705.02	722.01	376.00	385.51	380.76	378.81	172.9	514.2	A	0	0
100/10-33-073-08W4/00	Kgrand_rp	489345.51	6135690.57	700.01	326.02	331.99	329.00	326.90	137.3	508.3	A	0	0
100/11-29-073-08W4/00	Kgrand_rp	487168.68	6134066.00	689.49	312.70	324.00	318.35	314.62	122.8	493.9	A	0	0
100/11-29-073-08W4/00	Kgrand_rp	487168.68	6134066.00	689.49	311.81	320.01	315.91	313.61	128.3	501.9	A	0	0
1AA/06-35-073-08W4/00	Kgrand_rp	492022.21	6135032.77	701.32	320.01	335.31	327.66	322.51	150.7	524.4	A	0	0
100/06-11-073-09W4/00	Kgrand_rp	482260.00	6128586.49	685.89	352.01	358.99	355.50	352.90	163.0	493.4	A	0	0
100/08-08-073-09W4/00	Kgrand_rp	478085.41	6128882.30	665.90	310.99	316.99	313.99	314.19	150.8	502.7	A	0	0
100/08-08-073-09W4/00	Kgrand_rp	478085.41	6128882.30	665.90	305.01	309.01	307.01	299.19	155.1	514.0	B	0	6
100/08-08-073-09W4/00	Kgrand_rp	478085.41	6128882.30	665.90	310.01	314.01	312.01	303.61	162.5	516.3	A	0	6
100/10-01-073-09W4/00	Kgrand_rp	484466.36	6127576.61	685.89	328.00	334.00	331.00	330.01	142.9	497.8	A	0	0
100/10-03-073-09W4/00	Kgrand_rp	481225.43	6127594.74	682.30	326.02	333.00	329.51	328.00	146.3	499.1	A	0	0
100/10-17-073-09W4/00	Kgrand_rp	477880.20	6130754.08	668.70	358.42	366.40	362.41	360.31	169.7	476.0	A	0	0
100/10-17-073-09W4/00	Kgrand_rp	477880.20	6130754.08	668.70	334.70	342.60	338.65	336.50	151.0	481.1	A	0	0
100/10-17-073-09W4/00	Kgrand_rp	477880.20	6130754.08	668.70	304.80	312.70	308.75	306.60	202.0	562.0	D	0	0
100/11-21-073-09W4/00	Kgrand_rp	479113.09	6132357.31	664.80	300.02	313.00	306.51	302.00	156.5	514.8	A	0	0
100/11-23-073-09W4/00	Kgrand_rp	482354.99	6132342.06	654.50	320.01	331.01	325.51	321.99	165.8	494.8	A	0	0
100/11-31-073-09W4/00	Kgrand_rp	475893.53	6135651.17	659.41	293.01	298.00	295.50	294.01	162.9	526.8	A	0	0
100/11-31-073-09W4/00	Kgrand_rp	475893.53	6135651.17	659.41	300.99	305.99	303.49	301.30	181.0	536.9	C	0	0
100/16-33-073-09W4/00	Kgrand_rp	479807.16	6135853.00	658.89	294.01	297.00	295.50	294.89	163.8	527.2	A	0	0
100/09-29-073-10W4/00	Kgrand_rp	468660.77	6134063.96	661.11	307.00	310.99	308.99	309.01	197.2	549.3	A	0	0
100/09-32-073-10W4/00	Kgrand_rp	468444.16	6135695.92	662.52	307.00	315.01	311.00	311.69	170.7	522.2	A	0	0
100/10-06-073-10W4/00	Kgrand_rp	466570.80	6127687.85	665.11	311.51	324.89	318.20	322.21	157.2	504.1	A	0	0
100/10-14-073-10W4/00	Kgrand_rp	473083.82	6130782.91	663.89	362.99	378.99	370.99	364.82	199.5	492.4	A	0	0
100/12-22-073-10W4/00	Kgrand_rp	470659.17	6132213.94	664.71	307.00	310.01	308.50	307.61	157.1	513.3	B	0	0

TABLE 5B-5 GRAND RAPIDS FORMATION REGIONAL HYDRAULIC HEADS FROM DSTs

UWI	Formation	UTM Coordinates (Zone 12; Nad 27)		KB Elevation (masl)	Perforated Interval (m bKB)		Mid Point Perforated Interval (m bKB)	Recorder Depth (m bKB)	Pressure Head (m)	Freshwater Hydraulic Head (masl)	Hydro-Fax QC	QC Recorder Elevation	
		Easting	Northing		Top	Bottom						Below Perfs (m)	Above Perfs (m)
100/12-22-073-10W4/00	Kgrand_rp	470659.17	6132213.94	664.71	330.01	336.01	333.01	332.69	194.4	526.1	A	0	0
100/10-28-073-11W4/00	Kgrand_rp	460188.34	6134113.30	663.49	307.79	320.01	313.90	309.40	118.7	468.3	C	0	0
100/10-32-073-11W4/00	Kgrand_rp	458288.41	6135910.44	647.40	351.40	355.70	353.55	352.99	183.1	476.9	A	0	0
100/10-32-073-11W4/00	Kgrand_rp	458288.41	6135910.44	647.40	300.20	306.29	303.25	301.81	134.6	478.8	A	0	0
100/14-25-073-11W4/00	Kgrand_rp	464676.79	6134624.90	657.61	333.00	337.99	335.49	336.29	150.1	472.2	C	0	0
100/11-31-073-12W4/00	Kgrand_rp	446601.70	6135760.35	660.41	302.00	307.00	304.50	303.49	122.5	478.4	A	0	0
100/11-31-073-12W4/00	Kgrand_rp	446601.70	6135760.35	660.41	313.00	316.99	315.00	314.01	142.0	487.4	A	0	0
100/08-11-073-13W4/00	Kgrand_rp	444003.41	6129166.88	669.50	320.50	325.50	323.00	323.21	141.5	488.0	A	0	0
100/11-30-073-13W4/00	Kgrand_rp	436773.75	6134260.72	676.11	329.00	339.00	334.00	336.29	142.0	484.1	A	0	0
100/13-17-073-13W4/00	Kgrand_rp	437902.93	6131712.55	676.20	335.01	341.01	338.01	336.01	149.9	488.1	A	0	0
100/06-32-073-14W4/00	Kgrand_rp	428777.67	6135831.68	697.60	355.00	361.01	358.00	357.01	145.5	485.1	A	0	0
100/07-20-073-14W4/00	Kgrand_rp	428957.86	6132449.47	673.31	335.89	355.70	345.80	343.51	157.3	484.8	A	0	0
100/10-08-073-14W4/00	Kgrand_rp	429108.75	6129632.08	652.30	316.99	322.51	319.75	321.60	156.3	488.8	A	0	0
100/10-10-073-14W4/00	Kgrand_rp	432426.84	6129686.99	663.89	329.22	367.32	348.27	323.70	160.9	476.5	D	0	6
100/10-10-073-14W4/00	Kgrand_rp	432426.84	6129686.99	663.89	329.22	383.99	356.60	323.70	175.2	482.4	A	0	6
100/07-13-073-15W4/00	Kgrand_rp	425925.64	6130822.94	648.40	308.00	313.49	310.74	314.01	150.1	487.8	B	-1	0
100/07-23-073-15W4/00	Kgrand_rp	424172.79	6132690.40	641.30	299.01	305.99	302.50	304.01	151.3	490.1	A	0	0
100/10-25-073-15W4/00	Kgrand_rp	425728.32	6134375.92	657.91	318.00	323.00	320.50	320.01	160.7	498.1	D	0	0
100/11-26-073-15W4/00	Kgrand_rp	423696.84	6134410.56	645.69	305.01	310.01	307.51	307.91	149.8	488.0	A	0	0
100/11-32-073-17W4/00	Kgrand_rp	399409.77	6136846.46	579.40	249.91	257.31	253.61	252.41	139.1	464.9	B	0	0
100/11-29-074-01W4/00	Kgrand_rp	555277.18	6144047.56	697.11	345.00	361.01	353.01	377.01	153.7	497.8	A	-16	0
100/07-19-074-04W4/00	Kgrand_rp	525041.69	6141621.54	653.49	258.01	263.01	260.51	258.99	151.5	544.5	A	0	0
100/10-08-074-04W4/00	Kgrand_rp	526654.64	6138885.46	617.80	237.99	242.59	240.29	239.60	164.4	542.0	B	0	0
100/07-05-074-05W4/00	Kgrand_rp	517025.36	6136763.33	642.49	272.80	282.89	277.84	276.09	156.5	521.2	A	0	0
100/08-21-074-05W4/00	Kgrand_rp	519000.32	6141660.33	656.51	283.80	294.71	289.26	286.79	158.0	525.3	A	0	0
100/10-17-074-05W4/00	Kgrand_rp	517053.03	6140583.99	651.51	276.00	285.99	281.00	277.00	152.6	523.1	A	0	0
100/11-30-074-05W4/00	Kgrand_rp	514852.66	6143665.41	690.10	310.90	319.10	315.00	312.12	160.3	535.4	A	0	0
100/11-34-074-05W4/00	Kgrand_rp	519693.65	6145428.32	667.00	268.99	281.00	274.99	277.70	155.6	547.6	A	0	0
100/16-01-074-05W4/00	Kgrand_rp	523731.51	6137485.42	626.40	250.52	257.89	254.20	251.49	157.5	529.7	A	0	0
100/10-07-074-06W4/00	Kgrand_rp	505610.86	6138936.43	657.09	286.51	291.39	288.95	289.01	153.2	521.4	A	0	0
100/10-07-074-06W4/00	Kgrand_rp	505610.86	6138936.43	657.09	271.91	275.51	273.71	274.29	145.5	528.8	A	0	0
100/10-13-074-06W4/00	Kgrand_rp	513724.97	6140293.03	631.91	243.81	247.50	245.65	236.50	153.0	539.3	A	0	7
100/10-29-074-06W4/00	Kgrand_rp	507299.08	6143696.48	633.71	257.89	264.60	261.24	259.69	148.1	520.6	A	0	0
100/11-31-074-06W4/00	Kgrand_rp	505178.61	6145115.74	636.21	248.99	261.00	255.00	250.00	142.7	523.9	A	0	0
100/06-24-074-07W4/00	Kgrand_rp	503488.27	6141626.30	667.79	332.51	340.19	336.35	335.89	167.7	499.2	A	0	0
100/10-25-074-07W4/00	Kgrand_rp	504012.39	6143681.13	650.41	277.40	283.50	280.45	280.39	145.5	515.5	C	0	0
100/11-23-074-07W4/00	Kgrand_rp	501977.83	6142042.69	665.72	300.99	305.01	303.00	290.99	52.5	415.2	A	0	10
100/11-23-074-07W4/00	Kgrand_rp	501977.83	6142042.69	665.72	293.49	297.49	295.49	294.50	129.7	500.0	A	0	0
100/11-23-074-07W4/00	Kgrand_rp	501977.83	6142042.69	665.72	278.01	282.00	280.01	279.01	144.4	530.1	C	0	0
100/12-29-074-07W4/00	Kgrand_rp	496753.68	6143546.95	678.70	305.99	313.00	309.49	310.71	146.3	515.5	A	0	0
100/06-30-074-08W4/00	Kgrand_rp	485606.38	6143190.90	677.60	299.89	307.79	303.84	303.61	138.8	512.6	A	0	0
100/06-30-074-08W4/00	Kgrand_rp	485606.38	6143190.90	677.60	300.50	306.29	303.40	302.39	140.8	515.0	A	0	0
100/10-02-074-08W4/00	Kgrand_rp	492629.43	6137266.37	701.80	319.00	325.01	322.01	319.89	152.8	532.6	A	0	0
100/10-11-074-08W4/00	Kgrand_rp	492623.15	6138813.28	716.50	363.99	367.99	365.99	367.01	155.7	506.2	A	0	0
100/10-11-074-08W4/00	Kgrand_rp	492623.15	6138813.28	716.50	339.00	341.99	340.49	335.01	134.7	510.7	A	0	4
100/11-10-074-08W4/00	Kgrand_rp	490414.00	6138836.45	695.80	314.01	320.99	317.50	315.01	138.9	517.2	A	0	0
100/11-26-074-08W4/00	Kgrand_rp	491993.27	6143517.42	695.19	341.50	346.50	344.00	342.50	146.7	497.9	A	0	0

TABLE 5B-5 GRAND RAPIDS FORMATION REGIONAL HYDRAULIC HEADS FROM DSTs

UWI	Formation	UTM Coordinates (Zone 12; Nad 27)		KB Elevation (masl)	Perforated Interval (m bKB)		Mid Point Perforated Interval (m bKB)	Recorder Depth (m bKB)	Pressure Head (m)	Freshwater Hydraulic Head (masl)	Hydro-Fax QC	QC Recorder Elevation	
		Easting	Northing		Top	Bottom						Below Perfs (m)	Above Perfs (m)
100/07-27-074-09W4/00	Kgrand_rp	481240.85	6143148.36	665.41	345.00	350.49	347.75	346.59	169.4	487.1	A	0	0
100/07-27-074-09W4/00	Kgrand_rp	481240.85	6143148.36	665.41	289.59	296.30	292.94	291.12	129.5	502.0	A	0	0
100/07-27-074-09W4/00	Kgrand_rp	481240.85	6143148.36	665.41	298.70	304.80	301.75	300.20	144.4	508.1	A	0	0
100/10-14-074-09W4/00	Kgrand_rp	482909.34	6140514.02	659.01	302.00	305.99	303.99	302.79	156.5	511.5	A	0	0
100/10-34-074-09W4/00	Kgrand_rp	481272.44	6145366.23	675.50	293.01	299.01	296.01	294.19	111.2	490.7	A	0	0
100/11-08-074-09W4/00	Kgrand_rp	477506.67	6139008.05	669.62	326.11	335.31	330.71	328.61	167.1	506.0	B	0	0
100/11-28-074-09W4/00	Kgrand_rp	479134.36	6143810.00	668.40	289.01	298.00	293.51	290.99	136.2	511.1	C	0	0
100/11-28-074-09W4/00	Kgrand_rp	479134.36	6143810.00	668.40	289.01	325.01	307.01	295.99	151.7	513.0	C	0	0
100/09-34-074-10W4/00	Kgrand_rp	471681.54	6145199.38	678.30	329.00	341.01	335.01	331.01	155.8	499.1	A	0	0
100/12-08-074-10W4/00	Kgrand_rp	467518.60	6138949.02	662.30	311.99	316.51	314.25	315.10	160.9	509.0	A	0	0
100/12-08-074-10W4/00	Kgrand_rp	467518.60	6138949.02	662.30	289.01	305.99	297.50	294.01	250.6	615.4	A	0	0
100/05-31-074-11W4/00	Kgrand_rp	455870.96	6145024.61	660.02	293.01	295.99	294.50	298.00	109.5	475.0	A	-2	0
100/06-08-074-11W4/00	Kgrand_rp	457873.01	6138475.28	664.80	304.19	322.51	313.35	310.29	142.9	494.4	A	0	0
100/06-05-074-12W4/00	Kgrand_rp	448151.07	6137060.76	664.59	303.00	307.00	305.00	305.01	116.2	475.8	A	0	0
100/10-03-074-12W4/00	Kgrand_rp	452083.33	6137529.38	663.89	303.61	312.70	308.15	306.29	139.0	494.7	A	0	0
100/13-01-074-12W4/00	Kgrand_rp	454564.91	6137614.41	666.90	394.99	399.99	397.49	396.00	215.2	484.6	C	0	0
100/13-01-074-12W4/00	Kgrand_rp	454564.91	6137614.41	666.90	302.00	315.01	308.50	302.79	144.0	502.4	A	0	0
100/13-01-074-12W4/00	Kgrand_rp	454564.91	6137614.41	666.90	302.00	315.01	308.50	302.70	144.1	502.5	C	0	0
100/14-18-074-12W4/00	Kgrand_rp	446688.09	6141224.11	682.91	320.01	324.49	322.25	326.29	128.1	488.7	A	-2	0
100/11-26-074-14W4/00	Kgrand_rp	433568.83	6144074.89	774.50	446.81	450.80	448.80	436.20	153.0	478.7	A	0	11
100/06-08-074-15W4/00	Kgrand_rp	418888.30	6139084.68	651.69	303.31	315.50	309.40	310.01	137.6	479.9	A	0	0
100/10-06-074-15W4/00	Kgrand_rp	417808.06	6137931.41	637.00	291.12	300.81	295.96	299.89	146.3	487.3	A	0	0
100/11-04-074-15W4/00	Kgrand_rp	420497.44	6137879.89	641.70	295.50	299.50	297.50	289.50	145.0	489.2	G	0	6
100/11-07-074-15W4/00	Kgrand_rp	417346.40	6139370.45	641.91	296.60	299.89	298.25	298.40	133.5	477.1	A	0	0
100/06-24-074-17W4/00	Kgrand_rp	406023.77	6142511.79	602.59	260.60	271.30	265.95	255.09	138.2	474.9	A	0	6
100/06-25-074-17W4/00	Kgrand_rp	405996.64	6144117.69	616.31	283.50	286.51	285.00	278.31	147.9	479.2	A	0	5
100/07-09-074-17W4/00	Kgrand_rp	401500.68	6139676.01	575.71	237.99	243.99	240.99	241.71	145.9	480.6	B	0	0
100/07-21-074-17W4/00	Kgrand_rp	401836.92	6142821.34	582.90	231.01	243.99	237.50	247.89	115.9	461.3	A	-4	0
100/07-22-074-17W4/00	Kgrand_rp	403385.00	6142588.94	589.79	246.89	261.49	254.19	234.70	151.3	486.9	C	0	12
100/10-10-074-17W4/00	Kgrand_rp	403232.99	6139761.22	577.90	237.71	246.89	242.30	245.09	140.9	476.5	A	0	0
100/10-10-074-17W4/00	Kgrand_rp	403232.99	6139761.22	577.90	246.89	256.00	251.45	254.20	156.8	483.2	A	0	0
100/12-03-074-17W4/00	Kgrand_rp	402342.54	6138063.07	574.09	238.99	245.00	242.00	241.01	145.4	477.4	B	0	0
100/12-03-074-17W4/00	Kgrand_rp	402342.54	6138063.07	574.09	256.00	262.01	259.00	258.01	164.2	479.3	A	0	0
100/16-27-075-04W4/00	Kgrand_rp	529799.54	6153799.88	598.99	246.00	252.50	249.25	248.69	228.3	578.0	A	0	0
100/08-09-075-05W4/00	Kgrand_rp	518396.68	6148263.95	623.20	261.00	266.00	263.50	263.90	150.9	510.5	A	0	0
100/12-30-075-05W4/00	Kgrand_rp	514230.14	6153217.60	620.79	258.99	263.01	261.00	261.92	137.5	497.3	A	0	0
100/01-30-075-06W4/00	Kgrand_rp	505444.27	6152741.61	618.81	220.01	224.49	222.25	222.90	119.6	516.2	A	0	0
100/04-11-075-06W4/00	Kgrand_rp	510885.62	6147812.69	632.19	257.01	262.01	259.51	259.90	130.6	503.3	A	0	0
100/06-08-075-06W4/00	Kgrand_rp	506179.57	6147974.94	648.62	258.01	262.01	260.01	258.90	152.4	541.0	B	0	0
100/06-10-075-06W4/00	Kgrand_rp	509428.39	6147948.43	647.40	271.30	280.39	275.84	273.71	142.7	514.3	A	0	0
100/07-07-075-06W4/00	Kgrand_rp	505242.82	6148019.35	623.99	236.01	238.99	237.50	229.21	160.5	547.0	A	0	7
1AA/06-31-075-06W4/00	Kgrand_rp	504599.30	6154738.31	611.10	236.01	240.00	238.00	237.99	134.7	507.8	C	0	0
1AA/01-28-075-06W4/00	Kgrd_rp_L	508797.48	6152738.15	622.71	288.01	295.99	292.00	289.99	161.4	492.1	C	0	0
1AA/06-31-075-06W4/00	Kgrd_rp_L	504599.30	6154738.31	611.10	267.01	277.00	272.00	268.99	162.8	501.9	C	0	0
100/06-29-075-07W4/00	Kgrand_rp	496356.47	6152837.69	671.81	265.21	273.71	269.46	258.20	136.6	538.9	A	0	7
100/07-13-075-07W4/00	Kgrand_rp	503521.09	6149642.46	645.60	263.99	268.99	266.49	264.99	149.4	528.6	A	0	0
100/10-10-075-07W4/00	Kgrand_rp	500224.35	6148555.98	660.02	292.00	295.99	294.00	292.91	139.8	505.8	C	0	0

TABLE 5B-5 GRAND RAPIDS FORMATION REGIONAL HYDRAULIC HEADS FROM DSTs

UWI	Formation	UTM Coordinates (Zone 12; Nad 27)		KB Elevation (masl)	Perforated Interval (m bKB)		Mid Point Perforated Interval (m bKB)	Recorder Depth (m bKB)	Pressure Head (m)	Freshwater Hydraulic Head (masl)	Hydro-Fax QC	QC Recorder Elevation	
		Easting	Northing		Top	Bottom						Below Perfs (m)	Above Perfs (m)
100/10-10-075-07W4/00	Kgrand_rp	500224.35	6148555.98	660.02	273.01	279.01	276.01	274.02	146.4	530.4	C	0	0
100/10-11-075-07W4/00	Kgrand_rp	501887.68	6148585.32	648.01	274.29	281.91	278.10	274.29	136.1	506.0	A	0	0
100/06-04-075-08W4/00	Kgrand_rp	488438.21	6146428.86	713.81	336.99	340.01	338.50	331.01	135.0	510.3	A	0	6
100/11-18-075-08W4/00	Kgrand_rp	484926.10	6149994.10	665.01	271.49	277.70	274.60	272.71	113.1	503.6	B	0	0
100/10-01-075-09W4/00	Kgrand_rp	483836.06	6146837.33	680.19	294.99	302.30	298.64	296.21	110.2	491.7	A	0	0
100/10-34-075-09W4/00	Kgrand_rp	480676.53	6154953.20	677.21	272.00	292.00	282.00	280.20	113.8	509.0	A	0	0
100/11-24-075-09W4/00	Kgrand_rp	483234.61	6151915.55	677.30	331.01	344.39	337.70	341.99	144.1	483.7	A	0	0
100/11-24-075-09W4/00	Kgrand_rp	483234.61	6151915.55	677.30	286.51	293.19	289.85	290.20	125.2	512.6	D	0	0
100/12-19-075-09W4/00	Kgrand_rp	474917.57	6151779.35	681.90	289.99	294.99	292.49	292.00	125.3	514.7	A	0	0
100/02-34-075-11W4/00	Kgrand_rp	460893.87	6154307.04	656.51	274.02	295.69	284.85	272.49	122.9	494.6	A	0	2
100/06-14-075-13W4/00	Kgrand_rp	442673.49	6150022.91	696.99	321.99	326.02	324.00	324.19	103.7	476.7	C	0	0
100/15-06-075-13W4/00	Kgrand_rp	436389.54	6147601.69	745.39	383.99	394.02	389.00	379.29	131.0	487.4	B	0	5
100/05-12-075-14W4/00	Kgrand_rp	434012.02	6148390.29	759.72	399.99	407.00	403.50	402.70	128.0	484.2	A	0	0
100/06-27-075-14W4/00	Kgrand_rp	431123.67	6153630.54	756.21	402.31	405.42	403.86	402.92	116.2	468.6	A	0	0
100/06-31-075-14W4/00	Kgrand_rp	426060.58	6155118.84	733.29	367.01	371.19	369.10	369.39	117.8	482.0	A	0	0
100/06-31-075-14W4/00	Kgrand_rp	426060.58	6155118.84	733.29	367.01	371.19	369.10	369.39	118.2	482.4	A	0	0
100/06-32-075-14W4/00	Kgrand_rp	427789.61	6155084.46	742.19	399.29	402.31	400.80	400.51	134.5	475.9	A	0	0
100/11-11-075-14W4/00	Kgrand_rp	432832.97	6148842.25	767.79	418.19	425.50	421.84	422.09	132.6	478.5	A	0	0
100/11-29-075-14W4/00	Kgrand_rp	427843.05	6154111.83	745.91	375.00	386.49	380.74	382.31	111.1	476.3	A	0	0
100/11-33-075-14W4/00	Kgrand_rp	429375.44	6155604.06	726.01	362.71	371.19	366.95	366.40	116.7	475.7	A	0	0
100/06-36-075-15W4/00	Kgrand_rp	424486.03	6155106.72	732.10	368.81	372.50	370.65	370.30	116.5	478.0	A	0	0
100/06-36-075-15W4/00	Kgrand_rp	424486.03	6155106.72	732.10	360.91	368.81	364.86	366.10	121.9	489.1	A	0	0
100/10-08-075-15W4/00	Kgrand_rp	418552.45	6149102.67	704.61	355.00	360.00	357.50	349.79	137.2	484.3	G	0	5
100/10-08-075-15W4/00	Kgrand_rp	418552.45	6149102.67	704.61	347.02	354.00	350.51	347.99	132.1	486.2	A	0	0
100/10-25-075-15W4/00	Kgrand_rp	425107.87	6154148.77	744.69	399.99	404.99	402.49	402.61	131.6	473.8	A	0	0
100/06-06-075-16W4/00	Kgrand_rp	406320.39	6147370.41	646.79	299.31	317.60	308.46	330.01	120.8	459.2	B	-12	0
100/06-23-075-16W4/00	Kgrand_rp	412970.59	6152273.26	732.80	371.49	390.51	381.00	372.31	130.6	482.4	C	0	0
100/07-05-075-16W4/00	Kgrand_rp	408627.29	6147320.74	669.01	320.59	326.72	323.65	324.61	125.3	470.7	A	0	0
100/07-24-075-16W4/00	Kgrand_rp	415265.32	6152025.76	729.11	374.91	383.99	379.45	382.19	120.5	470.2	A	0	0
100/12-17-075-17W4/00	Kgrand_rp	398126.31	6151282.31	619.20	294.01	298.00	296.01	295.99	148.9	472.1	B	0	0
100/16-36-075-17W4/00	Kgrand_rp	405847.55	6156367.96	729.39	383.99	395.60	389.79	389.20	139.2	478.8	B	0	0
100/08-24-076-02W4/00	Kgrand_rp	552714.65	6161339.12	633.71	240.79	268.80	254.80	234.70	187.2	566.1	A	0	6
100/11-09-076-02W4/00	Kgrand_rp	546941.87	6158623.31	658.49	282.00	289.99	285.99	287.79	185.4	557.9	D	0	0
100/06-25-076-05W4/00	Kgrand_rp	522387.76	6162631.41	597.11	205.01	211.01	208.01	208.00	156.5	545.6	A	0	0
100/07-18-076-05W4/00	Kgrand_rp	514912.58	6159337.56	573.30	164.99	173.01	169.00	167.00	183.9	588.2	A	0	0
100/10-08-076-05W4/00	Kgrand_rp	516463.82	6158227.97	581.90	195.01	205.01	200.01	196.99	182.2	564.1	A	0	0
100/07-18-076-05W4/00	Kgrd_rp_L	514912.58	6159337.56	573.30	210.01	217.99	214.00	211.01	164.5	523.8	A	0	0
100/10-05-076-05W4/00	Kgrd_rp_L	516499.11	6156724.55	615.70	249.91	259.11	254.51	252.41	156.2	517.4	A	0	0
100/07-19-076-06W4/00	Kgrand_rp	505131.62	6160932.24	570.31	240.21	243.81	242.01	242.01	181.0	509.3	A	0	0
100/07-28-076-06W4/00	Kgrand_rp	508390.99	6162556.57	563.91	221.01	225.61	223.31	214.00	180.7	521.3	C	0	7
100/11-03-076-06W4/00	Kgrand_rp	509420.35	6156691.38	594.39	189.01	208.79	198.90	196.29	128.8	524.3	D	0	0
100/11-03-076-06W4/00	Kgrand_rp	509420.35	6156691.38	594.39	189.01	208.79	198.90	196.29	130.7	526.2	A	0	0
100/10-14-076-07W4/00	Kgrand_rp	501871.46	6159904.64	595.31	178.61	198.09	188.35	171.60	150.7	557.7	A	0	7
100/11-32-076-07W4/00	Kgrd_rp_L	496467.12	6164767.99	559.00	221.01	224.61	222.81	222.81	184.9	521.1	A	0	0
100/06-17-076-10W4/00	Kgrand_rp	466983.82	6159690.40	671.60	290.99	303.00	297.00	301.51	103.5	478.1	A	0	0
100/06-17-076-10W4/00	Kgrand_rp	466983.82	6159690.40	671.60	279.01	285.99	282.50	284.41	96.5	485.6	A	0	0
100/08-10-076-10W4/00	Kgrand_rp	471038.21	6157917.72	670.20	268.99	274.02	271.50	269.99	97.1	495.8	A	0	0

TABLE 5B-5 GRAND RAPIDS FORMATION REGIONAL HYDRAULIC HEADS FROM DSTs

UWI	Formation	UTM Coordinates (Zone 12; Nad 27)		KB Elevation (masl)	Perforated Interval (m bKB)		Mid Point Perforated Interval (m bKB)	Recorder Depth (m bKB)	Pressure Head (m)	Freshwater Hydraulic Head (masl)	Hydro-Fax QC	QC Recorder Elevation	
		Easting	Northing		Top	Bottom						Below Perfs (m)	Above Perfs (m)
100/10-01-076-10W4/00	Kgrand_rp	474067.17	6156842.56	683.52	284.99	293.01	289.00	287.00	86.7	481.2	A	0	0
100/10-24-076-10W4/00	Kgrand_rp	474156.08	6161644.37	659.80	283.01	287.00	285.00	284.99	115.1	489.9	C	0	0
100/12-13-076-10W4/00	Kgrand_rp	473362.08	6160080.99	665.99	277.00	289.99	283.50	278.01	109.6	492.1	A	0	0
100/14-04-076-10W4/00	Kgrand_rp	468716.96	6156974.32	665.50	269.99	274.99	272.49	272.00	102.0	495.1	A	0	0
100/10-24-076-10W4/00	Kgrd_rp_L	474156.08	6161644.37	659.80	298.00	313.00	305.50	300.02	131.5	485.8	A	0	0
100/10-32-076-12W4/00	Kgrand_rp	448147.96	6165042.99	690.40	301.81	308.49	305.15	304.19	92.3	477.6	A	0	0
100/06-18-076-13W4/00	Kgrand_rp	436211.51	6159864.77	683.91	316.99	325.01	321.00	323.61	116.8	479.7	A	0	0
100/10-14-076-13W4/00	Kgrand_rp	443190.74	6159989.03	720.00	340.01	347.02	343.51	334.79	115.1	491.5	A	0	5
100/06-18-076-13W4/00	Kgrd_rp_L	436211.51	6159864.77	683.91	350.00	357.99	354.00	356.31	145.6	475.5	A	0	0
100/06-05-076-14W4/00	Kgrand_rp	427771.67	6156906.95	730.91	360.31	364.51	362.41	360.61	110.5	479.0	B	0	0
100/06-05-076-14W4/00	Kgrand_rp	427771.67	6156906.95	730.91	364.51	368.81	366.66	366.10	115.3	479.6	A	0	0
100/10-30-076-14W4/00	Kgrand_rp	426617.69	6163681.77	685.80	313.91	318.79	316.35	315.80	101.1	470.6	B	0	0
100/10-30-076-14W4/00	Kgrand_rp	426617.69	6163681.77	685.80	301.11	305.99	303.55	303.00	94.6	476.8	C	0	0
100/11-10-076-14W4/00	Kgrand_rp	431091.52	6158812.56	698.30	329.00	333.00	331.00	323.91	112.4	479.7	C	0	5
100/06-14-076-15W4/00	Kgrand_rp	422922.68	6160036.27	716.31	346.31	352.29	349.30	347.50	146.8	513.8	D	0	0
100/07-05-076-15W4/00	Kgrand_rp	418610.71	6156838.20	766.91	409.71	413.31	411.51	411.51	120.3	475.7	A	0	0
100/07-05-076-15W4/00	Kgrand_rp	418610.71	6156838.20	766.91	413.89	417.61	415.75	411.51	128.4	479.6	D	0	2
100/07-06-076-15W4/00	Kgrand_rp	417062.32	6156782.62	745.21	389.51	393.19	391.35	391.70	122.8	476.6	C	0	0
100/07-08-076-15W4/00	Kgrand_rp	418597.60	6158408.04	739.29	367.99	372.01	370.00	370.00	116.5	485.8	A	0	0
100/10-30-076-15W4/00	Kgrand_rp	417186.70	6164018.32	692.69	320.99	330.01	325.50	323.00	101.4	468.6	A	0	0
100/11-10-076-15W4/00	Kgrand_rp	421261.62	6159080.67	718.69	346.31	365.79	356.05	350.80	119.7	482.4	B	0	0
100/16-07-076-15W4/00	Kgrand_rp	417227.99	6159270.83	722.10	352.01	355.00	353.51	353.11	111.9	480.5	B	0	0
100/07-22-076-16W4/00	Kgrand_rp	412194.25	6161882.57	722.99	350.49	371.19	360.84	359.39	107.1	469.2	C	0	0
100/08-32-076-16W4/00	Kgrand_rp	409176.53	6165335.19	684.22	326.99	331.01	329.00	328.51	120.0	475.2	A	0	0
100/06-08-076-17W4/00	Kgrand_rp	398417.76	6159136.86	664.19	305.01	320.01	312.51	308.09	127.3	479.0	A	0	0
100/06-28-076-17W4/00	Kgrand_rp	400281.81	6163778.94	695.71	345.31	348.11	346.71	339.61	150.1	499.1	D	0	6
100/06-29-076-17W4/00	Kgrand_rp	398524.42	6163788.20	698.30	335.31	355.09	345.20	342.90	132.0	485.1	A	0	0
100/10-20-076-17W4/00	Kgrand_rp	399162.88	6162697.93	711.41	347.50	362.71	355.11	349.00	131.2	487.5	D	0	0
100/11-27-076-17W4/00	Kgrand_rp	401906.12	6164272.14	716.59	353.60	371.89	362.74	361.80	121.4	475.3	D	0	0
100/10-20-077-08W4/00	Kgrd_rp_L	487306.80	6171353.52	567.20	209.70	213.39	211.55	121.31	227.4	583.0	A	0	88
100/07-29-077-09W4/00	Kgrand_rp	477342.58	6172326.56	582.81	167.61	173.71	170.66	170.11	72.5	484.7	A	0	0
100/10-22-077-09W4/00	Kgrd_rp_L	480607.22	6171170.04	585.80	211.50	222.50	217.00	213.39	116.1	484.9	A	0	0
100/15-23-077-09W4/00	Kgrd_rp_L	482406.08	6171655.45	591.59	240.79	246.89	243.84	242.29	127.1	474.8	A	0	0
100/10-14-077-10W4/00	Kgrand_rp	472645.38	6169738.04	634.99	224.00	232.01	228.01	230.09	89.1	496.1	D	0	0
100/11-19-077-10W4/00	Kgrand_rp	465632.20	6171374.75	695.80	315.99	320.01	318.00	318.00	101.5	479.3	A	0	0
100/09-11-077-11W4/00	Kgrand_rp	462964.81	6167930.75	681.60	290.99	298.00	294.50	293.01	87.6	474.7	A	0	0
100/06-11-077-13W4/00	Kgrand_rp	442649.82	6167817.54	681.20	287.09	294.41	290.75	289.59	98.1	488.5	A	0	0
100/07-10-077-14W4/00	Kgrand_rp	431796.00	6167901.25	671.81	289.99	294.01	292.00	290.99	99.8	479.6	B	0	0
100/07-10-077-14W4/00	Kgrand_rp	431796.00	6167901.25	671.81	284.01	288.01	286.01	284.99	94.9	480.7	B	0	0
100/07-28-077-14W4/00	Kgrand_rp	430189.68	6172766.55	677.39	288.01	300.02	294.01	296.69	99.4	482.7	D	0	0
100/10-23-077-14W4/00	Kgrand_rp	433356.31	6171656.19	668.31	277.00	287.00	282.00	279.01	99.7	486.0	A	0	0
100/11-17-077-14W4/00	Kgrand_rp	428024.00	6170222.60	680.59	304.80	310.29	307.54	306.29	102.7	475.7	B	0	0
100/04-24-077-15W4/00	Kgrand_rp	424681.10	6171131.72	683.30	308.49	312.51	310.50	309.49	87.9	460.7	B	0	0
100/04-24-077-15W4/00	Kgrand_rp	424681.10	6171131.72	683.30	297.49	301.51	299.50	298.00	88.6	472.4	B	0	0
100/07-11-077-15W4/00	Kgrand_rp	423557.31	6168015.46	653.80	258.81	272.31	265.56	269.81	82.6	470.9	B	0	0
100/07-21-077-15W4/00	Kgrand_rp	420396.51	6171608.57	689.79	300.99	311.99	306.49	290.90	103.6	486.9	A	0	10
100/07-22-077-15W4/00	Kgrand_rp	422179.79	6171345.96	693.70	307.00	313.00	310.00	310.50	87.1	470.8	B	0	0

TABLE 5B-5 GRAND RAPIDS FORMATION REGIONAL HYDRAULIC HEADS FROM DSTs

UWI	Formation	UTM Coordinates (Zone 12; Nad 27)		KB Elevation (masl)	Perforated Interval (m bKB)		Mid Point Perforated Interval (m bKB)	Recorder Depth (m bKB)	Pressure Head (m)	Freshwater Hydraulic Head (masl)	Hydro-Fax QC	QC Recorder Elevation	
		Easting	Northing		Top	Bottom						Below Perfs (m)	Above Perfs (m)
100/10-20-077-15W4/00	Kgrand_rp	418944.68	6171998.23	694.49	309.01	316.99	313.00	315.29	100.1	481.6	B	0	0
100/10-27-077-15W4/00	Kgrand_rp	421938.90	6173557.72	673.70	285.99	302.00	294.00	289.99	89.8	469.5	A	0	0
100/10-20-077-15W4/00	Kgrd_rp_L	418944.68	6171998.23	694.49	366.49	368.99	367.74	359.51	159.5	486.2	C	0	7
100/10-27-077-15W4/00	Kgrd_rp_L	421938.90	6173557.72	673.70	325.01	334.00	329.51	331.99	124.1	468.3	A	0	0
100/10-27-077-15W4/00	Kgrd_rp_L	421938.90	6173557.72	673.70	345.00	355.00	350.00	352.99	146.5	470.2	A	0	0
100/07-09-077-16W4/00	Kgrand_rp	410773.28	6168602.01	684.31	310.01	319.00	314.51	311.99	111.2	481.0	A	0	0
100/07-19-077-16W4/00	Kgrand_rp	407552.30	6171619.26	628.90	251.00	273.01	262.01	252.01	102.6	469.5	A	0	0
100/09-04-077-16W4/00	Kgrand_rp	410859.25	6167078.42	699.30	337.51	356.50	347.00	339.00	115.9	468.2	A	0	0
100/11-31-077-16W4/00	Kgrand_rp	406984.93	6175477.79	597.11	182.91	224.30	203.61	190.81	90.5	484.0	A	0	0
100/03-25-077-16W4/00	Kgrd_rp_L	415114.10	6172929.43	686.50	337.99	340.19	339.09	330.31	132.6	480.0	A	0	8
100/09-04-077-16W4/00	Kgrd_rp_L	410859.25	6167078.42	699.30	366.00	378.99	372.50	367.50	143.8	470.6	A	0	0
100/11-31-077-16W4/00	Kgrd_rp_L	406984.93	6175477.79	597.11	260.60	276.09	268.35	272.19	122.6	451.4	A	0	0
100/10-10-077-17W4/00	Kgrd_rp_L	402457.77	6168995.89	626.09	288.01	300.20	294.10	299.31	143.8	475.8	C	0	0
100/11-05-078-06W4/00	Kgrand_rp	506207.70	6176167.38	592.99	164.99	172.49	168.74	166.51	71.3	495.6	A	0	0
100/06-11-078-07W4/00	Kgrand_rp	501252.57	6177115.81	536.82	126.49	141.70	134.10	119.79	90.7	493.4	A	0	7
100/06-16-078-07W4/00	Kgrand_rp	498000.40	6178742.10	548.92	166.70	170.41	168.55	169.19	97.3	477.6	A	0	0
100/07-29-078-07W4/00	Kgrand_rp	496985.27	6181966.89	548.61	160.29	189.01	174.65	153.59	88.7	462.6	A	0	7
100/11-17-078-07W4/00	Kgrand_rp	496469.53	6179378.56	545.59	191.99	195.71	193.85	195.10	120.7	472.4	A	0	0
100/07-33-078-09W4/00	Kgrand_rp	479100.10	6183577.59	662.00	288.62	292.30	290.46	291.39	111.0	482.6	A	0	0
100/07-09-078-10W4/00	Kgrand_rp	469385.70	6177277.83	641.30	227.99	232.59	230.29	231.01	72.6	483.6	A	0	0
100/10-18-078-10W4/00	Kgrand_rp	466134.70	6179471.14	666.29	303.61	309.10	306.36	305.99	114.5	474.4	A	0	0
100/10-33-078-11W4/00	Kgrand_rp	459684.19	6184371.12	699.70	313.00	318.00	315.50	313.00	80.7	464.9	A	0	0
100/10-33-078-11W4/00	Kgrand_rp	459684.19	6184371.12	699.70	308.00	313.00	310.50	309.01	80.1	469.3	C	0	0
100/10-18-078-12W4/00	Kgrand_rp	446609.72	6179632.50	676.41	265.21	269.41	267.31	266.70	77.3	486.4	D	0	0
100/06-28-078-13W4/00	Kgrand_rp	439569.42	6182412.78	671.20	294.50	299.50	297.00	296.51	98.5	472.7	A	0	0
100/06-28-078-13W4/00	Kgrand_rp	439569.42	6182412.78	671.20	268.01	273.01	270.51	269.99	80.8	481.5	A	0	0
100/11-25-078-13W4/00	Kgrand_rp	444677.07	6182719.85	672.39	277.40	281.00	279.20	279.20	83.7	476.9	D	0	0
100/07-06-078-14W4/00	Kgrand_rp	427029.35	6176148.90	673.61	295.20	300.99	298.10	298.10	90.6	466.1	A	0	0
100/06-10-078-15W4/00	Kgrand_rp	421565.19	6177831.33	635.51	256.00	260.00	258.00	257.01	91.2	468.7	A	0	0
100/06-12-078-15W4/00	Kgrand_rp	424912.68	6177775.62	624.20	235.49	243.51	239.50	236.50	87.1	471.8	B	0	0
100/10-33-078-15W4/00	Kgrd_rp_L	420490.51	6184614.75	655.11	300.99	309.01	305.00	303.00	118.2	468.4	D	0	0
100/09-25-078-16W4/00	Kgrand_rp	416132.76	6183359.72	627.71	263.01	267.01	265.01	264.99	97.8	460.5	A	0	0
100/10-15-078-16W4/00	Kgrand_rp	412548.13	6180247.56	614.20	184.40	241.40	212.90	191.69	94.1	495.4	A	0	0
100/05-19-079-02W4/00	Kgrand_rp	543087.65	6190447.09	524.59	117.99	128.99	123.49	120.00	98.6	499.7	A	0	0
100/06-03-079-04W4/00	Kgrand_rp	528678.68	6185534.11	552.91	207.30	216.41	211.85	210.31	145.3	486.4	A	0	0
100/11-02-079-07W4/00	Kgrand_rp	500965.57	6185899.12	550.41	146.00	151.49	148.74	148.01	61.5	463.2	A	0	0
100/11-02-079-07W4/00	Kgrand_rp	500965.57	6185899.12	550.41	146.00	151.49	148.74	148.01	91.9	493.6	C	0	0
100/08-19-079-09W4/00	Kgrand_rp	475344.95	6190344.19	678.70	252.01	256.00	254.01	253.99	52.9	477.6	A	0	0
100/07-26-079-10W4/00	Kgrand_rp	471994.75	6191798.09	682.82	259.11	263.71	261.41	260.60	55.9	477.3	A	0	0
100/06-31-079-12W4/00	Kgrand_rp	445484.05	6193913.98	685.31	263.01	273.01	268.01	264.99	68.2	485.5	A	0	0
100/07-22-079-12W4/00	Kgrand_rp	450446.92	6190290.26	692.29	295.99	300.99	298.49	299.01	77.9	471.7	A	0	0
100/07-22-079-12W4/00	Kgrand_rp	450446.92	6190290.26	692.29	268.99	274.02	271.50	272.00	61.3	482.1	A	0	0
100/07-28-079-12W4/00	Kgrand_rp	449152.58	6191972.64	687.81	281.00	284.99	282.99	283.01	71.5	476.4	D	0	0
100/07-28-079-12W4/00	Kgrand_rp	449152.58	6191972.64	687.81	262.49	266.40	264.45	264.51	59.4	482.8	A	0	0
100/07-01-079-13W4/00	Kgrand_rp	444096.59	6185809.42	682.82	278.89	291.12	285.00	281.91	78.4	476.2	D	0	0
100/16-18-079-13W4/00	Kgrand_rp	436475.39	6189746.79	685.01	276.52	279.50	278.01	271.09	70.1	477.1	A	0	5
100/12-23-079-14W4/00	Kgrand_rp	431918.25	6190928.03	699.21	284.01	297.00	290.51	285.11	65.6	474.3	A	0	0

TABLE 5B-5 GRAND RAPIDS FORMATION REGIONAL HYDRAULIC HEADS FROM DSTs

UWI	Formation	UTM Coordinates (Zone 12; Nad 27)		KB Elevation (masl)	Perforated Interval (m bKB)		Mid Point Perforated Interval (m bKB)	Recorder Depth (m bKB)	Pressure Head (m)	Freshwater Hydraulic Head (masl)	Hydro-Fax QC	QC Recorder Elevation	
		Easting	Northing		Top	Bottom						Below Perfs (m)	Above Perfs (m)
100/14-30-079-14W4/00	Kgrand_rp	425740.12	6193113.44	659.31	291.51	294.99	293.25	293.71	87.2	453.3	C	0	0
100/14-30-079-14W4/00	Kgrand_rp	425740.12	6193113.44	659.31	258.99	262.49	260.74	261.21	59.3	457.9	C	0	0
100/14-30-079-14W4/00	Kgrd_rp_L	425740.12	6193113.44	659.31	304.50	308.00	306.25	306.69	100.9	454.0	C	0	0
100/06-28-079-15W4/00	Kgrand_rp	419231.93	6192545.32	623.01	234.70	239.30	237.00	236.80	70.1	456.1	A	0	0
100/11-09-079-15W4/00	Kgrand_rp	419131.30	6187888.27	630.69	258.99	264.99	261.99	263.10	93.8	462.5	A	0	0
100/15-10-079-15W4/00	Kgrand_rp	421169.96	6188258.18	641.30	247.01	260.79	253.90	248.11	73.6	461.0	A	0	0
100/06-28-079-15W4/00	Kgrd_rp_L	419231.93	6192545.32	623.01	269.69	275.81	272.75	273.41	99.8	450.0	A	0	0
100/10-07-079-15W4/00	Kgrd_rp_L	416411.14	6188235.98	610.52	256.00	268.01	262.01	257.01	109.1	457.6	A	0	0
100/06-10-079-17W4/00	Kgrand_rp	401097.77	6188039.37	559.31	181.11	201.20	191.16	189.31	72.2	440.4	A	0	0
100/06-10-079-17W4/00	Kgrd_rp_L	401097.77	6188039.37	559.31	217.60	233.51	225.55	212.11	111.9	445.7	A	0	5
100/12-11-080-12W4/00	Kgrand_rp	451592.38	6197150.51	685.41	258.99	269.99	264.49	261.00	68.4	489.3	A	0	0
100/08-21-080-15W4/00	Kgrand_rp	420202.72	6200510.42	576.99	156.00	189.01	172.50	158.01	43.9	448.4	E	0	0
100/11-29-081-12W4/00	Kgrand_rp	447378.75	6212128.71	736.00	303.00	308.00	305.50	292.00	65.1	495.6	A	0	11
100/11-26-082-12W4/00	Kgrand_rp	451974.90	6221401.66	744.29	298.00	310.10	304.05	300.02	44.2	484.5	A	0	0
100/06-10-082-13W4/00	Kgrand_rp	440636.12	6216359.65	634.02	198.70	222.50	210.60	202.69	59.1	482.6	D	0	0
100/10-21-082-13W4/00	Kgrand_rp	439735.98	6220240.43	596.80	164.99	180.99	172.99	165.99	58.6	482.4	A	0	0
100/10-15-082-14W4/00	Kgrand_rp	431597.35	6218601.39	589.09	151.00	156.00	153.50	153.01	19.3	454.8	A	0	0
100/07-32-083-06W4/00	Kgrd_rp_L	505542.98	6232228.70	530.29	144.99	154.99	149.99	153.10	68.4	448.7	C	0	0
100/07-21-083-07W4/00	Kgrand_rp	497359.29	6229197.37	678.70	224.00	227.20	225.60	226.01	34.7	487.8	C	0	0
100/11-31-083-09W4/00	Kgrd_rp_L	473971.37	6232933.27	716.31	300.50	304.19	302.35	302.39	52.0	465.9	A	0	0
100/14-16-083-10W4/00	Kgrand_rp	467400.10	6228379.15	735.00	284.50	288.49	286.50	285.99	69.0	517.5	A	0	0
100/03-13-083-10W4/00	Kgrd_rp_L	472337.36	6227151.17	717.59	305.50	307.51	306.51	298.00	59.9	471.0	A	0	7
100/02-02-083-11W4/00	Kgrand_rp	461554.56	6224037.68	736.49	299.01	303.00	301.01	300.99	60.0	495.5	A	0	0
100/07-20-084-09W4/00	Kgrand_rp	476339.60	6238844.32	701.99	268.29	286.70	277.49	269.99	53.0	477.5	A	0	0
100/11-10-084-10W4/00	Kgrd_rp_L	469162.98	6236121.97	662.00	238.42	242.01	240.21	240.21	50.7	472.5	A	0	0

Data point eliminated due to depth of pressure recorder
Data point eliminated due to Hydro-Fax QC
Anomalous pressure data point eliminated

TABLE 5B-6 CLEARWATER FORMATION REGIONAL HYDRAULIC HEADS FROM DSTs

UWI	Formation	UTM Coordinates (Zone 12; Nad 27)		KB Elevation (masl)	Perforated Interval (m bKB)		Mid Point Perforated Interval (m bKB)	Recorder Depth (m bKB)	Pressure Head (m)	Freshwater Hydraulic Head (masl)	Hydro-Fax QC	QC Recorder Elevation	
		Easting	Northing		Top	Bottom						Below Perfs (m)	Above Perfs (m)
100/05-30-070-03W4/00	Kclwtr_ss	534651.87	6104635.98	671.60	412.00	415.99	414.00	414.90	230.1	487.7	A	0	0
100/06-15-070-03W4/00	Kclwtr_ss	539882.39	6101339.93	707.72	465.49	469.52	467.50	467.29	74.4	314.6	E	0	0
100/06-15-070-03W4/00	Kclwtr_ss	539882.39	6101339.93	707.72	476.50	480.49	478.49	477.29	264.4	493.6	A	0	0
100/06-22-070-03W4/00	Kclwtr_ss	539728.59	6103044.60	709.00	458.51	464.52	461.51	459.49	230.9	478.4	C	0	0
100/07-02-070-03W4/00	Kclwtr_ss	541868.49	6098266.52	709.79	483.51	487.50	485.50	485.49	272.3	496.6	C	0	0
100/11-03-070-03W4/00	Kclwtr_ss	539824.95	6098252.30	666.20	480.49	488.50	484.50	481.49	298.8	480.5	D	0	0
100/05-14-070-04W4/00	Kclwtr_ss	531188.87	6101277.41	669.10	422.00	426.51	424.25	423.00	253.6	498.4	B	0	0
100/05-25-070-04W4/00	Kclwtr_ss	533077.28	6104617.34	669.80	410.51	414.01	412.26	412.49	232.3	489.9	A	0	0
100/05-35-070-04W4/00	Kclwtr_ss	531460.32	6106261.58	669.01	409.99	415.99	412.99	412.79	231.2	487.2	B	0	0
100/05-35-070-04W4/00	Klloyd_ss	531460.32	6106261.58	669.01	399.99	405.99	402.99	402.79	230.2	496.2	A	0	0
100/06-21-070-05W4/00	Kclwtr_ss	518851.96	6102846.35	671.11	418.31	422.00	420.15	420.29	232.4	483.3	A	0	0
100/06-19-070-13W4/00	Kclwtr_ss	437451.61	6103047.94	619.90	431.99	441.99	436.99	441.02	301.6	484.5	A	0	0
100/03-17-071-03W4/00	Kclearwtr	536084.68	6110568.97	678.70	419.50	423.49	421.49	422.30	231.0	488.2	A	0	0
100/03-17-071-03W4/00	Kclearwtr	536084.68	6110568.97	678.70	408.01	412.00	410.00	410.81	230.1	498.8	C	0	0
100/06-02-071-04W4/00	Kclwtr_ss	531546.36	6107807.96	668.92	404.99	409.01	407.00	407.00	232.7	494.6	A	0	0
100/07-12-071-04W4/00	Kclwtr_ss	533338.42	6109553.75	672.60	409.99	417.00	413.49	412.00	245.1	504.2	A	0	0
100/07-12-071-04W4/00	Kclwtr_ss	533338.42	6109553.75	672.60	394.99	402.00	398.50	397.00	243.0	517.1	A	0	0
100/06-02-071-04W4/00	Klloyd_ss	531546.36	6107807.96	668.92	393.50	397.49	395.49	394.99	233.1	506.6	A	0	0
100/05-05-072-04W4/00	Kclwtr_ss	525805.78	6117570.85	677.21	414.01	417.00	415.50	415.99	231.2	492.9	A	0	0
100/11-15-072-13W4/00	Kclearwtr	441609.31	6121362.34	656.82	428.49	432.79	430.64	430.99	271.2	497.4	A	0	0
100/15-17-072-14W4/00	Kclearwtr	428893.11	6121770.62	618.01	403.01	418.00	410.51	404.01	255.3	462.8	A	0	0
100/10-20-072-14W4/00	Kclwtr_ss	429132.17	6123237.14	608.41	393.19	403.89	398.54	395.60	267.3	477.2	A	0	0
100/09-12-073-01W4/00	Kclearwtr	563123.02	6129542.21	669.50	414.01	418.00	416.01	414.99	215.2	468.7	C	0	0
100/02-16-073-03W4/00	Kclwtr_ss	538080.93	6130241.75	692.51	446.02	450.01	448.01	448.91	241.6	486.1	A	0	0
100/11-10-073-03W4/00	Kclwtr_ss	539535.51	6129041.43	717.50	467.41	471.01	469.21	469.00	242.3	490.6	A	0	0
100/07-06-073-04W4/00	Kclearwtr	525097.05	6127294.44	719.21	449.79	453.00	451.39	451.01	227.3	495.1	A	0	0
100/10-16-073-04W4/00	Kclearwtr	528288.28	6130851.57	704.70	430.99	445.01	438.00	431.99	230.7	497.4	A	0	0
100/10-14-073-05W4/00	Kclwtr_ss	521736.54	6130881.27	687.39	407.00	415.50	411.25	409.01	216.2	492.3	A	0	0
100/10-08-074-04W4/00	Kclearwtr	526654.64	6138885.46	617.80	326.11	330.71	328.41	327.69	214.4	503.8	A	0	0
100/11-30-074-05W4/00	Kclearwtr	514852.66	6143665.41	690.10	405.69	413.89	409.79	406.91	219.1	499.4	A	0	0
100/16-01-074-05W4/00	Kclwtr_ss	523731.51	6137485.42	626.40	341.71	346.89	344.30	339.91	220.4	502.5	A	0	2
100/06-24-074-07W4/00	Kclwtr_ss	503488.27	6141626.30	667.79	396.21	403.89	400.05	399.59	236.1	503.9	C	0	0
100/09-13-075-04W4/00	Kclearwtr	533144.81	6150253.56	617.40	368.99	375.09	372.04	371.00	238.5	483.9	B	0	0
100/04-34-075-05W4/00	Kclwtr_ss	519037.91	6154298.67	621.61	342.50	348.51	345.51	344.70	172.8	448.9	C	0	0
1AA/06-31-075-06W4/00	Kclwtr_ss	504599.30	6154738.31	611.10	320.99	326.02	323.50	323.00	138.4	426.0	C	0	0
100/07-06-076-04W4/00	Kclwtr_ss	524445.91	6156411.10	633.80	373.02	378.01	375.51	375.00	242.4	500.7	B	0	0
100/13-10-076-04W4/00	Kclwtr_ss	528562.95	6158828.83	603.11	335.01	341.99	338.50	337.90	225.0	489.6	C	0	0
100/13-17-076-04W4/00	Kclwtr_ss	525268.16	6160306.59	626.40	351.01	355.00	353.01	345.61	197.1	470.5	A	0	5
100/04-19-076-05W4/00	Kclwtr_ss	514158.91	6160797.44	575.31	303.49	308.49	305.99	306.29	216.8	486.1	A	0	0
100/07-18-076-05W4/00	Kclwtr_ss	514912.58	6159337.56	573.30	298.00	305.99	302.00	299.01	217.1	488.4	A	0	0
100/09-20-076-05W4/00	Kclwtr_ss	516909.04	6161321.37	576.99	310.01	315.99	313.00	311.99	233.8	497.8	B	0	0
100/06-26-076-06W4/00	Kclwtr_ss	511002.18	6162550.11	570.01	262.10	271.30	266.70	262.10	201.0	504.4	A	0	0
100/07-28-076-06W4/00	Kclwtr_ss	508390.99	6162556.57	563.91	242.59	255.39	248.99	235.61	203.8	518.8	D	0	7
100/11-14-076-06W4/00	Kclwtr_ss	511142.13	6159785.98	570.01	260.60	265.79	263.20	248.41	204.5	511.3	C	0	12
100/15-02-076-06W4/00	Kclwtr_ss	511647.98	6156829.17	585.00	310.01	315.99	313.00	311.99	222.0	494.1	D	0	0
100/15-02-076-06W4/00	Kclwtr_ss	511647.98	6156829.17	585.00	284.99	290.99	287.99	287.00	197.8	494.8	A	0	0
100/10-14-076-07W4/00	Kclwtr_ss	501871.46	6159904.64	595.31	277.40	288.01	282.70	270.69	201.9	514.5	A	0	7

TABLE 5B-6 CLEARWATER FORMATION REGIONAL HYDRAULIC HEADS FROM DSTs

UWI	Formation	UTM Coordinates (Zone 12; Nad 27)		KB Elevation (masl)	Perforated Interval (m bKB)		Mid Point Perforated Interval (m bKB)	Recorder Depth (m bKB)	Pressure Head (m)	Freshwater Hydraulic Head (masl)	Hydro-Fax QC	QC Recorder Elevation	
		Easting	Northing		Top	Bottom						Below Perfs (m)	Above Perfs (m)
100/10-32-076-08W4/00	Kclwtr_ss	487185.84	6164837.66	618.11	301.81	313.91	307.86	294.71	204.5	514.8	A	0	7
100/11-21-076-08W4/00	Kclwtr_ss	488128.09	6161477.31	646.79	380.39	385.30	382.85	381.92	233.1	497.0	A	0	0
100/07-32-076-15W4/00	Kclwtr_ss	418857.15	6164915.41	684.10	396.00	407.00	401.50	404.29	183.0	465.6	A	0	0
100/07-25-077-06W4/00	Kclearwtr	512964.31	6172576.32	568.79	241.01	245.00	243.00	242.01	175.5	501.3	A	0	0
100/06-16-077-06W4/00	Kclwtr_ss	507766.53	6169028.18	569.40	265.21	268.80	267.01	265.79	193.4	495.8	A	0	0
100/06-16-077-06W4/00	Kclwtr_ss	507766.53	6169028.18	569.40	238.99	259.11	249.05	247.50	181.3	501.7	A	0	0
100/06-16-077-06W4/00	Kclwtr_ss	507766.53	6169028.18	569.40	265.21	286.51	275.86	258.81	210.3	503.9	A	0	6
100/10-03-077-06W4/00	Kclwtr_ss	510012.51	6166399.56	561.11	273.71	277.40	275.56	276.52	199.8	485.4	A	0	0
100/06-24-077-07W4/00	Kclwtr_ss	502837.67	6170723.86	567.20	254.81	266.40	260.60	257.89	199.3	505.9	A	0	0
100/06-27-077-07W4/00	Kclwtr_ss	499873.66	6172263.23	561.69	251.19	255.39	253.29	253.02	190.2	498.6	A	0	0
100/11-15-077-07W4/00	Kclwtr_ss	499651.57	6169618.92	571.20	259.11	266.70	262.91	261.49	194.7	503.0	A	0	0
100/10-03-077-08W4/00	Kclwtr_ss	490498.63	6166428.47	586.41	256.00	263.71	259.86	258.50	185.8	512.4	B	0	0
100/10-13-077-08W4/00	Kclwtr_ss	493623.10	6169535.65	557.21	242.29	251.49	246.89	244.79	197.8	508.1	A	0	0
100/10-22-077-09W4/00	Kclwtr_ss	480607.22	6171170.04	585.80	289.59	303.31	296.45	291.39	205.6	494.9	A	0	0
100/10-22-077-09W4/00	Kclwtr_ss	480607.22	6171170.04	585.80	275.81	290.51	283.16	277.09	204.7	507.3	B	0	0
100/11-06-077-09W4/00	Kclwtr_ss	475214.17	6166554.12	631.00	324.00	330.01	327.01	327.60	205.8	509.7	A	0	0
100/11-18-077-09W4/00	Kclwtr_ss	475214.42	6169701.55	619.69	303.89	318.79	311.34	306.29	198.7	507.1	A	0	0
100/02-25-077-10W4/00	Kclwtr_ss	474195.52	6172145.94	613.59	308.00	314.49	311.25	310.01	171.1	473.5	A	0	0
100/05-17-077-10W4/00	Kclwtr_ss	466977.01	6169375.48	694.00	391.00	394.99	393.00	393.01	111.2	412.2	A	0	0
100/11-14-078-06W4/00	Kclwtr_ss	510980.51	6179132.78	596.31	289.99	297.61	293.80	291.51	193.0	495.5	A	0	0
100/06-11-078-07W4/00	Kclwtr_ss	501252.57	6177115.81	536.82	222.50	231.59	227.05	215.49	203.6	513.3	A	0	7
100/06-16-078-07W4/00	Kclwtr_ss	498000.40	6178742.10	548.92	235.92	252.71	244.31	238.42	199.9	504.5	A	0	0
100/06-16-078-07W4/00	Kclwtr_ss	498000.40	6178742.10	548.92	214.00	217.60	215.80	216.41	175.2	508.4	A	0	0
100/07-35-078-07W4/00	Kclwtr_ss	501821.21	6183573.32	544.40	235.92	239.60	237.76	239.60	191.2	497.8	A	0	0
100/07-35-078-07W4/00	Kclwtr_ss	501821.21	6183573.32	544.40	215.19	218.79	216.99	215.19	174.5	501.9	A	0	0
100/07-35-078-07W4/00	Kclwtr_ss	501821.21	6183573.32	544.40	221.29	224.91	223.10	224.30	194.8	516.1	A	0	0
100/10-27-078-07W4/00	Kclwtr_ss	499966.77	6182677.01	552.12	242.01	246.00	244.01	243.99	190.6	498.7	A	0	0
100/11-17-078-07W4/00	Kclwtr_ss	496469.53	6179378.56	545.59	249.91	253.59	251.75	253.02	205.4	499.2	A	0	0
100/10-01-078-08W4/00	Kclearwtr	493825.36	6176012.63	558.40	251.80	255.39	253.59	254.20	191.8	496.6	A	0	0
100/10-01-078-08W4/00	Kclearwtr	493825.36	6176012.63	558.40	249.30	253.02	251.16	251.80	196.6	503.8	B	0	0
100/02-30-078-08W4/00	Kclwtr_ss	485583.02	6181811.68	592.72	279.99	288.01	284.00	282.00	186.7	495.4	B	0	0
100/10-13-078-08W4/00	Kclwtr_ss	493744.02	6179279.24	529.99	219.79	223.39	221.59	221.59	193.3	501.7	B	0	0
100/10-21-078-08W4/00	Kclwtr_ss	488736.88	6180749.51	570.01	259.69	263.29	261.49	262.10	191.8	500.3	B	0	0
100/10-35-078-08W4/00	Kclwtr_ss	492026.48	6184089.99	569.40	264.60	270.11	267.36	266.09	197.7	499.7	B	0	0
100/10-35-078-08W4/00	Kclwtr_ss	492026.48	6184089.99	569.40	253.02	258.50	255.76	256.00	187.8	501.4	A	0	0
100/07-11-078-09W4/00	Kclwtr_ss	482218.56	6177151.95	600.49	291.39	296.30	293.84	293.19	204.0	510.6	A	0	0
100/07-33-078-09W4/00	Kclwtr_ss	479100.10	6183577.59	662.00	350.49	355.40	352.94	352.99	197.5	506.6	B	0	0
100/10-09-078-09W4/00	Kclwtr_ss	479012.01	6177663.73	602.59	303.61	308.21	305.91	305.11	194.9	491.6	C	0	0
100/10-09-078-09W4/00	Kclwtr_ss	479012.01	6177663.73	602.59	294.10	298.70	296.40	295.99	190.4	496.6	A	0	0
100/10-27-078-09W4/00	Kclwtr_ss	480762.26	6182620.55	629.11	320.01	325.19	322.60	321.60	198.6	505.1	C	0	0
100/10-11-078-10W4/00	Kclwtr_ss	472513.88	6177698.81	622.10	313.91	318.21	316.06	315.50	188.5	494.5	C	0	0
100/10-33-078-11W4/00	Kclearwtr	459684.19	6184371.12	699.70	372.01	377.01	374.51	373.02	157.3	482.5	A	0	0
100/10-32-078-12W4/00	Kclwtr_ss	448313.79	6184493.81	679.61	361.01	365.00	363.00	362.50	168.0	484.6	A	0	0
100/10-32-078-12W4/00	Kclwtr_ss	448313.79	6184493.81	679.61	381.00	384.99	383.00	382.49	205.1	501.7	B	0	0
100/16-11-079-03W4/00	Kclwtr_ss	540761.47	6187978.14	528.80	235.00	253.02	244.01	236.40	274.8	559.5	A	0	0
100/06-34-079-06W4/00	Kclwtr_ss	508889.27	6193289.29	506.30	189.01	201.81	195.41	195.99	191.1	502.0	C	0	0
100/06-34-079-06W4/00	Kclwtr_ss	508889.27	6193289.29	506.30	207.30	219.49	213.39	216.99	212.9	505.9	C	0	0

TABLE 5B-6 CLEARWATER FORMATION REGIONAL HYDRAULIC HEADS FROM DSTs

UWI	Formation	UTM Coordinates (Zone 12; Nad 27)		KB Elevation (masl)	Perforated Interval (m bKB)		Mid Point Perforated Interval (m bKB)	Recorder Depth (m bKB)	Pressure Head (m)	Freshwater Hydraulic Head (masl)	Hydro-Fax QC	QC Recorder Elevation	
		Easting	Northing		Top	Bottom						Below Perfs (m)	Above Perfs (m)
100/11-02-079-07W4/00	Kclwtr_ss	500965.57	6185899.12	550.41	237.01	242.50	239.76	238.99	176.6	487.3	A	0	0
100/10-12-079-08W4/00	Kclwtr_ss	493126.90	6187444.78	572.51	267.01	272.00	269.50	268.01	201.2	504.2	A	0	0
100/10-12-079-08W4/00	Kclwtr_ss	493126.90	6187444.78	572.51	256.00	260.00	258.00	257.01	194.5	509.0	A	0	0
100/06-03-079-09W4/00	Kclearwtr	479572.43	6185361.66	658.10	355.40	364.21	359.80	361.19	200.2	498.5	B	0	0
100/08-19-079-09W4/00	Kclwtr_ss	475344.95	6190344.19	678.70	367.99	372.01	370.00	370.00	191.5	500.2	B	0	0
100/08-19-079-09W4/00	Kclwtr_ss	475344.95	6190344.19	678.70	376.00	388.99	382.49	378.01	205.6	501.8	B	0	0
100/06-06-080-09W4/00	Kclwtr_ss	474891.79	6195206.12	705.49	399.99	404.01	402.00	402.00	201.9	505.3	B	0	0
100/10-06-083-05W4/00	Kclwtr_ss	513817.77	6224563.07	491.00	123.41	129.51	126.46	127.10	88.5	453.1	C	0	0
100/07-21-083-06W4/00	Kclwtr_ss	507237.59	6229017.91	575.80	220.01	231.01	225.51	221.01	105.6	455.9	A	0	0
100/07-32-083-06W4/00	Kclwtr_ss	505542.98	6232228.70	530.29	174.99	185.01	180.00	182.79	100.5	450.7	C	0	0
100/07-16-083-09W4/00	Kclwtr_ss	477778.96	6227470.07	736.70	365.79	371.61	368.70	370.30	91.0	459.0	A	0	0
100/10-01-083-09W4/00	Kclwtr_ss	482853.95	6224482.72	728.50	359.09	362.99	361.04	352.72	98.4	465.8	A	0	6
100/11-31-083-09W4/00	Kclwtr_ss	473971.37	6232933.27	716.31	344.39	348.11	346.25	346.31	84.2	454.3	A	0	0
100/03-13-083-10W4/00	Kclwtr_ss	472337.36	6227151.17	717.59	347.99	351.01	349.50	353.60	90.2	458.3	A	-3	0
100/10-32-083-15W4/00	Kclwtr_ss	417582.59	6233557.91	547.39	189.01	192.91	190.96	191.41	72.3	428.7	A	0	0
100/07-34-083-16W4/00	Kclearwtr	411067.80	6232997.20	529.50	180.11	181.39	180.75	174.19	88.4	437.1	A	0	6
100/11-25-083-17W4/00	Kclwtr_ss	403848.38	6232229.46	513.89	187.09	222.81	204.95	189.01	121.5	430.5	A	0	0
100/06-03-084-09W4/00	Kclearwtr	479130.95	6233891.11	736.09	364.51	368.81	366.66	357.50	94.3	463.8	A	0	7
100/07-20-084-09W4/00	Kclearwtr	476339.60	6238844.32	701.99	329.00	337.99	333.50	334.00	81.7	450.1	D	0	0
100/08-07-084-09W4/00	Kclearwtr	474934.27	6235734.66	711.41	332.20	342.90	337.55	341.10	89.2	463.1	A	0	0
100/10-13-084-11W4/00	Kclwtr_ss	463075.00	6237595.08	618.99	247.50	253.02	250.26	250.52	85.5	454.2	C	0	0
100/04-02-084-15W4/00	Kclearwtr	421696.16	6234377.82	555.80	194.49	197.51	196.00	195.50	81.6	441.4	B	0	0
100/04-26-084-15W4/00	Kclwtr_ss	421812.12	6240832.89	530.81	168.01	173.01	170.51	170.99	80.8	441.1	A	0	0
100/03-02-084-17W4/00	Kclearwtr	402507.75	6234772.90	546.11	248.50	252.50	250.50	250.00	125.7	421.3	C	0	0
100/01-03-085-15W4/00	Kclwtr_ss	421120.04	6244096.55	531.91	190.99	195.01	193.00	192.79	105.8	444.7	A	0	0

Data point eliminated due to depth of pressure recorder
Data point eliminated due to Hydro-Fax QC
Anomalous pressure data point eliminated

TABLE 5B-7 McMURRAY FORMATION REGIONAL HYDRAULIC HEADS FROM DSTs

UWI	Formation	TM Coordinates (Zone 12; Nad 2		KB Elevation (masl)	Perforated Interval (m bKB)		Mid Point Perforated Interval (m bKB)	Recorder Depth (m bKB)	Pressure Head (m)	Freshwater Hydraulic Head (masl)	Hydro-Fax QC	QC Recorder Elevatio	
		Easting	Northing		Top	Bottom						Below Perfs (m)	Above Perfs (m)
100/06-15-070-03W4/00	Kmcm_a1sq	539882.39	6101339.93	707.72	497.01	501.00	499.00	498.99	78.2	286.9	E	0	0
100/07-03-070-08W4/00	Kmcmurray	491518.86	6098012.79	643.50	454.49	457.41	455.95	445.01	263.0	450.6	A	0	9
100/07-32-070-09W4/00	Kmcmurray	478612.38	6106038.28	602.10	425.99	430.01	428.00	428.49	257.5	431.6	A	0	0
100/11-35-070-09W4/00	Kmcmurray	483115.93	6106363.92	619.90	423.00	428.00	425.50	425.90	244.2	438.6	C	0	0
100/06-28-070-10W4/00	Kmcmurray	470120.57	6104509.08	634.02	461.01	465.00	463.01	463.51	266.6	437.6	C	0	0
100/06-28-070-10W4/00	Kmcmurray	470120.57	6104509.08	634.02	467.50	471.01	469.26	470.49	296.8	461.6	C	0	0
100/07-20-070-10W4/00	Kmcmurray	468816.76	6102814.22	653.49	483.99	487.99	485.99	485.21	265.5	433.0	B	0	0
100/14-22-070-10W4/00	Kmcmurray	471595.16	6103416.64	648.80	492.01	495.00	493.50	492.59	274.9	430.2	A	0	0
100/06-07-070-11W4/00	Kmcmurray	456899.16	6099804.00	603.81	434.89	454.21	444.55	438.30	255.1	414.3	A	0	0
100/06-16-070-11W4/00	Kmcmurray	460087.76	6101216.67	647.40	471.19	498.72	484.95	472.72	323.3	485.8	D	0	0
100/11-08-070-11W4/00	Kmcmurray	458669.06	6099987.60	645.29	491.00	496.00	493.50	493.29	271.4	423.2	D	0	0
100/11-20-070-11W4/00	Kmcmurray	458471.88	6103106.62	639.90	477.01	480.49	478.75	479.91	254.0	415.2	A	0	0
100/11-20-070-11W4/00	Kmcmurray	458471.88	6103106.62	639.90	461.99	465.49	463.74	463.91	242.1	418.3	A	0	0
100/06-10-070-12W4/00	Kmcmurray	451910.48	6099893.88	605.00	443.52	463.30	453.41	445.31	256.2	407.8	B	0	0
100/07-08-070-12W4/00	Kmcmurray	449434.54	6099925.68	595.00	449.89	453.51	451.70	452.90	253.4	396.7	C	0	0
100/07-08-070-12W4/00	Kmcmurray	449434.54	6099925.68	595.00	440.71	444.40	442.56	443.79	245.2	397.6	B	0	0
100/07-16-070-12W4/00	Kmcmurray	451022.56	6101440.46	607.50	452.60	467.02	459.81	455.40	246.2	393.9	A	0	0
100/07-16-070-12W4/00	Kmcmurray	451022.56	6101440.46	607.50	437.39	451.41	444.40	444.70	246.7	409.8	A	0	0
100/10-04-070-12W4/00	Kmcmurray	450747.89	6098661.20	604.39	437.69	450.50	444.09	439.80	249.1	409.4	A	0	0
100/10-27-070-12W4/00	Kmcmurray	452621.29	6105147.00	592.81	427.00	437.39	432.19	434.31	250.9	411.5	A	0	0
100/11-21-070-12W4/00	Kmcmurray	450320.67	6103177.69	582.20	402.31	432.79	417.55	404.20	244.5	409.2	C	0	0
100/11-22-070-12W4/00	Kmcmurray	451940.58	6103164.40	598.90	433.09	441.11	437.10	437.11	244.1	406.0	B	0	0
100/11-25-070-12W4/00	Kmcmurray	455549.45	6104991.09	601.01	448.51	452.51	450.51	449.49	250.2	400.7	A	0	0
100/11-25-070-12W4/00	Kmcmurray	455549.45	6104991.09	601.01	420.99	428.00	424.50	422.00	244.7	421.2	A	0	0
100/01-01-070-13W4/00	Kmcmurray	446373.44	6097738.86	581.59	432.79	434.62	433.70	426.69	259.4	407.3	D	0	6
100/06-05-070-13W4/00	Kmcmurray	438986.97	6098140.76	580.89	435.99	440.50	438.24	438.70	219.0	361.6	B	0	0
100/06-08-070-13W4/00	Kmcmurray	438961.11	6099803.88	602.01	458.39	462.11	460.25	460.62	260.0	401.8	B	0	0
100/06-11-070-13W4/00	Kmcmurray	443803.80	6099823.80	583.30	431.99	441.02	436.51	436.99	238.5	385.3	A	0	0
100/06-13-070-13W4/00	Kmcmurray	445462.76	6101333.53	583.91	431.99	451.99	441.99	440.19	249.6	391.5	A	0	0
100/06-19-070-13W4/00	Kmcmurray	437451.61	6103047.94	619.90	534.01	538.00	536.01	540.59	279.7	363.6	A	-3	0
100/06-19-070-13W4/00	Kmcmurray	437451.61	6103047.94	619.90	486.01	503.50	494.75	506.09	257.5	382.6	A	-3	0
100/09-14-070-13W4/00	Kmcmurray	444836.07	6101904.37	590.89	445.01	456.01	450.51	448.00	240.7	381.1	A	0	0
100/09-14-070-13W4/00	Kmcmurray	444836.07	6101904.37	590.89	438.00	449.00	443.50	441.02	235.5	382.9	A	0	0
100/10-01-070-13W4/00	Kmcmurray	446073.38	6098517.07	583.21	430.01	438.00	434.01	432.91	181.2	330.4	A	0	0
100/06-16-070-14W4/00	Kmcmurray	431038.71	6101433.97	593.20	467.99	482.01	475.00	470.31	247.2	365.4	C	0	0
100/07-08-070-14W4/00	Kmcmurray	429877.37	6099901.63	580.62	461.80	472.41	467.11	470.61	260.9	374.4	C	0	0
100/11-21-070-14W4/00	Kmcmurray	430966.04	6103798.02	626.09	503.50	508.50	506.00	506.40	243.6	363.7	B	0	0
100/06-16-070-15W4/00	Kmcmurray	421082.46	6101675.68	568.91	460.01	472.01	466.01	461.99	261.2	364.1	A	0	0
100/06-35-070-15W4/00	Kmcmurray	424602.97	6106586.84	572.60	433.40	444.00	438.70	441.81	239.2	373.1	A	0	0
100/07-21-070-16W4/00	Kmcmurray	412069.14	6103459.28	580.62	482.20	488.90	485.55	485.49	266.0	361.1	C	0	0
100/07-27-070-16W4/00	Kmcmurray	413668.94	6104997.54	579.70	449.61	466.31	457.96	454.49	250.9	372.7	B	0	0
100/07-35-070-16W4/00	Kmcmurray	415327.09	6106775.68	590.09	451.99	477.01	464.50	456.81	250.7	376.3	B	0	0
100/08-34-070-16W4/00	Kmcmurray	413950.65	6106888.87	592.41	464.00	475.00	469.50	472.50	264.7	387.6	D	0	0
100/12-01-070-16W4/00	Kmcmurray	416137.57	6098850.62	563.52	444.00	451.01	447.51	446.02	205.5	321.5	E	0	0
100/02-24-070-17W4/00	Kmcmurray	406914.10	6103387.98	580.31	477.01	479.51	478.26	471.80	265.2	367.3	A	0	5

TABLE 5B-7 McMURRAY FORMATION REGIONAL HYDRAULIC HEADS FROM DSTs

UWI	Formation	TM Coordinates (Zone 12; Nad 2		KB Elevation (masl)	Perforated Interval (m bKB)		Mid Point Perforated Interval (m bKB)	Recorder Depth (m bKB)	Pressure Head (m)	Freshwater Hydraulic Head (masl)	Hydro-Fax QC	QC Recorder Elevatior	
		Easting	Northing		Top	Bottom						Below Perfs (m)	Above Perfs (m)
100/07-09-070-17W4/0(	Kmcmurray	402344.51	6100341.95	545.29	428.49	440.41	434.45	430.99	258.4	369.2	B	0	0
100/07-14-070-17W4/0(	Kmcmurray	405289.21	6102224.38	581.01	467.99	474.00	470.99	472.20	255.0	365.0	B	0	0
100/07-29-070-17W4/0(	Kmcmurray	400746.19	6105420.09	552.21	428.00	434.19	431.10	430.01	234.8	356.0	A	0	0
100/07-35-070-17W4/0(	Kmcmurray	405731.89	6106841.42	573.70	460.01	463.51	461.76	461.01	222.3	334.3	A	0	0
100/06-02-071-04W4/0(	Kmcmurray	531546.36	6107807.96	668.92	431.99	435.99	433.99	435.01	224.1	459.0	A	0	0
100/10-28-071-07W4/0(	Kmcmrry_c	499071.47	6114553.62	660.81	470.00	474.00	472.00	460.71	263.2	452.0	A	0	9
100/12-09-071-08W4/0(	Kmcmurray	488365.04	6109798.02	666.20	464.00	471.01	467.50	466.89	238.4	437.1	A	0	0
100/06-30-071-09W4/0(	Kmcmurray	475790.18	6114256.66	681.81	493.02	507.01	500.01	495.21	248.5	430.3	A	0	0
100/11-28-071-09W4/0(	Kmcmurray	479075.70	6124444.93	665.29	480.00	482.99	481.49	481.49	242.4	426.2	C	0	0
100/13-31-071-09W4/0(	Kmcmurray	475475.95	6116407.32	677.91	477.99	482.01	480.00	479.51	233.0	430.9	A	0	0
100/06-04-071-10W4/0(	Kmcmurray	469182.30	6107655.96	660.02	501.00	504.99	503.00	502.62	262.6	419.6	A	0	0
100/06-33-071-10W4/0(	Kmcmurray	469081.47	6115810.66	668.40	495.79	499.69	497.74	497.59	252.7	423.4	D	0	0
100/07-08-071-10W4/0(	Kmcmurray	468136.02	6109327.06	658.89	481.01	486.01	483.51	484.30	250.2	425.6	A	0	0
100/10-18-071-10W4/0(	Kmcmurray	466342.69	6111397.96	653.80	468.81	479.12	473.97	470.31	246.1	425.9	A	0	0
100/10-18-071-10W4/0(	Kmcmurray	466342.69	6111397.96	653.80	489.51	499.90	494.71	491.00	318.1	477.2	F	0	0
100/11-05-071-10W4/0(	Kmcmurray	467635.71	6108043.08	655.20	477.99	481.01	479.50	479.51	242.4	418.1	B	0	0
100/06-05-071-11W4/0(	Kmcmurray	457742.90	6107914.49	607.50	427.00	433.00	430.00	430.01	250.1	427.6	C	0	0
100/06-05-071-11W4/0(	Kmcmurray	457742.90	6107914.49	607.50	436.99	443.00	440.00	440.01	272.7	440.2	E	0	0
100/09-21-071-11W4/0(	Kmcmurray	460127.21	6113246.65	609.11	430.50	436.51	433.50	433.00	246.4	422.0	A	0	0
100/10-01-071-11W4/0(	Kmcmurray	464603.77	6108080.61	646.00	467.02	488.99	478.00	470.40	252.9	420.9	B	0	0
100/06-27-071-12W4/0(	Kmcmurray	451208.96	6114299.36	611.49	453.21	463.21	458.21	464.70	247.2	400.4	A	-1	0
100/06-34-071-12W4/0(	Kmcmurray	451190.29	6115905.53	625.79	482.80	486.49	484.65	483.41	255.7	396.8	A	0	0
100/07-17-071-12W4/0(	Kmcmurray	448288.60	6110975.74	609.21	459.00	461.99	460.49	451.81	270.3	419.0	D	0	7
100/10-12-071-12W4/0(	Kmcmurray	455073.02	6109711.26	588.30	420.99	430.99	425.99	423.31	246.6	408.9	A	0	0
100/10-12-071-12W4/0(	Kmcmurray	455073.02	6109711.26	588.30	410.51	420.50	415.50	412.79	242.2	415.0	A	0	0
100/10-14-071-12W4/0(	Kmcmurray	453362.31	6111661.99	618.99	443.52	466.31	454.92	445.89	253.5	417.5	D	0	0
100/10-20-071-12W4/0(	Kmcmurray	448588.40	6113308.33	596.19	433.09	440.10	436.60	439.49	240.1	399.7	A	0	0
100/10-30-071-12W4/0(	Kmcmurray	446872.81	6114925.58	646.51	503.01	514.02	508.51	513.01	256.2	394.2	A	0	0
100/10-30-071-12W4/0(	Kmcmurray	446872.81	6114925.58	646.51	493.99	503.01	498.50	502.01	250.3	398.3	B	0	0
100/10-30-071-12W4/0(	Kmcmurray	446872.81	6114925.58	646.51	482.01	490.00	486.01	487.99	319.5	480.0	D	0	0
100/11-25-071-12W4/0(	Kmcmurray	454339.89	6114753.56	602.71	454.00	460.01	457.00	452.51	260.2	405.9	A	0	1
100/11-25-071-12W4/0(	Kmcmurray	454339.89	6114753.56	602.71	436.99	443.00	440.00	435.59	244.9	407.6	B	0	1
100/11-01-071-13W4/0(	Kmcmurray	444638.91	6108503.25	587.90	433.00	448.51	440.76	435.29	243.6	390.7	C	0	0
100/11-18-071-13W4/0(	Kmcmurray	436564.35	6111640.51	647.40	498.01	524.29	511.15	503.50	263.2	399.4	B	0	0
100/05-19-071-14W4/0(	Kmcmurray	426169.79	6113086.45	630.39	481.49	486.49	483.99	483.51	472.2	618.6	F	0	0
100/06-15-071-14W4/0(	Kmcmurray	431505.97	6111290.34	662.30	529.99	539.19	534.59	535.50	238.9	366.6	A	0	0
100/06-15-071-14W4/0(	Kmcmurray	431505.97	6111290.34	662.30	514.81	520.90	517.86	517.61	240.6	385.1	B	0	0
100/07-20-071-14W4/0(	Kmcmurray	428861.63	6113008.07	642.49	490.70	501.40	496.05	498.72	73.4	219.8	F	0	0
100/07-20-071-14W4/0(	Kmcmurray	428861.63	6113008.07	642.49	493.81	535.81	514.81	497.71	230.7	358.4	A	0	0
100/07-26-071-14W4/0(	Kmcmurray	433679.47	6114598.68	648.89	513.59	522.70	518.15	520.90	232.2	362.9	B	0	0
100/07-26-071-14W4/0(	Kmcmurray	433679.47	6114598.68	648.89	487.71	513.59	500.65	492.59	249.7	397.9	C	0	0
100/07-33-071-14W4/0(	Kmcmurray	430570.43	6116125.39	653.80	498.29	515.39	506.84	503.81	235.4	382.3	D	0	0
100/11-22-071-14W4/0(	Kmcmurray	431530.19	6113567.22	649.20	526.39	528.19	527.29	521.51	231.5	353.4	A	0	5
100/11-22-071-14W4/0(	Kmcmurray	431530.19	6113567.22	649.20	497.71	521.21	509.46	499.60	241.2	380.9	A	0	0
100/11-30-071-14W4/0(	Kmcmurray	426784.15	6115138.79	671.81	524.99	529.99	527.49	528.62	200.9	345.3	C	0	0

TABLE 5B-7 McMURRAY FORMATION REGIONAL HYDRAULIC HEADS FROM DSTs

UWI	Formation	TM Coordinates (Zone 12; Nad 2		KB Elevation (masl)	Perforated Interval (m bKB)		Mid Point Perforated Interval (m bKB)	Recorder Depth (m bKB)	Pressure Head (m)	Freshwater Hydraulic Head (masl)	Hydro-Fax QC	QC Recorder Elevatior	
		Easting	Northing		Top	Bottom						Below Perfs (m)	Above Perfs (m)
102/13-29-071-14W4/0(	Kmcmurray	427813.96	6115362.36	645.90	506.00	511.00	508.50	507.49	180.1	317.5	A	0	0
102/13-29-071-14W4/0(	Kmcmurray	427813.96	6115362.36	645.90	500.00	504.99	502.49	501.49	214.2	357.7	A	0	0
100/06-03-071-15W4/0(	Kmcmurray	421719.46	6108403.01	594.00	464.00	467.99	465.99	466.89	218.7	346.7	A	0	0
100/07-05-071-15W4/0(	Kmcmurray	419078.30	6108302.17	606.19	470.00	480.00	475.00	478.60	231.8	363.0	B	0	0
100/08-19-071-15W4/0(	Kmcmurray	417889.18	6113286.17	605.61	467.02	475.00	471.01	459.21	230.3	364.9	C	0	8
100/10-10-071-15W4/0(	Kmcmurray	422255.61	6110462.83	623.29	481.62	497.71	489.66	486.19	228.0	361.7	A	0	0
100/10-30-071-15W4/0(	Kmcmurray	417493.25	6115371.70	596.19	445.01	457.51	451.26	446.81	233.8	378.7	A	0	0
100/10-36-071-15W4/0(	Kmcmurray	425770.58	6116541.37	608.11	465.00	472.99	469.00	472.01	191.5	330.6	A	0	0
100/10-36-071-15W4/0(	Kmcmurray	425770.58	6116541.37	608.11	475.00	485.00	480.00	475.00	261.0	389.1	D	0	0
100/11-01-071-15W4/0(	Kmcmurray	424865.69	6108541.39	584.39	440.01	446.99	443.50	429.31	245.8	386.7	B	0	11
100/11-02-071-15W4/0(	Kmcmurray	423533.58	6108572.96	572.69	434.01	439.00	436.51	436.60	233.7	369.9	B	0	0
100/11-25-071-15W4/0(	Kmcmurray	425303.95	6115299.21	630.51	492.01	496.49	494.25	493.99	169.2	305.5	A	0	0
100/11-35-071-15W4/0(	Kmcmurray	423537.01	6116854.19	598.29	459.49	463.51	461.50	461.01	197.4	334.2	A	0	0
100/12-28-071-15W4/0(	Kmcmurray	419844.42	6115160.59	611.00	461.99	477.99	469.99	464.00	226.9	367.9	C	0	0
100/10-15-071-16W4/0(	Kmcmurray	412302.99	6112182.84	600.09	456.99	476.01	466.50	459.00	256.4	390.0	D	0	0
100/11-06-071-16W4/0(	Kmcmurray	407011.19	6108896.19	580.71	464.00	470.00	467.00	468.20	235.7	349.4	A	0	0
100/11-08-071-16W4/0(	Kmcmurray	408571.66	6110756.28	584.70	450.01	462.99	456.50	451.81	288.2	416.4	D	0	0
100/11-36-071-17W4/0(	Kmcmurray	405481.88	6117203.96	583.39	436.51	449.61	443.06	437.11	235.0	375.3	B	0	0
100/07-27-072-03W4/0(	Kmcmurray	539712.33	6124118.33	696.10	491.00	495.00	493.00	493.02	219.0	422.1	A	0	0
100/07-27-072-03W4/0(	Kmcmurray	539712.33	6124118.33	696.10	487.01	491.00	489.01	488.99	220.2	427.3	A	0	0
100/10-15-072-03W4/0(	Kmcmurray	540013.27	6121053.84	693.60	487.01	491.00	489.01	488.99	219.3	423.9	A	0	0
100/10-15-072-03W4/0(	Kmcmurray	540013.27	6121053.84	693.60	482.01	486.01	484.01	483.99	220.1	429.7	A	0	0
100/10-32-072-03W4/0(	Kmcmurray	536599.02	6125787.59	698.51	486.01	492.50	489.25	487.01	239.4	448.7	A	0	0
100/12-36-072-03W4/0(	Kmcmurray	542095.82	6125836.44	701.99	492.01	496.00	494.01	493.02	237.7	445.7	A	0	0
100/10-01-072-07W4/0(	Kmcmrry_c	504040.36	6117841.57	667.39	467.99	474.51	471.25	469.00	241.9	438.0	C	0	0
100/10-27-072-08W4/0(	Kmcm_c_ch	491016.07	6124348.98	691.01	521.00	530.99	525.99	522.49	260.7	425.8	A	0	0
100/02-06-072-09W4/0(	Kmcmurray	476362.29	6117159.27	681.02	492.50	498.11	495.30	493.99	248.6	434.4	C	0	0
100/03-04-072-09W4/0(	Kmcmurray	479042.36	6117114.65	670.01	466.01	470.00	468.01	467.02	236.6	438.7	B	0	0
100/03-19-072-09W4/0(	Kmcmurray	475892.65	6121861.43	663.31	460.01	467.02	463.51	464.61	228.0	427.8	D	0	0
100/06-09-072-09W4/0(	Kmcmurray	479054.37	6118849.54	681.50	476.01	481.01	478.51	478.60	231.1	434.1	B	0	0
100/06-30-072-09W4/0(	Kmcmurray	475885.86	6124000.41	665.99	464.00	467.99	465.99	465.61	235.4	435.4	A	0	0
100/07-17-072-09W4/0(	Kmcmurray	478027.58	6120543.83	668.70	460.19	469.39	464.79	466.59	226.4	430.3	A	0	0
100/11-28-072-09W4/0(	Kmcmurray	479075.70	6124444.93	668.22	478.51	480.49	479.50	479.12	247.8	436.6	A	0	0
100/03-04-072-10W4/0(	Kmcmurray	469058.96	6117240.87	659.19	498.01	504.99	501.50	500.00	263.0	420.7	A	0	0
100/03-04-072-10W4/0(	Kmcmurray	469058.96	6117240.87	659.19	470.00	483.99	477.00	472.01	239.4	421.6	A	0	0
100/06-24-072-10W4/0(	Kmcmurray	474073.42	6122164.38	673.09	472.01	477.99	475.00	476.19	227.0	425.1	A	0	0
100/06-24-072-10W4/0(	Kmcmurray	474073.42	6122164.38	673.09	486.01	490.00	488.00	488.20	246.7	431.8	A	0	0
100/06-28-072-10W4/0(	Kmcmurray	469118.73	6123809.82	663.00	472.01	475.00	473.51	473.51	234.8	424.3	C	0	0
100/07-27-072-10W4/0(	Kmcmurray	471373.24	6123839.19	672.12	467.02	479.79	473.40	470.31	224.0	422.7	B	0	0
100/07-35-072-10W4/0(	Kmcmurray	473027.22	6125450.29	672.39	498.99	503.99	501.49	501.09	246.5	417.4	A	0	0
100/07-35-072-10W4/0(	Kmcmurray	473027.22	6125450.29	672.39	472.01	478.99	475.50	475.70	232.0	428.9	C	0	0
100/09-21-072-10W4/0(	Kmcmurray	469986.53	6122722.13	665.59	470.49	475.49	472.99	472.01	232.6	425.2	B	0	0
100/10-23-072-10W4/0(	Kmcmurray	473055.45	6122779.20	672.12	469.39	481.62	475.50	474.00	232.2	428.8	B	0	0
100/10-32-072-10W4/0(	Kmcmurray	468187.82	6126048.87	669.31	475.49	482.80	479.15	480.09	237.8	428.0	A	0	0
100/14-01-072-10W4/0(	Kmcmurray	474195.58	6118133.96	668.09	475.00	490.00	482.50	476.01	234.6	420.2	A	0	0

TABLE 5B-7 McMURRAY FORMATION REGIONAL HYDRAULIC HEADS FROM DSTs

UWI	Formation	TM Coordinates (Zone 12; Nad 2		KB Elevation (masl)	Perforated Interval (m bKB)		Mid Point Perforated Interval (m bKB)	Recorder Depth (m bKB)	Pressure Head (m)	Freshwater Hydraulic Head (masl)	Hydro-Fax QC	QC Recorder Elevation	
		Easting	Northing		Top	Bottom						Below Perfs (m)	Above Perfs (m)
100/06-02-072-11W4/00	Kmcmurray	462570.31	6117687.01	625.21	453.00	457.99	455.49	458.51	235.5	405.2	A	-1	0
100/08-01-072-12W4/00	Kmcmurray	455400.17	6117717.63	628.90	467.99	476.01	472.00	469.00	242.0	398.9	A	0	0
100/08-30-072-12W4/00	Kmcmurray	447384.80	6124094.73	632.61	459.00	464.00	461.50	461.01	206.2	377.3	E	0	0
100/11-06-072-12W4/00	Kmcmurray	446543.80	6118122.60	624.60	490.00	493.02	491.51	490.61	271.9	405.0	D	0	0
100/10-17-072-13W4/00	Kmcmurray	438772.24	6121515.24	645.90	482.20	506.61	494.40	486.49	238.2	389.7	A	0	0
100/10-20-072-13W4/00	Kmcmurray	438701.56	6122842.92	647.92	483.99	501.49	492.74	486.01	229.8	385.0	A	0	0
100/10-32-072-13W4/00	Kmcmurray	438755.33	6126316.99	659.89	487.71	526.70	507.20	490.09	241.5	394.1	A	0	0
100/11-15-072-13W4/00	Kmcmurray	441609.31	6121362.34	656.82	494.39	503.50	498.94	502.01	252.0	409.9	A	0	0
100/10-01-072-14W4/00	Kmcmurray	435392.76	6118213.00	655.29	521.51	524.90	523.21	522.70	236.6	368.7	D	0	0
100/10-20-072-14W4/00	Kmcmurray	429132.17	6123237.14	608.41	441.99	469.39	455.69	446.50	236.3	389.1	A	0	0
100/11-12-072-14W4/00	Kmcmurray	434895.76	6119955.46	620.91	460.19	469.39	464.79	466.01	233.7	389.9	C	0	0
100/15-17-072-14W4/00	Kmcmurray	428893.11	6121770.62	618.01	465.00	480.00	472.50	465.80	227.7	373.3	B	0	0
100/06-01-072-15W4/00	Kmcmurray	425184.80	6117792.27	599.30	451.99	459.00	455.49	461.99	138.0	281.8	A	-3	0
100/06-01-072-15W4/00	Kmcmurray	425184.80	6117792.27	599.30	440.01	446.99	443.50	441.99	212.5	368.3	B	0	0
100/07-27-072-15W4/00	Kmcmurray	422591.34	6124396.21	594.39	441.99	454.21	448.10	442.60	223.7	370.0	B	0	0
100/07-27-072-15W4/00	Kmcmurray	422591.34	6124396.21	594.39	432.79	442.60	437.69	433.40	228.5	385.2	B	0	0
100/10-09-072-15W4/00	Kmcmurray	420848.55	6120242.82	610.52	452.29	472.41	462.35	457.81	213.4	361.6	C	0	0
100/10-16-072-15W4/00	Kmcmurray	420874.22	6121788.47	597.71	429.80	454.21	442.01	421.81	243.1	398.8	B	0	8
100/10-20-072-15W4/00	Kmcmurray	419165.36	6123267.47	584.30	422.09	440.41	431.25	439.19	222.2	375.3	B	0	0
100/11-14-072-15W4/00	Kmcmurray	423521.95	6121742.02	607.50	446.20	462.69	454.44	449.89	220.0	373.1	B	0	0
100/11-17-072-15W4/00	Kmcmurray	418617.88	6121847.12	596.19	435.29	443.79	439.54	434.31	232.9	389.6	A	0	1
100/11-32-072-15W4/00	Kmcmurray	418821.16	6126586.43	577.99	413.01	426.90	419.95	415.81	221.8	379.9	C	0	0
100/06-03-072-16W4/00	Kmcmurray	412005.62	6118023.89	575.19	417.61	421.81	419.71	412.40	79.0	234.5	E	0	5
100/06-06-072-16W4/00	Kmcmurray	407137.59	6118207.64	582.81	426.69	433.40	430.04	432.51	231.5	384.3	A	0	0
100/06-22-072-16W4/00	Kmcmurray	412194.41	6123056.12	582.81	419.10	437.39	428.25	425.81	228.3	382.9	B	0	0
100/06-31-072-16W4/00	Kmcmurray	407240.40	6126218.37	578.51	422.52	435.90	429.21	425.20	233.3	382.6	C	0	0
100/07-02-072-16W4/00	Kmcmurray	414216.73	6118057.42	590.70	434.89	437.69	436.29	428.92	218.3	372.7	B	0	6
100/07-07-072-16W4/00	Kmcmurray	407780.15	6119808.39	596.80	441.99	447.81	444.90	445.89	236.0	387.9	B	0	0
100/07-10-072-16W4/00	Kmcmurray	412661.49	6119744.13	575.19	411.51	423.70	417.61	418.19	231.0	388.6	A	0	0
100/10-13-072-16W4/00	Kmcmurray	415729.43	6121913.32	577.60	420.59	426.69	423.64	423.70	228.9	382.8	B	0	0
100/11-09-072-16W4/00	Kmcmurray	410443.24	6120358.29	582.20	422.52	431.29	426.90	428.92	228.5	383.8	D	0	0
100/13-16-072-16W4/00	Kmcmurray	410377.65	6122181.90	582.11	414.50	427.00	420.75	417.52	182.0	343.3	B	0	0
100/10-17-072-17W4/00	Kmcmurray	399572.40	6122119.59	595.00	448.09	452.29	450.19	451.11	242.8	387.6	D	0	0
100/10-23-072-17W4/00	Kmcmurray	404588.30	6123708.72	563.91	408.40	415.69	412.05	413.01	220.4	372.2	B	0	0
100/11-25-072-17W4/00	Kmcmurray	405690.19	6125316.00	593.42	434.31	437.11	435.71	430.99	212.7	370.4	B	0	3
100/11-30-072-17W4/00	Kmcmurray	397499.60	6125578.14	585.19	437.11	454.21	445.66	442.60	228.2	367.7	B	0	0
100/09-12-073-01W4/00	Kmcmurray	563123.02	6129542.21	669.50	459.00	462.99	461.00	460.01	221.0	429.5	A	0	0
100/07-26-073-03W4/00	Kmcmurray	541512.13	6133866.31	685.50	480.49	485.00	482.74	483.41	224.0	426.8	A	0	0
100/11-10-073-03W4/00	Kmcmurray	539535.51	6129041.43	717.50	515.39	518.59	516.99	517.00	225.8	426.3	A	0	0
100/06-06-073-06W4/00	Kmcmry_ch	505030.73	6127223.91	730.00	524.01	537.00	530.51	524.99	246.3	445.8	C	0	0
100/10-34-073-08W4/00	Kmcmurray	491085.44	6135734.56	703.69	482.01	492.01	487.01	482.99	221.8	438.5	A	0	0
100/06-32-073-09W4/00	Kmcm_a2sq	477500.15	6135368.92	659.50	443.00	449.00	446.00	446.59	216.7	430.2	A	0	0
100/16-33-073-09W4/00	Kmcmrry_c	479807.16	6135853.00	658.89	456.01	459.49	457.75	457.69	231.5	432.6	A	0	0
100/11-23-073-09W4/00	Kmcmry_ch	482354.99	6132342.06	654.50	446.99	476.01	461.50	446.99	232.1	425.1	A	0	0
100/11-31-073-09W4/00	Kmcmry_ch	475893.53	6135651.17	659.41	462.99	465.00	464.00	463.30	236.8	432.2	C	0	0

TABLE 5B-7 McMURRAY FORMATION REGIONAL HYDRAULIC HEADS FROM DSTs

UWI	Formation	TM Coordinates (Zone 12; Nad 2		KB Elevation (masl)	Perforated Interval (m bKB)		Mid Point Perforated Interval (m bKB)	Recorder Depth (m bKB)	Pressure Head (m)	Freshwater Hydraulic Head (masl)	Hydro-Fax QC	QC Recorder Elevation	
		Easting	Northing		Top	Bottom						Below Perfs (m)	Above Perfs (m)
100/08-08-073-09W4/00	Kmcmurray	478085.41	6128882.30	665.90	453.00	461.99	457.49	457.81	235.1	443.5	B	0	0
100/10-17-073-09W4/00	Kmcmurray	477880.20	6130754.08	668.70	462.11	470.00	466.06	463.91	225.4	428.1	A	0	0
100/10-17-073-09W4/00	Kmcmurray	477880.20	6130754.08	668.70	452.60	460.89	456.74	454.49	218.5	430.5	A	0	0
100/09-32-073-10W4/00	Kmcm_a_ch	468444.16	6135695.92	662.52	456.01	464.00	460.01	450.31	232.7	435.2	B	0	6
100/09-29-073-10W4/00	Kmcmurray	468660.77	6134063.96	661.11	472.01	477.99	475.00	474.00	232.0	418.1	A	0	0
100/09-29-073-10W4/00	Kmcmurray	468660.77	6134063.96	661.11	472.01	477.99	475.00	474.00	237.4	423.5	D	0	0
100/12-22-073-10W4/00	Kmcmurray	470659.17	6132213.94	664.71	461.01	464.00	462.50	461.59	226.3	428.5	A	0	0
100/14-25-073-11W4/00	Kmcmurray	464676.79	6134624.90	657.61	482.01	485.49	483.75	483.69	250.4	424.3	A	0	0
100/11-31-073-12W4/00	Kmcmurray	446601.70	6135760.35	660.41	467.99	488.99	478.49	485.00	216.8	398.7	A	0	0
100/08-11-073-13W4/00	Kmcmurray	444003.41	6129166.88	669.50	482.99	487.99	485.49	485.70	226.0	410.0	A	0	0
100/10-17-073-13W4/00	Kmcmurray	438938.91	6131282.96	671.51	490.70	516.91	503.81	494.69	217.8	385.5	D	0	0
100/10-17-073-13W4/00	Kmcmurray	438938.91	6131282.96	671.51	490.70	508.99	499.84	497.40	220.9	392.5	B	0	0
100/11-30-073-13W4/00	Kmcmurray	436773.75	6134260.72	676.11	514.02	525.99	520.01	515.51	227.4	383.5	A	0	0
100/13-17-073-13W4/00	Kmcmurray	437902.93	6131712.55	676.20	508.99	514.99	511.99	509.99	214.7	378.9	A	0	0
100/04-08-073-14W4/00	Kmcmurray	428375.22	6129029.48	647.49	470.00	500.00	485.00	470.80	223.6	386.1	B	0	0
100/06-06-073-14W4/00	Kmcmurray	427012.52	6127526.83	620.61	444.40	473.39	458.89	451.71	235.7	397.4	A	0	0
100/06-35-073-14W4/00	Kmcmurray	433490.67	6135532.19	686.72	501.09	538.89	519.99	505.70	218.7	385.5	B	0	0
100/07-20-073-14W4/00	Kmcmurray	428957.86	6132449.47	673.31	490.70	515.11	502.91	495.00	225.2	395.6	A	0	0
100/10-08-073-14W4/00	Kmcmurray	429108.75	6129632.08	652.30	478.51	485.21	481.86	484.30	227.2	397.7	C	0	0
100/10-10-073-14W4/00	Kmcmurray	432426.84	6129686.99	663.89	490.70	506.61	498.65	491.31	231.5	396.8	A	0	0
100/06-24-073-15W4/00	Kmcmurray	425283.98	6132665.90	652.00	512.00	518.59	515.30	513.71	199.3	336.0	A	0	0
100/06-24-073-15W4/00	Kmcmurray	425283.98	6132665.90	652.00	504.99	511.00	508.00	506.70	214.5	358.5	B	0	0
100/07-02-073-15W4/00	Kmcmurray	424235.31	6127596.88	608.41	440.41	451.71	446.06	449.61	237.0	399.3	B	0	0
100/07-23-073-15W4/00	Kmcmurray	424172.79	6132690.40	641.30	471.01	477.99	474.50	476.01	228.7	395.5	B	0	0
100/07-36-073-15W4/00	Kmcmurray	426089.58	6135875.88	672.21	525.51	535.99	530.75	530.69	187.5	329.0	C	0	0
100/08-35-073-15W4/00	Kmcmurray	424721.83	6135902.34	656.60	516.00	524.99	520.49	518.31	190.0	326.2	C	0	0
100/10-01-073-15W4/00	Kmcmurray	425883.19	6128175.61	629.11	469.39	480.09	474.74	478.20	224.7	379.0	A	0	0
100/10-25-073-15W4/00	Kmcmurray	425728.32	6134375.92	657.91	513.50	518.50	516.00	514.99	203.4	345.3	A	0	0
100/10-25-073-15W4/00	Kmcmurray	425728.32	6134375.92	657.91	482.99	487.99	485.49	485.00	226.3	398.7	A	0	0
100/11-26-073-15W4/00	Kmcmurray	423696.84	6134410.56	645.69	502.49	507.49	504.99	504.99	209.5	350.2	B	0	0
100/11-26-073-15W4/00	Kmcmurray	423696.84	6134410.56	645.69	475.00	480.00	477.50	477.90	225.1	393.3	A	0	0
100/11-32-073-15W4/00	Kmcmurray	418964.86	6136388.33	631.21	455.71	481.62	468.66	457.51	221.9	384.4	A	0	0
100/11-35-073-15W4/00	Kmcmurray	423731.60	6136349.00	660.20	490.79	515.39	503.09	495.09	235.4	392.5	A	0	0
100/07-21-073-16W4/00	Kmcmurray	411285.19	6132919.26	574.40	427.00	436.99	431.99	433.40	226.0	368.4	A	0	0
100/07-21-073-16W4/00	Kmcmurray	411285.19	6132919.26	574.40	410.51	419.01	414.76	414.50	225.0	384.7	A	0	0
100/07-33-073-16W4/00	Kmcmurray	411371.66	6135929.84	590.00	425.99	436.99	431.49	420.02	213.5	372.1	D	0	6
100/08-09-073-16W4/00	Kmcmurray	411724.96	6129711.14	574.00	413.01	420.02	416.51	414.99	222.6	380.1	A	0	0
100/10-36-073-16W4/00	Kmcmurray	416257.43	6136439.99	611.70	442.60	477.01	459.81	447.81	236.3	388.2	A	0	0
100/11-08-073-16W4/00	Kmcmurray	409014.01	6130105.61	575.19	414.50	424.31	419.41	417.91	230.1	385.8	A	0	0
100/11-18-073-16W4/00	Kmcmurray	407387.60	6131546.49	575.01	414.01	420.99	417.50	403.01	234.1	391.6	A	0	11
100/06-01-073-17W4/00	Kmcmurray	405715.78	6127949.36	581.59	425.20	430.41	427.80	427.91	189.7	343.5	E	0	0
100/06-24-073-17W4/00	Kmcmurray	406086.45	6132776.24	574.49	411.51	423.70	417.61	413.89	230.5	387.3	A	0	0
100/06-34-073-17W4/00	Kmcmurray	402716.33	6136358.18	575.89	414.01	424.01	419.01	415.99	212.0	368.8	B	0	0
100/10-06-073-17W4/00	Kmcmurray	398196.94	6128727.14	585.19	426.69	435.90	431.29	431.29	229.5	383.4	D	0	0
100/10-13-073-17W4/00	Kmcmurray	406219.74	6131820.48	575.80	411.51	415.11	413.31	413.61	238.0	400.4	B	0	0

TABLE 5B-7 McMURRAY FORMATION REGIONAL HYDRAULIC HEADS FROM DSTs

UWI	Formation	TM Coordinates (Zone 12; Nad 2		KB Elevation (masl)	Perforated Interval (m bKB)		Mid Point Perforated Interval (m bKB)	Recorder Depth (m bKB)	Pressure Head (m)	Freshwater Hydraulic Head (masl)	Hydro-Fax QC	QC Recorder Elevatio	
		Easting	Northing		Top	Bottom						Below Perfs (m)	Above Perfs (m)
100/10-15-073-17W4/0	Kmcmurray	403200.13	6131842.17	578.91	435.01	444.00	439.51	441.81	222.1	361.5	A	0	0
100/10-09-074-07W4/0	Kmcmry_ch	499036.65	6138811.66	696.20	511.79	524.90	518.34	513.32	281.7	459.5	D	0	0
100/10-11-074-08W4/0	Kmcm_c_ch	492623.15	6138813.28	716.50	529.99	534.01	532.00	530.99	265.3	449.8	A	0	0
100/06-30-074-08W4/0	Kmcmrry_c	485606.38	6143190.90	677.60	471.80	475.49	473.65	473.69	231.7	435.7	D	0	0
100/11-08-074-09W4/0	Kmcm_a2sq	477506.67	6139008.05	669.62	448.09	457.20	452.64	450.50	220.8	437.8	C	0	0
100/11-28-074-09W4/0	Kmcm_a2sq	479134.36	6143810.00	668.40	440.01	449.00	444.51	441.02	206.1	430.0	D	0	0
100/07-27-074-09W4/0	Kmcmry_ch	481240.85	6143148.36	665.41	445.01	451.11	448.06	446.50	208.7	426.1	E	0	0
100/11-08-074-09W4/0	Kmcmry_ch	477506.67	6139008.05	669.62	463.91	472.99	468.45	478.51	230.2	431.3	C	-6	0
100/09-34-074-10W4/0	Kmcm_a2sq	471681.54	6145199.38	678.30	455.01	467.02	461.01	456.99	224.3	441.6	B	0	0
100/12-08-074-10W4/0	Kmcm_b1sq	467518.60	6138949.02	662.30	464.00	469.00	466.50	467.41	253.8	449.6	D	0	0
100/05-31-074-11W4/0	Kmcmry_ch	455870.96	6145024.61	660.02	486.01	503.99	495.00	505.70	232.9	397.9	A	-2	0
100/07-33-074-11W4/0	Kmcmry_ch	460057.28	6145107.04	660.50	422.79	470.61	446.70	412.09	343.9	557.7	A	0	11
100/06-08-074-11W4/0	Kmcmurray	457873.01	6138475.28	664.80	467.60	476.71	472.15	474.30	248.6	441.2	C	0	0
100/06-05-074-12W4/0	Kmcmry_ch	448151.07	6137060.76	664.59	498.01	503.99	501.00	498.99	251.5	415.1	C	0	0
100/13-01-074-12W4/0	Kmcmry_ch	454564.91	6137614.41	666.90	481.01	493.99	487.50	482.01	244.7	424.1	C	0	0
100/06-33-074-13W4/0	Kmcmurray	440077.65	6145151.27	735.21	568.09	577.29	572.69	570.59	232.4	394.9	B	0	0
100/06-33-074-13W4/0	Kmcmurray	440077.65	6145151.27	735.21	550.50	559.61	555.06	552.91	220.7	400.9	B	0	0
100/06-33-074-13W4/0	Kmcmurray	440077.65	6145151.27	735.21	550.81	559.89	555.35	552.60	223.4	403.3	A	0	0
100/07-20-074-13W4/0	Kmcmurray	439011.16	6142051.63	732.41	545.99	576.01	561.00	550.01	255.7	427.1	A	0	0
100/07-20-074-13W4/0	Kmcmurray	439011.16	6142051.63	732.41	545.99	565.01	555.50	550.20	265.5	442.4	B	0	0
100/10-17-074-13W4/0	Kmcmurray	438870.01	6140730.19	726.89	540.99	551.99	546.49	550.20	212.3	392.7	A	0	0
100/10-17-074-13W4/0	Kmcmurray	438870.01	6140730.19	726.89	557.51	566.99	562.25	565.19	229.2	393.8	A	0	0
100/11-06-074-13W4/0	Kmcmurray	436713.93	6137650.78	698.21	523.01	540.02	531.51	528.01	217.2	383.9	A	0	0
100/05-20-074-14W4/0	Kmcmurray	428638.13	6142168.54	728.20	543.00	564.49	553.75	545.29	207.3	381.7	A	0	0
100/06-23-074-14W4/0	Kmcmurray	433587.67	6142093.35	774.50	603.99	607.01	605.50	605.00	215.6	384.6	A	0	0
100/06-27-074-14W4/0	Kmcmurray	432006.10	6143642.40	773.89	585.19	603.51	594.35	592.50	228.3	407.8	C	0	0
100/07-10-074-14W4/0	Kmcmurray	432256.40	6139092.74	725.79	560.01	568.00	564.00	562.30	212.1	373.9	C	0	0
100/11-28-074-14W4/0	Kmcmurray	430350.69	6144332.79	763.80	594.39	598.60	596.50	596.50	211.3	378.6	A	0	0
100/11-28-074-14W4/0	Kmcmurray	430350.69	6144332.79	763.80	575.49	591.89	583.69	588.30	234.2	414.3	B	0	0
100/06-08-074-15W4/0	Kmcmurray	418888.30	6139084.68	651.69	500.51	509.29	504.90	506.91	216.6	363.4	B	0	0
100/06-08-074-15W4/0	Kmcmurray	418888.30	6139084.68	651.69	477.01	499.29	488.15	483.69	211.8	375.3	B	0	0
100/07-11-074-15W4/0	Kmcmurray	424342.46	6139214.78	691.90	544.50	549.59	547.04	546.51	176.5	321.3	A	0	0
100/09-04-074-15W4/0	Kmcmurray	421639.65	6137926.23	654.90	497.01	517.00	507.01	498.99	193.8	341.7	A	0	0
100/09-04-074-15W4/0	Kmcmurray	421639.65	6137926.23	654.90	472.01	492.01	482.01	474.00	204.2	377.1	B	0	0
100/09-32-074-15W4/0	Kmcmurray	420117.78	6145942.62	720.00	548.00	565.01	556.51	551.60	176.1	339.6	D	0	0
100/10-06-074-15W4/0	Kmcmurray	417808.06	6137931.41	637.00	477.01	499.90	488.46	498.99	244.9	393.5	B	0	0
100/11-03-074-15W4/0	Kmcmurray	422246.25	6137896.57	660.81	464.79	517.89	491.34	486.49	222.9	392.4	A	0	0
100/11-04-074-15W4/0	Kmcmurray	420497.44	6137879.89	641.70	460.01	470.00	465.00	467.50	223.5	400.2	A	0	0
100/11-36-074-15W4/0	Kmcmurray	425617.91	6145856.18	751.00	571.50	597.41	584.46	574.92	224.1	390.7	B	0	0
100/11-14-074-16W4/0	Kmcmurray	414122.67	6141347.88	637.31	469.39	487.71	478.55	470.89	209.6	368.3	C	0	0
100/11-22-074-16W4/0	Kmcmurray	412578.94	6142956.76	648.62	471.19	485.49	478.34	476.10	208.6	378.9	A	0	0
100/11-28-074-16W4/0	Kmcmurray	411026.07	6144558.62	652.61	480.09	500.21	490.15	474.61	196.6	359.1	D	0	5
100/06-24-074-17W4/0	Kmcmurray	406023.77	6142511.79	602.59	426.69	443.52	435.10	421.20	208.7	376.1	A	0	5
100/07-09-074-17W4/0	Kmcmurray	401500.68	6139676.01	575.71	409.99	428.00	418.99	415.99	169.8	326.5	D	0	0
100/07-14-074-17W4/0	Kmcmurray	405061.87	6140833.59	587.99	410.60	430.99	420.79	419.10	203.7	370.9	A	0	0

TABLE 5B-7 McMURRAY FORMATION REGIONAL HYDRAULIC HEADS FROM DSTs

UWI	Formation	TM Coordinates (Zone 12; Nad 2		KB Elevation (masl)	Perforated Interval (m bKB)		Mid Point Perforated Interval (m bKB)	Recorder Depth (m bKB)	Pressure Head (m)	Freshwater Hydraulic Head (masl)	Hydro-Fax QC	QC Recorder Elevatior	
		Easting	Northing		Top	Bottom						Below Perfs (m)	Above Perfs (m)
100/07-22-074-17W4/00	Kmcmurray	403385.00	6142588.94	589.79	417.61	426.11	421.86	420.59	206.5	374.4	A	0	0
100/07-26-074-17W4/00	Kmcmurray	405043.00	6144158.20	613.02	435.90	450.80	443.35	436.51	207.3	377.0	A	0	0
100/10-10-074-17W4/00	Kmcmurray	403232.99	6139761.22	577.90	409.99	416.39	413.19	413.89	201.2	365.9	B	0	0
100/10-16-074-17W4/00	Kmcmurray	401818.54	6141599.36	578.21	406.91	419.10	413.01	414.19	199.7	364.9	B	0	0
100/09-13-075-04W4/00	Kmcm_a1sq	533144.81	6150253.56	617.40	397.00	403.10	400.05	399.01	209.6	426.9	B	0	0
100/16-27-075-04W4/00	Kmcmry_ch	529799.54	6153799.88	598.99	400.51	408.49	404.50	403.19	105.6	300.1	E	0	0
1AA/03-28-075-06W4/0	Kmcmurray	507756.98	6152738.42	613.90	430.99	440.01	435.50	433.00	266.1	444.5	C	0	0
100/11-08-075-08W4/00	Kmcm_a2sq	486472.25	6148419.88	669.31	440.01	450.01	445.01	433.91	343.8	568.1	E	0	6
100/11-24-075-09W4/00	Kmcm_a2sq	483234.61	6151915.55	677.30	448.09	457.20	452.64	453.21	221.5	446.2	G	0	0
100/11-18-075-12W4/00	Kmcm_b1sq	445795.03	6150588.76	688.70	495.00	500.00	497.50	498.29	212.7	403.9	B	0	0
100/06-25-075-12W4/00	Kmcmrry_c	453903.60	6153086.09	673.31	472.41	490.70	481.55	465.10	226.6	418.4	G	0	7
100/10-30-075-12W4/00	Kmcmry_ch	446295.96	6153782.54	697.99	500.00	506.00	503.00	503.99	215.8	410.8	A	0	0
100/07-12-075-13W4/00	Kmcm_b1sq	444589.37	6148368.86	685.19	493.20	496.80	495.00	482.50	210.8	401.0	B	0	11
100/07-24-075-13W4/00	Kmcm_b1sq	444528.58	6151663.07	702.90	506.00	511.09	508.55	508.41	210.1	404.4	C	0	0
100/13-36-075-13W4/00	Kmcm_b1sq	443930.20	6155598.57	715.40	519.02	529.01	524.01	521.61	209.1	400.5	C	0	0
100/07-12-075-13W4/00	Kmcmrry_c	444589.37	6148368.86	685.19	499.29	502.89	501.09	504.69	219.1	403.2	B	-2	0
100/07-12-075-13W4/00	Kmcmrry_c	444589.37	6148368.86	685.19	499.29	502.89	501.09	504.69	223.0	407.1	D	-2	0
100/06-28-075-13W4/00	Kmcmurray	439160.69	6153253.50	726.19	560.01	566.99	563.50	563.61	239.7	402.4	C	0	0
100/06-28-075-13W4/00	Kmcmurray	439160.69	6153253.50	726.19	519.99	544.01	532.00	521.61	211.5	405.7	A	0	0
100/05-12-075-14W4/00	Kmcmurray	434012.02	6148390.29	759.72	575.01	587.02	581.01	576.99	218.0	396.7	A	0	0
100/06-30-075-14W4/00	Kmcmurray	426195.93	6153671.72	754.41	562.11	575.80	568.96	566.02	208.2	393.6	A	0	0
100/06-31-075-14W4/00	Kmcmurray	426060.58	6155118.84	733.29	538.31	552.30	545.30	541.60	198.3	386.3	A	0	0
100/06-32-075-14W4/00	Kmcmurray	427789.61	6155084.46	742.19	546.20	561.41	553.81	549.59	213.8	402.2	A	0	0
100/07-03-075-14W4/00	Kmcmurray	431284.13	6146890.46	777.79	595.00	617.01	606.01	596.31	226.1	397.9	A	0	0
100/08-05-075-14W4/00	Kmcmurray	428567.24	6147236.53	780.11	606.01	612.01	609.01	608.90	184.7	355.8	A	0	0
100/11-11-075-14W4/00	Kmcmurray	432832.97	6148842.25	767.79	584.30	598.60	591.45	584.61	209.1	385.5	B	0	0
100/11-29-075-14W4/00	Kmcmurray	427843.05	6154111.83	745.91	561.02	569.00	565.01	566.50	188.6	369.5	A	0	0
100/11-33-075-14W4/00	Kmcmurray	429375.44	6155604.06	726.01	530.41	545.59	538.00	531.91	207.1	395.1	A	0	0
100/12-34-075-14W4/00	Kmcmurray	430864.23	6155477.93	723.20	529.99	544.01	537.00	532.61	310.5	496.7	D	0	0
100/07-20-075-15W4/00	Kmcmurray	418524.78	6151971.84	725.70	542.52	560.80	551.66	546.51	197.8	371.8	D	0	0
100/07-26-075-15W4/00	Kmcmurray	423230.65	6153747.09	762.00	566.90	589.21	578.05	569.40	202.2	386.2	A	0	0
100/10-08-075-15W4/00	Kmcmurray	418552.45	6149102.67	704.61	519.02	524.01	521.51	522.00	196.6	379.7	A	0	0
100/10-13-075-15W4/00	Kmcmurray	425137.47	6150626.30	812.11	637.00	641.00	639.00	639.72	142.2	315.4	A	0	0
100/11-29-075-15W4/00	Kmcmurray	417956.43	6154213.25	763.50	573.00	586.71	579.85	576.10	215.0	398.7	D	0	0
100/11-35-075-15W4/00	Kmcmurray	422838.47	6155718.69	748.32	552.30	568.09	560.19	555.99	209.4	397.5	A	0	0
100/06-08-075-16W4/00	Kmcmurray	407973.29	6148950.82	678.49	512.10	524.90	518.50	520.60	190.8	350.8	D	0	0
100/06-23-075-16W4/00	Kmcmurray	412970.59	6152273.26	732.80	547.00	570.01	558.50	550.99	181.0	355.3	A	0	0
100/07-03-075-16W4/00	Kmcmurray	411908.28	6147243.76	671.51	486.80	512.40	499.60	491.00	203.8	375.7	B	0	0
100/07-17-075-16W4/00	Kmcmurray	408702.00	6150549.83	688.51	519.41	536.39	527.90	524.90	200.2	360.8	B	0	0
100/07-22-075-16W4/00	Kmcmurray	411990.17	6152118.03	728.20	535.20	560.80	548.00	539.80	211.6	391.8	A	0	0
100/07-25-075-16W4/00	Kmcmurray	415199.13	6153798.14	745.51	550.50	570.01	560.25	557.51	201.6	386.9	A	0	0
100/11-02-075-17W4/00	Kmcmurray	403391.32	6148034.97	631.52	485.00	487.99	486.49	475.79	192.7	337.8	C	0	9
100/06-19-076-03W4/00	Kmcmry_ch	534095.57	6161293.55	613.99	399.01	402.70	400.86	401.00	189.6	402.8	B	0	0
100/14-29-076-03W4/00	Kmcmurray	535434.40	6163586.88	599.12	365.00	372.50	368.75	367.01	186.9	417.3	A	0	0
100/13-17-076-04W4/00	Kmcm_a1sq	525268.16	6160306.59	626.40	373.50	380.00	376.75	368.11	193.3	442.9	A	0	5

TABLE 5B-7 McMURRAY FORMATION REGIONAL HYDRAULIC HEADS FROM DSTs

UWI	Formation	TM Coordinates (Zone 12; Nad 2		KB Elevation (masl)	Perforated Interval (m bKB)		Mid Point Perforated Interval (m bKB)	Recorder Depth (m bKB)	Pressure Head (m)	Freshwater Hydraulic Head (masl)	Hydro-Fax QC	QC Recorder Elevatior	
		Easting	Northing		Top	Bottom						Below Perfs (m)	Above Perfs (m)
100/13-10-076-04W4/0	Kmcmry_ch	528562.95	6158828.83	603.11	362.99	367.50	365.24	365.91	164.2	402.1	C	0	0
100/13-10-076-04W4/0	Kmcmry_ch	528562.95	6158828.83	603.11	377.01	389.99	383.50	379.90	199.1	418.7	A	0	0
100/13-14-076-04W4/0	Kmcmry_ch	530139.96	6160467.64	604.82	371.00	380.00	375.50	373.02	203.7	433.0	G	0	0
100/13-14-076-04W4/0	Kmcmry_ch	530139.96	6160467.64	604.82	367.99	371.00	369.49	370.00	198.3	433.6	A	0	0
100/13-14-076-04W4/0	Kmcmry_ch	530139.96	6160467.64	604.82	371.00	380.00	375.50	361.89	226.9	456.2	G	0	9
100/13-17-076-04W4/0	Kmcmry_ch	525268.16	6160306.59	626.40	384.99	391.49	388.24	389.20	220.4	458.5	A	0	0
100/06-25-076-05W4/0	Kmcm_b1sq	522387.76	6162631.41	597.11	354.00	360.00	357.00	355.00	193.0	433.1	A	0	0
100/10-05-076-05W4/0	Kmcmry_ch	516499.11	6156724.55	615.70	361.19	374.91	368.05	363.60	201.0	448.6	A	0	0
100/10-08-076-05W4/0	Kmcmry_ch	516463.82	6158227.97	581.90	380.00	389.99	384.99	382.01	218.9	415.8	B	0	0
100/07-28-076-06W4/0	Kmcm_a1sq	508390.99	6162556.57	563.91	298.70	305.99	302.35	291.69	199.7	461.3	A	0	7
100/15-02-076-06W4/0	Kmcm_b1sq	511647.98	6156829.17	585.00	345.00	351.01	348.01	347.02	201.1	438.1	A	0	0
100/11-03-076-06W4/0	Kmcmry_ch	509420.35	6156691.38	594.39	353.60	362.71	358.16	360.61	203.1	439.4	A	0	0
100/10-24-076-10W4/0	Kmcmry_ch	474156.08	6161644.37	659.80	425.99	441.02	433.50	428.00	163.0	389.3	C	0	0
100/12-13-076-10W4/0	Kmcmry_ch	473362.08	6160080.99	665.99	433.00	450.01	441.50	434.01	516.1	740.6	B	0	0
100/07-17-076-11W4/0	Kmcmrry_c	457828.99	6159513.02	671.51	469.39	478.51	473.95	470.31	213.6	411.1	B	0	0
100/10-14-076-13W4/0	Kmcm_c_ch	443190.74	6159989.03	720.00	534.99	540.99	537.99	529.80	214.4	396.4	C	0	5
100/10-14-076-13W4/0	Kmcmrry_c	443190.74	6159989.03	720.00	517.00	528.01	522.50	511.79	221.1	418.6	A	0	5
100/11-12-076-13W4/0	Kmcmrry_c	444139.93	6158633.37	731.89	528.01	537.00	532.50	529.99	207.4	406.8	B	0	0
100/06-18-076-13W4/0	Kmcmurray	436211.51	6159864.77	683.91	492.01	511.00	501.50	500.00	212.7	395.1	D	0	0
100/05-35-076-14W4/0	Kmcmurray	432637.58	6164928.41	667.30	470.00	485.00	477.50	472.50	208.7	398.5	G	0	0
100/10-30-076-14W4/0	Kmcmurray	426617.69	6163681.77	685.80	518.80	523.59	521.19	520.60	209.5	374.2	A	0	0
100/10-30-076-14W4/0	Kmcmurray	426617.69	6163681.77	685.80	508.71	513.59	511.15	510.51	199.8	374.5	B	0	0
100/10-30-076-14W4/0	Kmcmurray	426617.69	6163681.77	685.80	492.59	497.40	495.00	495.00	206.0	396.8	B	0	0
100/11-18-076-14W4/0	Kmcmurray	426255.85	6160528.75	698.60	530.41	534.59	532.50	532.79	194.0	360.1	B	0	0
100/11-18-076-14W4/0	Kmcmurray	426255.85	6160528.75	698.60	521.21	527.31	524.26	523.59	204.7	379.0	B	0	0
100/11-18-076-14W4/0	Kmcmurray	426255.85	6160528.75	698.60	510.21	516.30	513.25	512.71	200.4	385.7	B	0	0
100/11-18-076-14W4/0	Kmcmurray	426255.85	6160528.75	698.60	506.61	512.71	509.66	508.99	200.6	389.5	C	0	0
100/11-18-076-14W4/0	Kmcmurray	426255.85	6160528.75	698.60	499.90	506.00	502.95	502.31	203.7	399.3	D	0	0
100/06-02-076-15W4/0	Kmcmurray	422996.45	6156986.03	716.59	515.11	537.70	526.41	516.91	213.7	403.8	B	0	0
100/06-13-076-15W4/0	Kmcmurray	424509.12	6160070.96	691.59	501.09	515.69	508.39	502.89	191.2	374.4	A	0	0
100/06-14-076-15W4/0	Kmcmurray	422922.68	6160036.27	716.31	553.21	556.90	555.06	554.40	201.3	362.6	B	0	0
100/06-14-076-15W4/0	Kmcmurray	422922.68	6160036.27	716.31	549.19	553.49	551.34	550.50	201.0	366.0	B	0	0
100/06-14-076-15W4/0	Kmcmurray	422922.68	6160036.27	716.31	544.40	548.61	546.51	545.59	203.6	373.4	B	0	0
100/07-06-076-15W4/0	Kmcmurray	417062.32	6156782.62	745.21	553.49	579.40	566.44	556.60	223.6	402.3	D	0	0
100/07-08-076-15W4/0	Kmcmurray	418597.60	6158408.04	739.29	571.99	576.01	574.00	574.00	195.2	360.5	B	0	0
100/07-15-076-15W4/0	Kmcmurray	421787.87	6160259.00	711.31	524.99	529.01	527.00	514.90	211.1	395.4	B	0	10
100/07-32-076-15W4/0	Kmcmurray	418857.15	6164915.41	684.10	482.99	512.00	497.50	477.29	219.2	405.8	A	0	6
100/10-26-076-15W4/0	Kmcmurray	423690.01	6163790.88	691.99	514.99	522.00	518.50	517.00	195.2	368.7	A	0	0
100/10-36-076-15W4/0	Kmcmurray	425168.51	6165402.78	684.89	475.49	512.10	493.79	481.01	208.4	399.5	A	0	0
100/11-10-076-15W4/0	Kmcmurray	421261.62	6159080.67	718.69	518.19	556.29	537.24	525.81	210.5	392.0	B	0	0
100/11-23-076-15W4/0	Kmcmurray	423073.85	6162143.06	693.39	506.00	531.91	518.95	511.49	209.7	384.1	B	0	0
100/16-07-076-15W4/0	Kmcmurray	417227.99	6159270.83	722.10	544.01	549.01	546.51	545.11	210.4	386.0	B	0	0
100/06-02-076-16W4/0	Kmcmurray	413107.09	6156928.28	791.90	637.61	644.99	641.30	639.20	218.9	369.5	A	0	0
100/06-02-076-16W4/0	Kmcmurray	413107.09	6156928.28	791.90	604.69	620.91	612.80	608.69	215.9	395.0	C	0	0
100/10-26-076-16W4/0	Kmcmurray	413909.43	6163706.47	718.90	538.00	555.01	546.51	529.01	224.7	397.1	A	0	9

TABLE 5B-7 McMURRAY FORMATION REGIONAL HYDRAULIC HEADS FROM DSTs

UWI	Formation	TM Coordinates (Zone 12; Nad 2 Easting	Northing	KB Elevation (masl)	Perforated Interval (m bKB) Top	Bottom	Mid Point Perforated Interval (m bKB)	Recorder Depth (m bKB)	Pressure Head (m)	Freshwater Hydraulic Head (masl)	Hydro-Fax QC	QC Recorder Elevation Below Perfs (m)	Above Perfs (m)
100/11-24-076-16W4/00	Kmcmurray	414761.10	6162078.95	704.91	555.01	561.50	558.26	559.61	234.0	380.6	B	0	0
100/11-28-076-16W4/00	Kmcmurray	409980.35	6163810.09	703.39	518.50	523.01	520.75	521.39	204.9	387.6	A	0	0
100/06-28-076-17W4/00	Kmcmurray	400281.81	6163778.94	695.71	512.19	518.01	515.10	504.69	211.4	392.0	A	0	7
100/06-29-076-17W4/00	Kmcmurray	398524.42	6163788.20	698.30	512.10	527.31	519.70	516.00	199.2	377.8	A	0	0
100/07-33-076-17W4/00	Kmcmurray	400853.32	6165221.07	708.30	537.00	551.99	544.50	540.29	192.1	355.9	B	0	0
100/07-33-076-17W4/00	Kmcmurray	400853.32	6165221.07	708.30	524.99	537.00	530.99	535.50	180.4	357.7	B	0	0
100/11-27-076-17W4/00	Kmcmurray	401906.12	6164272.14	716.59	538.89	543.22	541.05	541.30	192.1	367.6	A	0	0
100/06-03-077-03W4/00	Kmcmurray	538826.44	6166112.11	590.61	365.00	372.01	368.50	367.80	205.2	427.3	D	0	0
100/09-06-077-04W4/00	Kmcm_a1sq	524830.04	6166417.48	579.79	329.00	331.99	330.50	334.00	185.6	434.9	A	-2	0
100/02-18-077-04W4/00	Kmcmry_ch	524412.99	6168846.92	583.60	351.19	355.21	353.20	352.99	195.1	425.5	A	0	0
100/01-07-077-05W4/00	Kmcmry_ch	515029.46	6167145.14	578.91	330.01	335.01	332.51	333.00	167.6	414.0	A	0	0
100/05-03-077-05W4/00	Kmcmry_ch	518982.27	6165950.77	570.31	321.99	330.01	326.00	327.39	200.8	445.1	A	0	0
100/10-22-077-09W4/00	Kmcmry_ch	480607.22	6171170.04	585.80	328.00	347.50	337.75	329.79	207.6	455.7	B	0	0
100/10-14-077-10W4/00	Kmcm_a2sq	472645.38	6169738.04	634.99	387.80	396.30	392.05	394.02	210.6	453.5	B	0	0
100/05-17-077-10W4/00	Kmcmry_ch	466977.01	6169375.48	694.00	470.00	480.00	475.00	476.71	212.9	431.9	C	0	0
100/10-14-077-10W4/00	Kmcmry_ch	472645.38	6169738.04	634.99	408.01	429.01	418.51	415.29	218.8	435.3	A	0	0
100/10-22-077-11W4/00	Kmcmry_ch	461082.48	6171425.23	690.40	473.69	479.51	476.60	476.10	214.7	428.5	C	0	0
100/10-22-077-11W4/00	Kmcmry_ch	461082.48	6171425.23	690.40	466.59	472.41	469.50	469.09	216.4	437.3	A	0	0
100/14-27-077-13W4/00	Kmcmry_ch	441285.80	6173452.25	666.29	441.50	448.00	444.75	443.91	197.6	419.2	C	0	0
100/07-07-077-14W4/00	Kmcmurray	426776.53	6168195.16	660.02	451.99	470.00	461.00	453.51	198.2	397.2	B	0	0
100/07-10-077-14W4/00	Kmcmurray	431796.00	6167901.25	671.81	474.00	477.99	475.99	475.00	217.5	413.3	B	0	0
100/07-10-077-14W4/00	Kmcmurray	431796.00	6167901.25	671.81	468.51	472.50	470.51	470.00	212.9	414.2	B	0	0
100/07-10-077-14W4/00	Kmcmurray	431796.00	6167901.25	671.81	461.01	465.00	463.01	461.99	213.2	422.0	C	0	0
100/07-28-077-14W4/00	Kmcmurray	430189.68	6172766.55	677.39	480.00	492.50	486.25	482.01	207.8	398.9	A	0	0
100/10-23-077-14W4/00	Kmcmurray	433356.31	6171656.19	668.31	464.00	472.01	468.01	466.01	196.1	396.4	B	0	0
100/11-17-077-14W4/00	Kmcmurray	428024.00	6170222.60	680.59	485.21	490.70	487.96	486.80	204.1	396.8	A	0	0
100/04-24-077-15W4/00	Kmcmurray	424681.10	6171131.72	683.30	489.51	495.00	492.25	490.00	203.8	394.9	B	0	0
100/06-04-077-15W4/00	Kmcmurray	419752.58	6166547.52	675.41	504.42	516.61	510.51	506.61	203.3	368.2	A	0	0
100/06-04-077-15W4/00	Kmcmurray	419752.58	6166547.52	675.41	475.49	502.89	489.19	481.62	204.7	390.9	D	0	0
100/07-36-077-15W4/00	Kmcmurray	425434.82	6174674.24	665.41	467.99	490.00	478.99	469.00	214.7	401.1	B	0	0
100/10-06-077-15W4/00	Kmcmurray	417211.86	6167207.20	707.29	509.99	528.01	519.00	512.00	205.4	393.7	C	0	0
100/10-13-077-15W4/00	Kmcmurray	425398.81	6170032.94	678.40	496.00	507.40	501.70	503.71	216.8	393.5	B	0	0
100/10-13-077-15W4/00	Kmcmurray	425398.81	6170032.94	678.40	480.00	487.01	483.51	483.29	244.7	439.5	A	0	0
100/10-20-077-15W4/00	Kmcmurray	418944.68	6171998.23	694.49	498.01	509.99	504.00	508.99	191.5	382.0	B	0	0
100/10-27-077-15W4/00	Kmcmurray	421938.90	6173557.72	673.70	477.99	487.99	482.99	472.50	206.9	397.6	B	0	5
100/11-10-077-15W4/00	Kmcmurray	421480.00	6168701.31	668.92	469.00	486.01	477.50	470.00	189.3	380.7	B	0	0
100/07-09-077-16W4/00	Kmcmurray	410773.28	6168602.01	684.31	497.01	502.01	499.51	498.99	218.0	402.8	F	0	0
100/07-19-077-16W4/00	Kmcmurray	407552.30	6171619.26	628.90	435.01	443.00	439.00	435.99	188.7	378.6	B	0	0
100/07-19-077-16W4/00	Kmcmurray	407552.30	6171619.26	628.90	434.40	438.00	436.20	435.41	191.0	383.7	B	0	0
100/07-32-078-03W4/00	Kmcmurray	535736.90	6184022.71	553.00	299.01	307.00	303.00	288.01	188.7	438.7	C	0	11
100/07-32-078-03W4/00	Kmcmurray	535736.90	6184022.71	553.00	288.01	295.99	292.00	277.00	188.7	449.7	A	0	11
100/16-26-078-03W4/00	Kmcmurray	541014.82	6183038.70	546.11	297.00	303.00	300.00	299.01	172.7	418.8	D	0	0
100/06-22-078-04W4/00	Kmcmurray	528758.93	6180697.60	558.49	287.00	320.50	303.75	291.39	241.8	496.6	B	0	0
100/06-30-078-05W4/00	Kmcmry_ch	514509.29	6181966.69	556.29	305.01	309.49	307.25	305.99	179.6	428.7	A	0	0
100/14-24-078-05W4/00	Kmcmurray	522321.04	6181161.73	569.09	309.49	314.49	311.99	310.99	169.0	426.1	B	0	0

TABLE 5B-7 McMURRAY FORMATION REGIONAL HYDRAULIC HEADS FROM DSTs

UWI	Formation	TM Coordinates (Zone 12; Nad 2		KB Elevation (masl)	Perforated Interval (m bKB)		Mid Point Perforated Interval (m bKB)	Recorder Depth (m bKB)	Pressure Head (m)	Freshwater Hydraulic Head (masl)	Hydro-Fax QC	QC Recorder Elevatior	
		Easting	Northing		Top	Bottom						Below Perfs (m)	Above Perfs (m)
100/10-08-078-06W4/0(	Kmcm_a_ch	506481.48	6177451.00	582.60	321.99	325.01	323.50	324.49	167.6	426.7	A	0	0
100/06-11-078-07W4/0(	Kmcmry_ch	501252.57	6177115.81	536.82	257.31	304.80	281.06	250.21	243.5	499.2	A	0	7
100/02-30-078-08W4/0(	Kmcm_a1sq	485583.02	6181811.68	592.72	324.00	331.99	328.00	326.02	183.3	448.0	C	0	0
100/07-33-078-09W4/0(	Kmcmry_ch	479100.10	6183577.59	662.00	394.41	403.59	399.00	396.79	199.6	462.6	B	0	0
100/10-18-078-10W4/0(	Kmcm_a2sq	466134.70	6179471.14	666.29	415.11	420.59	417.85	417.61	203.6	452.0	B	0	0
100/06-31-078-10W4/0(	Kmcm_b1sq	465585.07	6184000.90	676.41	423.09	440.10	431.60	429.49	208.6	453.4	A	0	0
100/06-31-078-10W4/0(	Kmcm_b1sq	465585.07	6184000.90	676.41	423.09	440.10	431.60	424.59	219.7	464.5	A	0	0
100/07-35-078-10W4/0(	Kmcmrry_c	472544.82	6183886.77	661.39	406.60	437.11	421.86	408.10	209.2	448.7	D	0	0
100/10-33-078-11W4/0(	Kmcmry_ch	459684.19	6184371.12	699.70	464.00	469.00	466.50	465.00	225.8	459.0	C	0	0
100/10-32-078-12W4/0(	Kmcm_a2sq	448313.79	6184493.81	679.61	427.00	430.99	428.99	428.49	191.8	442.4	A	0	0
100/10-32-078-12W4/0(	Kmcmrry_c	448313.79	6184493.81	679.61	435.01	439.00	437.01	436.51	181.1	423.7	B	0	0
100/06-28-078-13W4/0(	Kmcmurray	439569.42	6182412.78	671.20	446.99	451.99	449.49	449.00	197.4	419.1	B	0	0
100/06-34-078-13W4/0(	Kmcmurray	441308.07	6184034.10	668.00	448.00	453.00	450.50	450.01	185.8	403.3	B	0	0
100/07-14-078-13W4/0(	Kmcmurray	443436.19	6179318.66	685.50	453.21	465.71	459.46	455.71	200.8	426.9	B	0	0
100/11-25-078-13W4/0(	Kmcmurray	444677.07	6182719.85	672.39	440.71	444.40	442.56	442.60	193.1	422.9	B	0	0
100/10-11-078-14W4/0(	Kmcmurray	433631.64	6178289.55	685.89	462.99	482.99	472.99	465.00	214.8	427.7	B	0	0
100/06-10-078-15W4/0(	Kmcmurray	421565.19	6177831.33	635.51	430.01	434.01	432.01	430.99	194.2	397.7	A	0	0
100/06-12-078-15W4/0(	Kmcmurray	424912.68	6177775.62	624.20	421.51	427.51	424.51	422.52	184.2	383.9	B	0	0
100/06-12-078-15W4/0(	Kmcmurray	424912.68	6177775.62	624.20	412.00	418.00	415.00	413.01	193.8	403.0	B	0	0
100/06-21-078-15W4/0(	Kmcmurray	420293.71	6181337.69	639.29	428.00	433.00	430.50	430.01	185.8	394.6	A	0	0
100/07-03-078-15W4/0(	Kmcmurray	421986.08	6176366.59	584.30	383.01	389.99	386.50	377.50	206.1	403.9	A	0	6
100/07-20-078-15W4/0(	Kmcmurray	418830.99	6181304.64	643.31	434.01	453.00	443.50	436.90	157.6	357.4	A	0	0
100/10-24-078-15W4/0(	Kmcmurray	425431.42	6181401.24	660.81	433.00	441.99	437.50	434.49	205.8	429.2	B	0	0
100/10-33-078-15W4/0(	Kmcmurray	420490.51	6184614.75	655.11	446.02	454.00	450.01	448.00	182.1	387.2	A	0	0
100/12-16-078-15W4/0(	Kmcmurray	419680.03	6180082.14	634.41	427.51	431.99	429.75	429.80	96.4	301.0	A	0	0
100/12-28-078-15W4/0(	Kmcmurray	419954.28	6183111.73	660.50	454.00	459.00	456.50	456.01	179.3	383.3	A	0	0
100/05-19-079-02W4/0(	Kmcmurray	543087.65	6190447.09	524.59	257.01	263.01	260.01	258.99	147.3	411.9	A	0	0
100/07-35-079-04W4/0(	Kmcmurray	530744.12	6193401.58	479.12	214.92	230.09	222.50	216.99	177.8	434.4	A	0	0
100/10-33-079-04W4/0(	Kmcmurray	527442.77	6193757.81	474.00	215.19	226.80	221.00	217.60	172.5	425.5	A	0	0
100/06-26-079-05W4/0(	Kmcmurray	520550.63	6191917.68	485.40	230.00	235.00	232.50	232.20	162.1	415.0	C	0	0
100/07-14-079-05W4/0(	Kmcmurray	521041.97	6188666.80	494.81	237.01	247.01	242.01	238.99	167.8	420.6	B	0	0
100/10-16-079-06W4/0(	Kmcm_a2sq	507754.83	6188952.11	491.40	230.00	238.99	234.50	217.99	185.9	442.8	A	0	12
100/06-34-079-06W4/0(	Kmcmry_ch	508889.27	6193289.29	506.30	259.11	265.21	262.16	264.29	187.8	432.0	A	0	0
100/06-34-079-06W4/0(	Kmcmry_ch	508889.27	6193289.29	506.30	234.70	251.19	242.94	239.60	186.0	449.4	A	0	0
100/11-08-079-06W4/0(	Kmcmry_ch	505617.62	6187145.82	510.51	243.99	256.00	250.00	245.70	165.0	425.5	A	0	0
100/11-22-079-06W4/0(	Kmcmurray	508897.77	6190673.83	479.12	221.29	228.60	224.94	226.80	181.0	435.2	A	0	0
100/11-13-079-07W4/0(	Kmcm_a_ch	502508.25	6189107.28	536.11	269.99	274.02	272.00	267.40	167.8	431.9	A	0	3
100/11-33-079-07W4/0(	Kmcm_a_ch	497418.13	6193749.49	593.51	319.00	322.51	320.76	319.00	180.6	453.4	A	0	0
100/10-11-079-07W4/0(	Kmcm_a2sq	501133.16	6187200.20	553.70	284.01	293.01	288.51	291.21	166.1	431.3	A	0	0
100/10-25-079-07W4/0(	Kmcm_a2sq	502868.16	6192113.61	569.31	289.99	305.01	297.50	292.00	170.0	441.8	A	0	0
100/11-08-079-07W4/0(	Kmcm_b1sq	495996.90	6187441.19	572.11	298.49	307.00	302.74	302.09	175.9	445.3	B	0	0
100/10-31-079-08W4/0(	Kmcm_b1sq	484941.23	6193846.15	673.91	400.51	410.90	405.71	407.49	197.8	466.0	B	0	0
100/10-31-079-08W4/0(	Kmcmrry_c	484941.23	6193846.15	673.91	397.80	419.10	408.45	405.42	197.2	462.7	A	0	0
100/08-13-079-09W4/0(	Kmcm_a2sq	483788.44	6188471.31	630.11	360.00	363.51	361.75	383.29	166.4	434.8	C	-20	0
100/08-13-079-09W4/0(	Kmcm_c_ch	483788.44	6188471.31	630.11	381.00	384.51	382.75	383.29	205.1	452.5	C	0	0

TABLE 5B-7 McMURRAY FORMATION REGIONAL HYDRAULIC HEADS FROM DSTs

UWI	Formation	TM Coordinates (Zone 12; Nad 2		KB Elevation (masl)	Perforated Interval (m bKB)		Mid Point Perforated Interval (m bKB)	Recorder Depth (m bKB)	Pressure Head (m)	Freshwater Hydraulic Head (masl)	Hydro-Fax QC	QC Recorder Elevatior	
		Easting	Northing		Top	Bottom						Below Perfs (m)	Above Perfs (m)
100/07-26-079-10W4/0(	Kmcm_a1sq	471994.75	6191798.09	682.82	422.09	426.69	424.39	423.70	208.5	466.9	C	0	0
100/12-36-079-11W4/0(	Kmcmry_ch	462700.47	6193807.05	686.02	424.01	440.01	432.01	425.99	214.4	468.4	B	0	0
100/07-22-079-12W4/0(	Kmcm_a2sq	450446.92	6190290.26	692.29	435.01	439.00	437.01	436.81	190.8	446.1	B	0	0
100/11-18-079-12W4/0(	Kmcm_a2sq	445088.00	6189465.49	711.31	464.00	470.00	467.00	465.49	189.3	433.6	C	0	0
100/07-28-079-12W4/0(	Kmcm_c_ch	449152.58	6191972.64	687.81	462.99	466.89	464.94	465.00	183.3	406.2	B	0	0
100/11-18-079-12W4/0(	Kmcm_c_ch	445088.00	6189465.49	711.31	488.99	495.00	491.99	490.52	184.4	403.7	B	0	0
100/11-18-079-12W4/0(	Kmcmrry_c	445088.00	6189465.49	711.31	477.01	482.99	480.00	478.51	189.1	420.5	A	0	0
100/06-31-079-12W4/0(	Kmcmry_ch	445484.05	6193913.98	685.31	431.99	450.01	441.00	434.01	195.8	440.1	B	0	0
100/11-32-079-12W4/0(	Kmcmry_ch	446762.49	6194051.67	687.91	461.01	469.00	465.00	464.00	188.3	411.2	A	0	0
100/02-29-079-13W4/0(	Kmcmurray	437531.41	6191761.79	699.00	482.99	485.00	483.99	476.01	189.1	404.1	A	0	7
100/02-29-079-13W4/0(	Kmcmurray	437531.41	6191761.79	699.00	472.01	476.01	474.01	474.00	185.4	410.4	A	0	0
100/05-31-079-13W4/0(	Kmcmurray	435118.67	6193733.03	697.29	481.01	487.99	484.50	486.01	191.3	404.1	A	0	0
100/16-18-079-13W4/0(	Kmcmurray	436475.39	6189746.79	685.01	456.99	461.99	459.49	451.59	189.2	414.7	A	0	5
100/14-07-079-14W4/0(	Kmcmurray	425688.86	6188553.53	687.69	456.01	477.01	466.51	457.99	227.4	448.6	B	0	0
100/14-30-079-14W4/0(	Kmcmurray	425740.12	6193113.44	659.31	425.50	429.01	427.25	427.70	185.9	417.9	C	0	0
100/03-31-079-15W4/0(	Kmcmurray	416058.86	6193785.74	591.10	371.00	377.01	374.01	373.69	55.1	272.2	E	0	0
100/07-23-079-15W4/0(	Kmcmurray	422811.32	6190646.56	646.12	422.00	441.99	431.99	425.01	182.9	397.0	A	0	0
100/09-03-079-15W4/0(	Kmcmurray	421628.47	6186276.13	659.80	445.01	450.01	447.51	447.30	152.4	364.7	C	0	0
100/09-24-079-15W4/0(	Kmcmurray	424899.72	6191345.69	663.89	436.99	461.01	449.00	439.00	186.7	401.6	A	0	0
100/10-20-079-15W4/0(	Kmcmurray	417815.03	6191365.21	611.89	388.01	408.01	398.01	390.30	179.5	393.4	C	0	0
100/11-35-079-15W4/0(	Kmcmurray	422347.30	6194378.59	634.50	418.00	427.00	422.50	420.02	257.8	469.8	F	0	0
100/15-10-079-15W4/0(	Kmcmurray	421169.96	6188258.18	641.30	430.99	448.79	439.89	432.12	198.0	399.4	A	0	0
100/10-01-079-16W4/0(	Kmcmurray	414598.34	6186633.68	606.61	396.79	401.70	399.24	398.71	177.9	385.3	A	0	0
100/05-33-079-17W4/0(	Kmcmurray	399206.76	6194674.25	557.82	358.11	388.01	373.06	367.01	174.3	359.1	B	0	0
100/10-27-080-06W4/0(	Kmcmry_ch	509346.67	6201892.46	512.10	247.50	262.71	255.10	249.91	166.7	423.7	A	0	0
100/11-34-080-06W4/0(	Kmcmry_ch	509123.48	6203523.62	513.50	237.01	257.01	247.01	238.99	169.3	435.8	G	0	0
100/10-11-080-07W4/0(	Kmcmry_ch	501271.23	6196942.02	583.21	315.01	329.00	322.01	316.69	168.4	429.6	A	0	0
100/11-25-080-07W4/0(	Kmcmry_ch	502335.52	6201706.00	537.52	268.01	279.99	274.00	270.91	89.5	353.1	A	0	0
100/09-01-080-08W4/0(	Kmcmurray	493653.75	6195612.04	622.10	388.59	397.80	393.19	388.59	222.5	451.4	B	0	0
100/09-01-080-08W4/0(	Kmcmurray	493653.75	6195612.04	622.10	371.89	390.11	381.00	371.89	229.8	470.9	C	0	0
100/09-01-080-08W4/0(	Kmcmurray	493653.75	6195612.04	622.10	345.61	353.60	349.61	345.61	204.9	477.4	B	0	0
100/09-01-080-08W4/0(	Kmcmurray	493653.75	6195612.04	622.10	353.60	371.89	362.74	353.60	221.3	480.7	B	0	0
100/06-08-080-09W4/0(	Kmcm_a2sq	476282.51	6196597.30	704.09	436.81	441.41	439.11	439.49	194.7	459.6	B	0	0
100/10-11-080-09W4/0(	Kmcm_b1sq	481524.25	6197179.42	715.22	440.01	448.00	444.00	444.70	200.8	472.0	B	0	0
100/06-08-080-09W4/0(	Kmcmrry_c	476282.51	6196597.30	704.09	441.99	454.21	448.10	445.01	206.3	462.3	B	0	0
100/15-03-080-10W4/0(	Kmcm_b1sq	470211.25	6195878.02	697.69	430.99	443.00	436.99	433.00	203.5	464.2	A	0	0
100/15-10-080-10W4/0(	Kmcmry_ch	470187.05	6197446.42	699.21	448.00	453.00	450.50	451.81	204.5	453.2	A	0	0
100/15-10-080-10W4/0(	Kmcmry_ch	470187.05	6197446.42	699.21	451.99	460.01	456.00	457.51	212.9	456.1	A	0	0
100/08-18-080-11W4/0(	Kmcmry_ch	456138.86	6198430.98	692.60	427.00	436.99	431.99	429.01	204.4	465.0	A	0	0
100/05-14-080-12W4/0(	Kmcmry_ch	451608.50	6198478.23	689.70	441.99	451.99	446.99	441.99	207.6	450.3	C	0	0
100/08-02-080-13W4/0(	Kmcmurray	442949.99	6195579.57	692.69	444.00	451.01	447.51	448.39	207.2	452.4	B	0	0
100/01-27-080-14W4/0(	Kmcmurray	431584.59	6201758.90	667.09	440.50	448.00	444.25	445.50	181.4	404.3	A	0	0
100/07-14-080-14W4/0(	Kmcmurray	432782.24	6198942.68	690.59	467.99	475.00	471.50	472.50	186.4	405.5	A	0	0
100/07-15-080-14W4/0(	Kmcmurray	431249.71	6198963.46	678.61	451.99	472.99	462.49	459.49	212.5	428.6	A	0	0
100/07-17-080-14W4/0(	Kmcmurray	427755.63	6199023.81	650.51	425.01	435.01	430.01	427.70	176.8	397.3	A	0	0

TABLE 5B-7 McMURRAY FORMATION REGIONAL HYDRAULIC HEADS FROM DSTs

UWI	Formation	TM Coordinates (Zone 12; Nad 2		KB Elevation (masl)	Perforated Interval (m bKB)		Mid Point Perforated Interval (m bKB)	Recorder Depth (m bKB)	Pressure Head (m)	Freshwater Hydraulic Head (masl)	Hydro-Fax QC	QC Recorder Elevatior	
		Easting	Northing		Top	Bottom						Below Perfs (m)	Above Perfs (m)
100/10-13-080-14W4/00	Kmcmurray	434458.60	6199052.73	697.99	476.50	482.59	479.54	479.51	157.1	375.6	A	0	0
100/10-13-080-14W4/00	Kmcmurray	434458.60	6199052.73	697.99	464.00	470.09	467.05	467.02	162.0	393.0	A	0	0
100/14-09-080-14W4/00	Kmcmurray	429255.60	6198081.72	665.41	435.99	446.11	441.05	439.00	185.8	410.2	C	0	0
100/14-09-080-14W4/00	Kmcmurray	429255.60	6198081.72	665.41	425.01	435.10	430.06	428.00	185.1	420.4	A	0	0
100/04-35-080-15W4/00	Kmcmurray	422418.89	6203304.35	583.39	337.99	347.99	342.99	340.31	206.9	447.3	C	0	0
100/08-21-080-15W4/00	Kmcmurray	420202.72	6200510.42	576.99	345.00	378.01	361.51	347.02	181.8	397.3	A	0	0
100/09-25-080-15W4/00	Kmcmurray	424937.01	6202458.28	610.39	381.00	386.00	383.50	383.90	94.0	320.9	B	0	0
100/11-33-080-15W4/00	Kmcmurray	419376.89	6204191.73	574.21	346.01	356.89	351.45	347.81	189.4	412.2	C	0	0
100/11-36-080-15W4/00	Kmcmurray	424229.50	6204162.76	584.21	337.99	347.02	342.50	340.62	168.7	410.4	A	0	0
100/11-29-081-08W4/00	Kmcmry_ch	486101.62	6211731.37	712.01	423.70	437.39	430.55	410.29	192.2	473.7	B	0	13
100/16-15-081-08W4/00	Kmcmry_ch	490141.33	6208676.16	734.60	455.01	467.99	461.50	456.01	184.9	458.0	A	0	0
100/02-14-081-09W4/00	Kmcm_a2sq	481525.10	6207584.82	715.09	431.60	438.30	434.95	426.69	199.3	479.4	A	0	5
100/09-29-081-09W4/00	Kmcm_a2sq	477287.02	6211532.92	709.00	416.39	431.60	423.99	411.60	206.7	491.7	C	0	5
100/13-09-081-09W4/00	Kmcm_b1sq	477769.77	6207188.52	701.99	418.19	428.21	423.20	413.61	201.7	480.5	A	0	5
100/10-23-081-09W4/00	Kmcmry_ch	481671.19	6209972.71	712.59	428.49	435.29	431.89	432.51	200.0	480.7	B	0	0
100/03-03-081-10W4/00	Kmcm_a1sq	469867.28	6204455.09	698.21	420.02	423.00	421.51	425.59	205.4	482.1	B	-3	0
100/07-22-081-10W4/00	Kmcmry_ch	470145.63	6209505.19	711.41	446.99	453.00	449.99	448.51	198.0	459.4	A	0	0
100/10-16-081-12W4/00	Kmcmrry_c	449017.08	6208559.28	729.60	472.99	480.00	476.50	476.01	65.2	318.3	E	0	0
100/07-16-081-13W4/00	Kmcmurray	439501.80	6208578.92	689.40	448.00	454.00	451.00	450.01	189.1	427.5	C	0	0
100/09-21-081-13W4/00	Kmcmurray	439984.18	6210265.27	679.80	431.99	440.01	436.00	434.01	199.8	443.6	A	0	0
100/06-15-081-15W4/00	Kmcmurray	420910.40	6208772.24	570.19	316.99	325.01	321.00	319.00	160.0	409.2	A	0	0
100/10-06-082-08W4/00	Kmcmry_ch	485066.53	6214988.16	716.59	432.79	445.01	438.90	443.21	198.6	476.3	A	0	0
100/07-17-082-10W4/00	Kmcm_a2sq	467113.36	6217927.45	705.49	420.50	422.52	421.51	425.11	214.3	498.3	A	-3	0
100/03-30-082-10W4/00	Kmcmry_ch	465100.63	6220534.55	708.39	420.02	446.02	433.02	424.40	230.2	505.6	A	0	0
100/06-12-082-12W4/00	Kmcm_c_ch	453600.61	6216489.44	760.42	517.00	523.01	520.01	508.01	237.0	477.5	C	0	9
100/03-18-082-12W4/00	Kmcmry_ch	445723.27	6217519.03	680.80	409.99	424.01	417.00	412.91	183.9	447.7	A	0	0
100/07-08-082-12W4/00	Kmcmry_ch	447518.11	6216449.26	738.41	465.89	483.99	474.94	468.91	207.5	470.9	A	0	0
100/06-06-082-13W4/00	Kmcmurray	435737.89	6214875.02	601.10	332.51	350.49	341.50	333.09	186.7	446.2	B	0	0
100/06-10-082-13W4/00	Kmcmurray	440636.12	6216359.65	634.02	371.89	378.01	374.95	366.10	206.7	465.8	C	0	6
100/10-03-082-13W4/00	Kmcmurray	441166.53	6215191.33	669.80	414.01	420.99	417.50	415.99	214.3	466.6	A	0	0
100/06-09-083-03W4/00	Kmcmurray	536066.59	6225725.56	480.40	226.80	233.51	230.16	228.60	152.9	403.1	G	0	0
100/06-09-083-03W4/00	Kmcmurray	536066.59	6225725.56	480.40	201.20	213.39	207.30	203.00	140.4	413.5	A	0	0
100/06-09-083-03W4/00	Kmcmurray	536066.59	6225725.56	480.40	198.09	204.80	201.44	199.89	142.3	421.3	A	0	0
100/08-21-083-05W4/00	Kmcmry_ch	517326.31	6229040.21	499.90	247.50	251.49	249.49	248.99	105.9	356.3	A	0	0
100/02-32-083-06W4/00	Kmcmurray	505367.60	6231697.56	567.60	276.79	294.80	285.80	279.81	105.1	386.9	A	0	0
100/10-31-083-06W4/00	Kmcmurray	503732.11	6232457.13	549.19	268.19	280.39	274.29	269.69	107.3	382.2	A	0	0
100/07-24-083-07W4/00	Kmcmurray	502357.93	6229024.68	598.90	310.01	318.00	314.01	316.41	135.4	420.3	A	0	0
100/10-22-083-08W4/00	Kmcmry_ch	489222.28	6229595.24	735.21	449.61	469.39	459.50	459.30	158.5	434.2	A	0	0
100/14-16-083-10W4/00	Kmcm_a2sq	467400.10	6228379.15	735.00	446.50	450.50	448.50	448.00	276.1	562.6	D	0	0
100/11-20-083-14W4/00	Kmcmurray	426755.54	6230030.90	554.10	270.39	281.00	275.69	273.41	143.8	422.2	A	0	0
100/10-15-083-15W4/00	Kmcmurray	420608.61	6228548.60	548.40	270.69	275.51	273.10	272.49	115.5	390.7	F	0	0
100/10-32-083-15W4/00	Kmcmurray	417582.59	6233557.91	547.39	266.40	270.39	268.39	268.80	124.1	403.1	C	0	0
100/10-32-083-15W4/00	Kmcmurray	417582.59	6233557.91	547.39	261.79	265.79	263.79	264.29	126.8	410.5	A	0	0
100/07-17-083-17W4/00	Kmcmurray	397717.89	6228539.20	547.09	278.89	306.29	292.59	284.10	133.5	387.9	B	0	0
100/11-34-083-17W4/00	Kmcmurray	400599.54	6233916.11	532.49	265.79	292.61	279.20	269.41	139.1	392.4	C	0	0

TABLE 5B-7 McMURRAY FORMATION REGIONAL HYDRAULIC HEADS FROM DSTs

UWI	Formation	TM Coordinates (Zone 12; Nad 2		KB Elevation (masl)	Perforated Interval (m bKB)		Mid Point Perforated Interval (m bKB)	Recorder Depth (m bKB)	Pressure Head (m)	Freshwater Hydraulic Head (masl)	Hydro-Fax QC	QC Recorder Elevatior	
		Easting	Northing		Top	Bottom						Below Perfs (m)	Above Perfs (m)
100/10-32-084-04W4/0(	Kmcmurray	525082.77	6242307.43	463.21	152.00	174.01	163.01	154.50	124.4	424.6	A	0	0
100/06-32-084-06W4/0(	Kmcm_a1sq	505135.63	6242070.80	480.61	195.99	204.00	200.00	196.99	79.3	359.9	B	0	0
100/06-32-084-06W4/0(	Kmcmry_ch	505135.63	6242070.80	480.61	204.00	211.99	208.00	205.01	79.7	352.3	A	0	0
100/10-29-084-06W4/0(	Kmcmry_ch	505580.17	6240752.40	494.91	198.00	217.99	208.00	199.00	92.5	379.4	A	0	0
100/10-29-084-06W4/0(	Kmcmry_ch	505580.17	6240752.40	494.91	200.01	220.01	210.01	200.99	95.8	380.6	A	0	0
100/10-34-084-06W4/0(	Kmcmry_ch	508624.04	6242520.55	510.21	212.99	230.00	221.50	215.19	86.8	375.5	A	0	0
100/04-30-084-14W4/0(	Kmcmurray	425058.46	6240746.71	544.71	247.01	253.02	250.01	250.61	127.5	422.2	A	0	0
100/15-31-084-14W4/0(	Kmcmurray	425901.28	6243265.81	533.71	234.00	242.01	238.00	239.70	135.2	430.9	C	0	0
100/10-01-084-16W4/0(	Kmcmurray	414306.78	6235234.53	531.91	253.59	260.00	256.79	255.39	129.6	404.7	D	0	0
100/09-09-085-05W4/0(	Kmcmurray	517234.96	6245627.66	478.60	187.51	190.99	189.25	190.01	67.3	356.7	A	0	0
100/10-02-085-06W4/0(	Kmcmry_ch	510485.86	6243835.90	481.19	184.01	200.99	192.50	185.81	89.1	377.8	A	0	0
100/10-06-085-06W4/0(	Kmcmry_ch	503852.45	6243997.25	485.91	195.99	208.00	201.99	198.00	81.4	365.4	A	0	0
100/11-05-085-06W4/0(	Kmcmry_ch	504976.89	6244010.66	480.70	206.99	216.99	211.99	208.51	84.7	353.4	A	0	0
100/12-23-085-06W4/0(	Kmcmry_ch	509718.06	6248702.60	460.19	174.01	177.49	175.75	176.51	73.8	358.2	A	0	0
100/01-03-085-15W4/0(	Kmcmurray	421120.04	6244096.55	531.91	237.01	241.01	239.01	238.90	127.9	420.8	B	0	0
100/07-20-086-06W4/0(	Kmcm_a1sq	505436.57	6258177.18	453.51	143.01	147.01	145.01	144.99	29.5	338.0	A	0	0
100/07-20-086-06W4/0(	Kmcmry_ch	505436.57	6258177.18	453.51	159.50	184.01	171.76	161.51	122.7	404.5	D	0	0
100/05-02-086-07W4/0(	Kmcm_a1sq	499724.28	6253355.22	481.80	170.99	177.00	174.00	164.01	55.4	363.2	B	0	7
100/06-08-086-16W4/0(	Kmcmurray	407525.93	6255744.05	501.70	203.61	221.29	212.45	209.70	82.9	372.2	D	0	0
100/11-11-090-12W4/0(	Kmcmurray	450996.44	6294349.38	529.99	206.01	225.00	215.51	201.20	45.2	359.7	D	0	5

Data point eliminated due to depth of pressure recorder
Data point eliminated due to Hydro-Fax QC
Anomalous pressure data point eliminated

TABLE 5B-8 GROSMONT FORMATION REGIONAL HYDRAULIC HEADS FROM DSTs

UWI	Formation	UTM Coordinates (Zone 12; Nad 27)		KB Elevation (masl)	Perforated Interval (m bKB)		Mid Point Perforated Interval (m bKB)	Recorder Depth (m bKB)	Pressure Head (m)	Freshwater Hydraulic Head (masl)	Hydro-Fax QC	QC Recorder Elevation	
		Easting	Northing		Top	Bottom						Below Perfs (m)	Above Perfs (m)
100/06-15-071-14W4/00	Dgrosmont	431505.97	6111290.34	662.30	559.31	563.91	561.61	561.69	251.7	352.4	A	0	0
100/07-20-071-14W4/00	Dgrosmont	428861.63	6113008.07	642.49	536.39	538.00	537.20	531.30	247.2	352.5	C	0	5
100/10-21-071-14W4/00	Dgrosmont	430421.15	6113423.04	658.10	542.52	560.80	551.66	544.10	263.4	369.8	A	0	0
100/06-34-071-16W4/00	Dgrosmont	411924.56	6116408.07	596.19	469.70	474.30	472.00	462.69	226.2	350.4	A	0	7
100/07-35-071-17W4/00	Dgrosmont	404453.98	6116639.28	585.80	444.09	452.60	448.35	450.50	314.7	452.1	D	0	0
100/11-08-072-14W4/00	Dgrosmont	428376.52	6120028.09	609.60	472.99	482.80	477.90	508.41	190.0	321.7	A	-26	0
100/11-08-072-14W4/00	Dgrosmont	428376.52	6120028.09	609.60	449.31	473.39	461.35	451.71	231.2	379.4	A	0	0
100/11-31-072-14W4/00	Dgrosmont	427108.44	6126562.44	616.31	446.81	472.11	459.46	452.29	235.3	392.2	C	0	0
100/10-20-072-14W4/00	Dgrsmnt_a	429132.17	6123237.14	608.41	466.31	482.80	474.56	470.00	230.1	363.9	A	0	0
100/06-33-072-15W4/00	Dgrosmont	420366.21	6126045.22	580.01	447.20	451.11	449.15	450.01	202.4	333.3	B	0	0
100/07-27-072-15W4/00	Dgrosmont	422591.34	6124396.21	594.39	457.20	464.52	460.86	449.89	219.1	352.6	A	0	7
100/07-31-072-15W4/00	Dgrosmont	417453.68	6126103.01	578.21	436.99	445.01	441.00	443.00	197.7	335.0	A	0	0
100/10-03-072-15W4/00	Dgrosmont	422483.82	6118532.06	613.41	471.01	477.01	474.01	470.00	214.7	354.1	A	0	1
100/10-09-072-15W4/00	Dgrosmont	420848.55	6120242.82	610.52	474.30	478.20	476.25	476.10	225.8	360.1	B	0	0
100/10-16-072-15W4/00	Dgrosmont	420874.22	6121788.47	597.71	460.19	467.60	463.89	452.90	225.7	359.5	A	0	7
100/11-14-072-15W4/00	Dgrosmont	423521.95	6121742.02	607.50	467.60	476.10	471.85	474.30	225.9	361.5	B	0	0
100/11-17-072-15W4/00	Dgrosmont	418617.88	6121847.12	596.19	458.12	467.02	462.57	463.30	230.2	363.8	A	0	0
100/11-24-072-15W4/00	Dgrosmont	425093.88	6123412.64	604.39	467.90	472.72	470.31	471.19	218.6	352.7	B	0	0
100/06-06-072-16W4/00	Dgrosmont	407137.59	6118207.64	582.81	438.91	454.21	446.56	445.89	235.0	371.2	C	0	0
100/06-18-072-16W4/00	Dgrosmont	407144.33	6121449.15	599.21	456.29	468.51	462.40	466.31	223.7	360.5	B	0	0
100/06-18-072-16W4/00	Dgrosmont	407144.33	6121449.15	599.21	447.39	456.59	451.99	454.21	225.6	372.9	B	0	0
100/07-05-072-16W4/00	Dgrosmont	409433.84	6118104.55	599.51	441.99	451.11	446.55	447.81	228.1	381.1	A	0	0
100/10-13-072-16W4/00	Dgrosmont	415729.43	6121913.32	577.60	442.91	448.09	445.50	445.31	224.7	356.8	A	0	0
100/10-17-072-17W4/00	Dgrosmont	399572.40	6122119.59	595.00	487.71	496.80	492.25	496.80	240.2	342.9	A	0	0
100/10-23-072-17W4/00	Dgrosmont	404588.30	6123708.72	563.91	415.69	433.70	424.69	422.79	231.0	370.2	B	0	0
100/10-17-072-17W4/00	Dgrsmnt_a	399572.40	6122119.59	595.00	566.90	575.80	571.35	572.42	333.5	357.1	D	0	0
100/10-08-073-14W4/00	Dgrosmont	429108.75	6129632.08	652.30	510.82	516.91	513.86	517.22	223.8	362.2	B	0	0
100/10-08-073-14W4/00	Dgrosmont	429108.75	6129632.08	652.30	512.10	518.19	515.14	517.61	225.6	362.8	A	0	0
100/07-02-073-15W4/00	Dgrosmont	424235.31	6127596.88	608.41	475.22	487.71	481.46	477.01	225.1	352.1	A	0	0
100/07-02-073-15W4/00	Dgrosmont	424235.31	6127596.88	608.41	472.41	478.51	475.46	476.10	225.0	358.0	B	0	0
100/10-36-073-16W4/00	Dgrosmont	416257.43	6136439.99	611.70	478.51	482.80	480.66	480.70	229.2	360.3	A	0	0
100/11-18-073-16W4/00	Dgrosmont	407387.60	6131546.49	575.01	435.01	445.01	440.01	438.00	198.0	333.0	C	0	0
100/06-25-073-17W4/00	Dgrosmont	405940.00	6134451.44	577.90	446.81	450.19	448.50	448.09	220.5	349.9	A	0	0
100/10-03-073-17W4/00	Dgrosmont	403086.95	6128617.32	570.01	435.90	446.50	441.20	445.01	222.1	351.0	D	0	0
100/10-03-073-17W4/00	Dgrosmont	403086.95	6128617.32	570.01	412.70	431.29	422.00	416.11	233.5	381.5	D	0	0
100/06-21-074-15W4/00	Dgrosmont	420867.84	6142305.76	683.70	551.99	559.31	555.65	555.71	227.3	355.4	C	0	0
100/07-30-074-15W4/00	Dgrosmont	418002.17	6143896.58	685.50	507.80	538.31	523.05	514.50	186.3	348.7	B	0	0
100/11-07-074-15W4/00	Dgrosmont	417346.40	6139370.45	641.91	470.89	501.40	486.14	481.31	210.5	366.2	B	0	0
100/06-34-074-16W4/00	Dgrosmont	412670.06	6145665.62	669.31	506.61	521.21	513.91	508.99	221.5	376.9	A	0	0
100/06-23-074-17W4/00	Dgrosmont	404323.97	6142469.36	592.81	417.61	429.80	423.70	424.59	200.8	369.9	A	0	0
100/07-22-074-17W4/00	Dgrosmont	403385.00	6142588.94	589.79	432.79	440.71	436.75	434.31	204.4	357.4	A	0	0
100/08-36-074-17W4/00	Dgrosmont	406863.68	6145906.07	635.81	478.51	482.01	480.26	480.79	59.3	214.9	A	0	0
100/10-10-074-17W4/00	Dgrosmont	403232.99	6139761.22	577.90	429.19	431.90	430.55	429.49	202.8	350.2	D	0	0
100/10-10-074-17W4/00	Dgrosmont	403232.99	6139761.22	577.90	417.61	434.62	426.11	423.09	205.6	357.4	A	0	0
100/06-14-075-15W4/00	Dgrosmont	422790.13	6150277.34	791.29	604.39	629.69	617.04	606.89	201.1	375.4	C	0	0
100/06-34-075-15W4/00	Dgrosmont	421239.94	6155170.50	800.10	604.12	630.30	617.21	609.30	214.3	397.2	A	0	0
100/07-06-075-15W4/00	Dgrosmont	416800.09	6147131.77	701.01	518.80	543.22	531.01	522.70	197.4	367.4	A	0	0

TABLE 5B-8 GROSMONT FORMATION REGIONAL HYDRAULIC HEADS FROM DSTs

UWI	Formation	UTM Coordinates (Zone 12; Nad 27)		KB Elevation (masl)	Perforated Interval (m bKB)		Mid Point Perforated Interval (m bKB)	Recorder Depth (m bKB)	Pressure Head (m)	Freshwater Hydraulic Head (masl)	Hydro-Fax QC	QC Recorder Elevation	
		Easting	Northing		Top	Bottom						Below Perfs (m)	Above Perfs (m)
100/10-08-075-15W4/00	Dgrosmont	418552.45	6149102.67	704.61	529.99	539.50	534.74	524.81	181.6	351.4	G	0	5
100/11-01-075-15W4/00	Dgrosmont	424503.56	6147529.28	765.42	582.20	612.59	597.39	592.20	207.5	375.5	D	0	0
100/11-16-075-15W4/00	Dgrosmont	419639.19	6150902.69	740.39	556.29	579.09	567.69	559.61	212.9	385.6	B	0	0
100/06-06-075-16W4/00	Dgrosmont	406320.39	6147370.41	646.79	510.82	516.91	513.86	515.11	223.0	355.9	A	0	0
100/07-05-075-16W4/00	Dgrosmont	408627.29	6147320.74	669.01	485.91	502.31	494.11	488.90	213.0	387.9	B	0	0
100/07-17-075-16W4/00	Dgrosmont	408702.00	6150549.83	688.51	537.70	552.91	545.30	541.91	207.3	350.5	A	0	0
100/07-24-075-16W4/00	Dgrosmont	415265.32	6152025.76	729.11	536.39	560.19	548.29	540.41	210.7	391.5	C	0	0
100/07-25-075-16W4/00	Dgrsmnt_b	415199.13	6153798.14	745.51	570.01	601.71	585.86	578.21	208.7	368.4	D	0	0
100/12-17-075-17W4/00	Dgrosmont	398126.31	6151282.31	619.20	504.99	513.01	509.00	507.01	215.7	325.9	A	0	0
100/16-36-075-17W4/00	Dgrsmnt_a	405847.55	6156367.96	729.39	610.79	628.50	619.65	617.80	271.4	381.1	D	0	0
100/16-36-075-17W4/00	Dgrsmnt_a	405847.55	6156367.96	729.39	630.91	649.81	640.36	644.01	313.5	402.6	D	0	0
100/07-05-076-15W4/00	Dgrosmont	418610.71	6156838.20	766.91	569.70	607.19	588.45	576.71	224.1	402.6	C	0	0
100/06-02-076-16W4/00	Dgrosmont	413107.09	6156928.28	791.90	668.70	677.91	673.31	670.29	256.0	374.6	B	0	0
100/08-32-076-16W4/00	Dgrosmont	409176.53	6165335.19	684.22	551.99	559.00	555.50	556.60	250.9	379.7	B	0	0
100/10-20-076-17W4/00	Dgrosmont	399162.88	6162697.93	711.41	547.09	554.10	550.59	548.92	185.7	346.6	B	0	0
100/11-31-077-16W4/00	Dgrsmnt_c	406984.93	6175477.79	597.11	395.60	416.11	405.86	401.09	170.1	361.4	A	0	0
100/10-32-077-17W4/00	Dgrosmont	399513.81	6175702.78	483.69	271.30	320.01	295.66	273.10	182.2	370.3	A	0	0
100/10-32-077-17W4/00	Dgrosmont	399513.81	6175702.78	483.69	271.30	320.01	295.66	272.80	186.2	374.2	A	0	0
100/11-33-077-17W4/00	Dgrosmont	400599.07	6175560.97	571.50	383.41	390.39	386.90	385.91	163.1	347.7	B	0	0
100/10-10-077-17W4/00	Dgrsmnt_c	402457.77	6168995.89	626.09	469.39	475.49	472.44	474.61	191.9	345.5	C	0	0
100/06-06-078-15W4/00	Dgrosmont	416658.83	6176209.26	644.99	448.70	495.61	472.15	441.02	223.6	396.4	B	0	8
100/07-28-078-16W4/00	Dgrosmont	410932.95	6182817.53	592.81	356.59	413.31	384.95	364.21	168.1	375.9	B	0	0
100/06-03-078-16W4/00	Dgrsmnt_b	411872.49	6176392.57	634.90	429.80	452.90	441.35	434.01	185.8	379.3	B	0	0
100/06-03-078-16W4/00	Dgrsmnt_b	411872.49	6176392.57	634.90	452.29	472.11	462.20	459.30	305.5	478.2	D	0	0
100/07-21-078-17W4/00	Dgrosmont	401280.72	6181472.99	553.49	337.11	378.29	357.70	341.71	184.7	380.5	C	0	0
100/10-16-078-17W4/00	Dgrosmont	401094.34	6180370.54	551.99	340.19	348.69	344.44	347.81	169.6	377.2	A	0	0
100/10-16-078-17W4/00	Dgrosmont	401094.34	6180370.54	551.99	347.50	357.50	352.50	356.59	188.1	387.6	C	0	0
100/10-07-079-15W4/00	Dgrosmont	416411.14	6188235.98	610.52	417.00	429.01	423.00	422.30	207.5	395.1	A	0	0
100/03-13-079-16W4/00	Dgrosmont	414390.73	6188912.19	596.19	383.99	425.01	404.50	386.21	204.2	395.9	C	0	0
100/10-01-079-16W4/00	Dgrsmnt_a	414598.34	6186633.68	606.61	416.39	466.31	441.35	429.19	222.6	387.9	A	0	0
100/06-10-079-17W4/00	Dgrosmont	401097.77	6188039.37	559.31	391.09	398.71	394.90	395.30	178.1	342.5	A	0	0
100/06-10-079-17W4/00	Dgrosmont	401097.77	6188039.37	559.31	400.20	406.30	403.25	402.92	186.6	342.6	A	0	0
100/05-33-079-17W4/00	Dgrsmnt_b	399206.76	6194674.25	557.82	388.59	411.51	400.05	396.21	194.4	352.2	A	0	0
100/06-24-083-16W4/00	Dgrosmont	413774.25	6230003.56	525.81	271.30	279.81	275.56	273.10	122.8	373.1	B	0	0
100/04-26-084-15W4/00	Dgrsmnt_a	421812.12	6240832.89	530.81	234.00	242.01	238.00	237.10	128.3	421.1	A	0	0
100/10-05-086-17W4/00	Dgrsmnt_a	398374.57	6254961.44	509.60	238.42	307.21	272.81	246.89	247.1	483.9	D	0	0

Data point eliminated due to depth of pressure recorder
Data point eliminated due to Hydro-Fax QC
Anomalous pressure data point eliminated

TABLE 5B-9 Pressure / Recovery Chart Quality Codes

Quality Code	Quality Rating	Test Characteristics
A	High Quality	Test mechanically sound, both shut-in pressures have stabilized.
B	Requires extrapolation	Slight mechanical difficulties, shut-in pressures not fully stabilised but pressures have been extrapolated and should be accurate.
C	Requires extrapolation, use with caution	Some mechanical difficulties apparent, shut-in pressures not fully stabilised, but pressures have been extrapolated thus are questionable.
D	Test results questionable	Test not mechanically sound, and pressures have not stabilised enough to obtain reasonable extrapolation. Results questionable.
E	Low perm, low pressure, low quality	Low perm, low pressure, but problems encountered throughout test and/or unable to extrapolate. Pressure should NOT be used.
F	Low perm, high pressure, low quality	Low perm, high pressure but problems encountered throughout test and/or unable to extrapolate. Pressure should NOT be used.
G	Misrun, low quality	Severe mechanical difficulties: packer failure, tool failure, plugged tool. Pressures invalid if present.

TABLE 5B-10 SUMMARY OF DST QUALITY CONTROL

Unit	Total Pressure Measurements	Hydro-Fax QC	Recorder Depth	Anomalous Pressure Measurement	Total Eliminated	Percent Eliminated
Grand Rapids	542	5	23	9	37	7%
Clearwater	119	1	1	1	3	3%
McMurray	560	24	10	19	53	9%
Grosmont	83	1	1	3	5	6%
Total	**1304**	**31**	**35**	**32**	**98**	**8%**

TABLE 5B-11 SUMMARY OF DST AND HYDRAULIC HEAD DATA BY FORMATION

Hydrostratigraphic Unit	Number of DST Data	Number of Reported Hydraulic Head Measurements
Empress	0	9
Grand Rapids	542	13
Clearwater	119	1
McMurray	560	8
Grosmont	83	0
Total:	**1304**	**31**

APPENDIX 5C
Salinity Mapping Methodology

5C1 SALINITY MAPPING METHODOLOGY

The salinity of the aquifer was calculated from wells logs using Archie's Law (1942):

$$Sw^2 = Rw / (\varphi^2 * Rt)$$

where:

Sw – water saturation (assumed to be 100%)
Rw – resistivity of the formation water
φ – porosity (derived from neutron-density log cross plot)
Rt – resistivity from deep resistivity log

Salinity was then calculated using Rw and the formation temperature:

Convert Rw to Rw_{75}:

$$Rw_{75} = (Rw \text{ at } T_f) * (T_f + 6.77) / 81.77$$

Calculate salinity:

$$\text{Salinity (ppm at } 75^{o}\text{F)} = 10^{x}$$

Where $x \approx (3.562 – \log (Rw_{75} – 0.0123)) / 0.955$

This formulation provides only a rough approximation of the actual salinity of the groundwater. Accordingly, the derived values are used to identify general distributions and trends.

Salinity maps were created for the Lower Grand Rapids, Clearwater A, Clearwater B and Basal McMurray aquifers. The salinity maps of the Lower Grand Rapids, Clearwater A and Clearwater B extend between Township 76 and 83 while the salinity map for the Basal McMurray Aquifer also includes Township 75.

The data was contoured in Golden Software's Surfer 8 by kriging (linear variogram) using a 500 m grid spacing.

5C1.1 Regional Groundwater Chemistry Review

Due to the fact that the calculated salinity values are rough approximations, additional regional chemistry data was reviewed to confirm general distributions and trends identified in the calculated salinity maps. The Geofluids database was queried for all water samples collected from the Grand Rapids, Clearwater and McMurray formations within the LSA (IHS, 2007). As well, groundwater samples collected from new North American water wells were also considered.

The Geofluids database was reviewed to select representative formation waters from the Lower Grand Rapids, Clearwater A, Clearwater B and Basal McMurray aquifers. This was accomplished by culling the provided dataset by:

- Removing groundwater samples described as KCL or Gel Mud samples;
- Removing groundwater samples contaminated with acid, alcohol or corrosion inhibitors;

- Removing groundwater samples with incomplete analyses;
- Selecting only groundwater samples collected from the four watersand zones; and
- Selecting groundwater samples that were comparable to Type Stiff diagrams.

Type Stiff diagrams were generated from selected groundwater samples collected during groundwater sampling from the four aquifers (Figure 5C-1). Once the representative samples were determined, the TDS concentrations were compiled for comparison to calculated salinity maps values. Note: these TDS values were not honoured in the contouring.

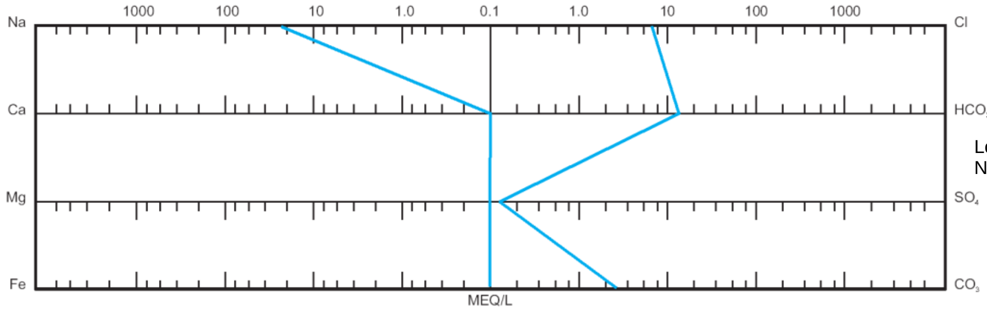
Culled Geofluids data and data from new North American water wells are summarized on Table 5C-1.

5C1.2 References

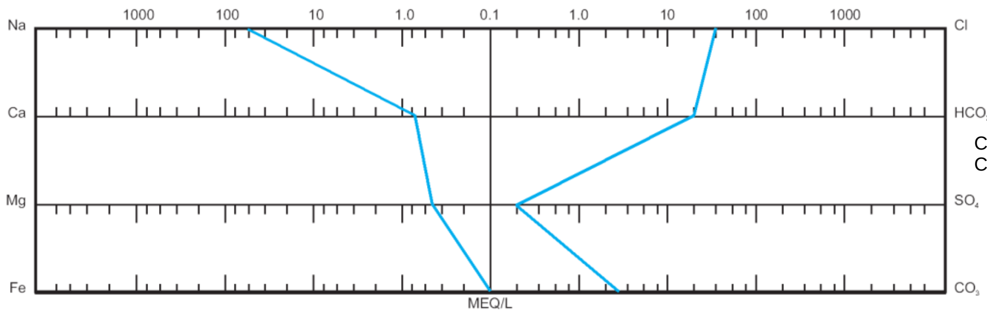
IHS Energy. 2007. Rakhit GeoFluids. Copyright 2006. Calgary, Alberta.

TABLE 5C-1 SALINITY VALUES OF GROUNDWATER SAMPLES

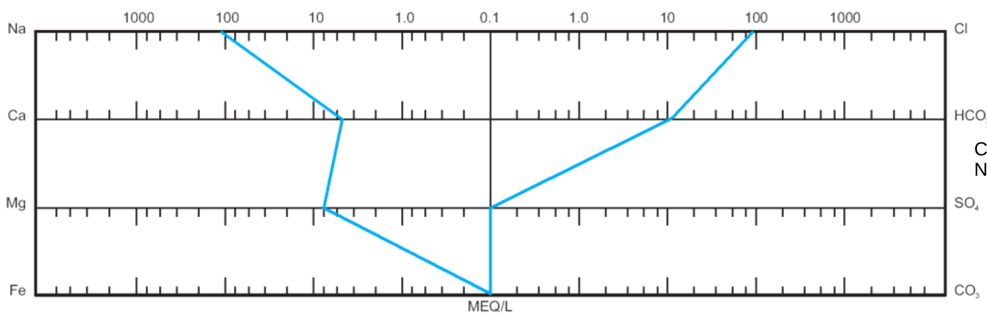
Aquifer	Legal Location	Easting (NAD 27)	Northing (NAD 27)	TDS Calculated (mg/L)	Source
Basal McMurray	7-16-76-6 W4M	508293	6159421	12015	Geofluids Database
Basal McMurray	10-30-76-14 W4M	426795	6163665	13163	Geofluids Database
Basal McMurray	10-4-77-14 W4M	430106	6166848	13114	Geofluids Database
Basal McMurray	7-9-77-14 W4M	430125	6168055	11455	Geofluids Database
Basal McMurray	9-2-78-10 W4M	472905	6176078	13000, 13200	Groundwater Sample - North American Oil Sands Corporation
Basal McMurray	1-28-78-10 W4M	469695	6181770	13000	Groundwater Sample - North American Oil Sands Corporation
Basal McMurray	13-33-78-10 W4M	468513	6184594	---	Groundwater Sample - North American Oil Sands Corporation
Basal McMurray	6-28-78-13 W4M	439695	6182485	12486	Geofluids Database
Basal McMurray	7-3-81-9 W4M	480069	6204776	10700, 10800	Groundwater Sample - North American Oil Sands Corporation
Clearwater B	15-2-76-6 W4M	511562	6156995	5093	Geofluids Database
Clearwater B	11-14-76-6 W4M	511151	6159829	4079	Geofluids Database
Clearwater B	6-26-76-6 W4M	511144	6162664	4105	Geofluids Database
Clearwater B	6-5-76-7 W4M	496468	6156179	4210	Geofluids Database
Clearwater B	10-32-76-8 W4M	487100	6164681	5834	Geofluids Database
Clearwater B	6-16-77-6 W4M	507873	6169131	5038	Geofluids Database
Clearwater B	10-20-77-8 W4M	487119	6171162	5713	Geofluids Database
Clearwater B	11-6-77-9 W4M	475298	6166366	4678	Geofluids Database
Clearwater B	6-11-77-9 W4M	481817	6167540	6660	Geofluids Database
Clearwater B	2-25-77-10 W4M	474105	6172037	6434	Geofluids Database
Clearwater B	10-35-77-10 W4M	472494	6174460	7290	Groundwater Sample - North American Oil Sands Corporation
Clearwater B	12-2-78-10 W4M	471701	6176086	6510, 6600	Groundwater Sample - North American Oil Sands Corporation
Clearwater B	10-9-78-9 W4M	479011	6177654	7374	Geofluids Database
Clearwater B	9-2-78-10 W4M	472905	6176078	6791	Geofluids Database
Clearwater B	10-11-78-10 W4M	472514	6177690	5586	Geofluids Database
Clearwater A	6-16-78-7 W4M	498104	6178839	3598	Geofluids Database
Clearwater A	8-34-81-7 W4M	500005	6212817	2947	Geofluids Database
Lower Grand Rapids	6-18-76-13 W4M	436119	6159880	2839	Geofluids Database
Lower Grand Rapids	10-20-77-8 W4M	487119	6171162	1528	Geofluids Database
Lower Grand Rapids	6-16-78-7 W4M	498104	6178839	1210	Geofluids Database
Lower Grand Rapids	7-9-78-10 W4M	469263	6177309	1797	Geofluids Database
Lower Grand Rapids	13-22-78-10 W4M	470113	6181345	1380	Groundwater Sample - North American Oil Sands Corporation
Lower Grand Rapids	7-21-79-10 W4M	468564	6190267	2079	Geofluids Database
Lower Grand Rapids	14-30-79-14 W4M	425721	6193221	3035	Geofluids Database
Lower Grand Rapids	9-1-80-8 W4M	493484	6195426	2147	Geofluids Database
Lower Grand Rapids	12-33-80-8 W4M	487402	6203523	1460, 1460	Groundwater Sample - North American Oil Sands Corporation
Lower Grand Rapids	9-21-81-9 W4M	478868	6210030	1520, 1490, 1470	Groundwater Sample - North American Oil Sands Corporation
Lower Grand Rapids	10-8-82-10 W4M	467131	6216582	1965	Geofluids Database
Lower Grand Rapids	5-27-83-6 W4M	508016	6230649	1846	Geofluids Database



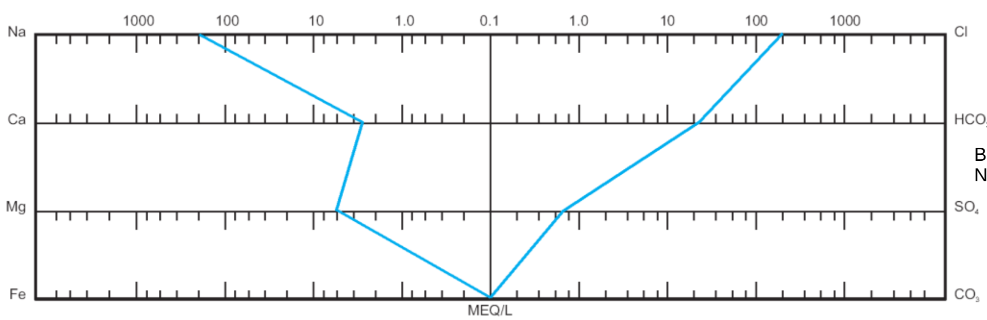
Lower Grand Rapids Aquifer
NAOSC 13-22-78-10W4



Clearwater A Aquifer
Connacher 09-28-82-12W4



Clearwater B Aquifer
NAOSC 12-02-78-10W4



Basal McMurray Aquifer
NAOSC 01-28-78-10W4

Title: **TYPE STIFF DIAGRAMS MANNVILLE AQUIFERS**	NORTH AMERICAN OIL SANDS CORPORATION	
	Approved: LP	Revision Date: 07/05/22
	File: 4455-Strat-07.cdr	
	Drawn by: GDE	Checked: BW
	Fig. No.: **5C-1**	

APPENDIX 5D
Numerical Modelling Construction and Calibration

5D1 CONSTRUCTION AND CALIBRATION OF NUMERICAL MODEL

5D1.1 Software Selection

This work assumes that a representative elementary volume (Bear, 1972) of the porous medium exists and can represent the effective hydraulic behaviour of the medium. Groundwater flow within the study area was interpreted to be normal gravity driven flow and can be represented by the fluid continuity equation:

$$\frac{\partial}{\partial \times}\left(K_x \frac{\partial h}{\partial \times}\right)+\frac{\partial}{\partial y}\left(K_y \frac{\partial h}{\partial y}\right)+\frac{\partial}{\partial z}\left(K_z \frac{\partial h}{\partial z}\right)=S_s \frac{\partial h}{\partial t}$$

where:

x, y, z	=	the principal components of space (L)
h	=	hydraulic head (L)
S_s	=	specific storage (L-1)
K	=	hydraulic conductivity (L/t)
t	=	time

The major assumptions within the continuity equation and in this application are that the fluid is incompressible, groundwater flow follows Darcy's Law, and the fluid throughout the study area has a constant density.

Groundwater flow was simulated in this study using the three dimensional FEFLOW simulator developed by WASY Ltd. (2004). FEFLOW was used to solve for mass conservative groundwater flow within fully saturated porous media using finite element discretization of the media. Documentation of the validation and verification of the FEFLOW program (WASY, 2004) was reviewed and the FEFLOW program was judged to be a suitable simulator for this study.

5D1.2 Model Discretization

The model domain covers an area of approximately 31,000 km^2. The regional study area (RSA) and model domain boundaries are defined by the following:

- North – The Clearwater River, extending from the Saskatchewan border to the confluence of the Athabasca River and the eastward flowing section of the Athabasca River to the confluence of the Clearwater River;
- East – The Saskatchewan border extending from the centre of Township 69 to the Clearwater River;
- South – The centre of Township 69 extending from the Saskatchewan border to the Athabasca River; and
- West – The northerly flowing portion of the Athabasca River, extending from the centre of Township 69 to Township 89.

The finite element grid is displayed on Figure 5D-1 and contains 36,785 elements per layer and 18,644 nodes per slice. The mesh was considerably refined in the vicinity of water supply, injection and observation wells and within the local study area (LSA; Figure 5D-2). Mesh elements increase from less than 30 m in the vicinity of the pumping/injection wells to 5,000 m outside of the LSA.

The model domain was discretized vertically into 45 slices and 44 model layers (Table 5D-1). Increased vertical discretization was assigned to layers in which large vertical gradients were expected or where pumping/injection was to occur. These layers include the Undifferentiated Overburden Aquifer/Aquitard, LaBiche Aquitard, Joli Fou Aquitard, Upper Grand Rapids Aquifer, Lower Grand Rapids Aquifer, Clearwater Shale Aquitard, Clearwater A Aquifer, Clearwater B Aquifer, McMurray Aquifer/Aquitard, McMurray Bitumen Aquitard, Basal McMurray Aquifer and Cooking Lake/Beaverhill Lake Aquifer/Aquitard.

Table 5D-1 Hydrostratigraphic Units – Assessed Hydraulic Parameters

Hydrostratigraphic Unit	Slice Number	Number of Layers	Hydraulic Conductivity		Specific Storage
			Horizontal (m/sec)	Vertical (m/sec)	(m^{-1})
Undifferentiated Overburden Aquifer/Aquitard	1-3	3	1.0E-07	3.0E-09	3.0E-06
Terrace Sand Aquifer	4	1	1.0E-04	1.0E-05	3.0E-06
Empress Channel Aquifer	5	1	1.0E-04	1.0E-05	3.0E-06
LaBiche Aquitard	6-9	4	1.0E-09	6.0E-12	3.0E-06
Viking Aquifer	10	1	1.0E-06	1.0E-08	3.0E-06
Joli Fou Aquitard	11-13	3	1.0E-09	6.0E-12	3.0E-06
Upper Grand Rapids Aquifer	14-16	3	3.0E-07	1.0E-10	3.0E-06
Lower Grand Rapids Aquifer	17-18	2	1.7E-05	3.0E-06	3.0E-06
Lower Grand Rapids Aquifer/Aquitard	19	1	3.0E-07	3.0E-10	3.0E-06
Clearwater Shale Aquitard	20-21	2	1.0E-09	6.0E-12	3.0E-06
Clearwater A Aquifer	22-23	2	1.7E-05	3.0E-06	3.0E-06
Clearwater Aquifer/Aquitard	24	1	1.0E-08	1.0E-10	3.0E-06
Clearwater B Aquifer	25-26	2	1.7E-05	3.0E-06	3.0E-06
Clearwater Aquifer/Aquitard	27	1	1.0E-08	1.0E-10	3.0E-06
Clearwater C Aquifer	28	1	1.7E-05	3.0E-06	3.0E-06
Clearwater Aquifer/Aquitard	29	1	1.0E-08	1.0E-10	3.0E-06
Wabiskaw Bitumen Aquitard	30	1	1.0E-09	1.0E-11	3.0E-06
Wabiskaw Aquifer/Aquitard	31	1	1.0E-07	1.0E-10	3.0E-06
McMurray Aquifer/Aquitard	32-33	2	1.0E-07	1.0E-10	3.0E-06
McMurray Bitumen Aquitard	34-36	3	1.0E-09	1.0E-11	3.0E-06
Basal McMurray Aquifer	37-38	2	2.3E-05	3.0E-07	3.0E-06
Winterburn Aquifer/Aquitard	39	1	3.0E-09	1.0E-11	3.0E-06
Grosmont Aquifer	40	1	7.0E-06	7.0E-07	3.0E-06
Ireton Aquitard	41	1	3.0E-09	1.0E-10	3.0E-06
Cooking Lake/Beaverhill Lake Aquifer/Aquitard	42-43	2	3.0E-07	1.0E-09	3.0E-06
Watt Mountain Aquitard	44	1	1.0E-09	7.0E-12	3.0E-06
Prairie Aquiclude	45	N/A	Base of model coincident with top of aquiclude		

The following figures are presented to illustrate the hydrostratigraphic units as represented in the numerical model:

Figure 5D-3: Ground Surface (Top Slice) Elevation and Assigned Boundary Conditions

Figure 5D-4: Top of Bedrock Surface and Subcroping Formations

Figure 5D-5: Undifferentiated Surficial Sediments (Top of Bedrock to Ground Surface) Isopach

Figure 5D-6: Terrace Sand Aquifer Isopach

Figure 5D-7: Empress Channel Aquifer Isopach and Assigned Boundary Conditions

Figure 5D-8: LaBiche Aquitard Structure

Figure 5D-9: LaBiche Aquitard Isopach

Figure 5D-10: Viking Aquifer Structure and Assigned Boundary Conditions

Figure 5D-11: Joli Fou Aquitard Structure

Figure 5D-12: Joli Fou Aquitard Isopach

Figure 5D-13: Upper Grand Rapids Aquifer Structure

Figure 5D-14: Upper Grand Rapids Aquifer Isopach and Assigned Boundary Conditions

Figure 5D-15: Lower Grand Rapids Aquifer Structure

Figure 5D-16: Lower Grand Rapids Aquifer Isopach and Assigned Boundary Conditions

Figure 5D-17: Lower Grand Rapids Aquifer/Aquitard Structure and Assigned Boundary Conditions

Figure 5D-18: Clearwater Shale Aquitard (Top of Clearwater Formation) Structure

Figure 5D-19: Clearwater Shale Aquitard Isopach

Figure 5D-20: Clearwater A Aquifer Isopach and Assigned Boundary Conditions

Figure 5D-21: Clearwater B Aquifer Isopach

Figure 5D-22: Clearwater C Aquifer Isopach

Figure 5D-23: Wabiskaw Bitumen Aquitard Isopach Structure

Figure 5D-24: Wabiskaw Aquifer/Aquitard

Figure 5D-25: McMurray Aquifer/Aquitard Structure

Figure 5D-26: McMurray Bitumen Aquitard Isopach

Figure 5D-27: Basal McMurray Aquifer Isopach and Assigned Boundary Conditions

Figure 5D-28: Top of Devonian Structure and Subcroping Formations

Figure 5D-29: Undifferentiated Devonian Units Isopach and Assigned Boundary Conditions

Figure 5D-30: Prairie Aquiclude Structure (Base of Model) and Assigned Boundary Conditions

5D1.3 Boundary Conditions

Boundary conditions assigned to the model were chosen to approximate the regional groundwater flow patterns and to approximate the major groundwater fluxes in the RSA.

Groundwater recharge and discharge to surface waterbodies was represented by assigning a specified hydraulic head boundary condition to the top of the model (Figure 5D-3). The specified head value assigned to each node at the ground surface was equal to the topographic elevation at the node, corresponding to the digital topographic elevation for that location. Specified hydraulic head values at ground surface range from 226 masl to 843 masl (Figure 5D-3). Within the major river valleys (Clearwater and Athabasca Rivers) a constraint was placed on the specified head nodes to allow flux out of the model only.

Based on the large permeability contrast between the Empress Channel Aquifer and the LaBiche/Joli Fou Aquitards, it is likely that a significant amount of groundwater flows across the eastern and western Empress Channel Aquifer boundaries in this model. Boundary conditions for the Empress Channel were approximated using reported hydraulic head measurements in the Wiau and Christina Channels as discussed in Appendix 5B. The western boundary of the Empress Channel Aquifer was assigned a specified head value of 470 masl, which is approximately equal the ground elevation where the Empress Channel Aquifer outcrops in the Athabasca River Valley (Figure 5D-7). The eastern boundary of the Empress Channel Aquifer within the Wiau Channel was assigned a specified head value of 680 masl (Figure 5D-7). The eastern boundary of the Empress Channel Aquifer within the Christina Channel was assigned a specified head value of 625 masl (Figure 5D-7). The specified head values on the eastern boundaries were based on interpreted water levels in the channels.

Where hydrostratigraphic units, such as the Empress Channel Aquifer, the Viking Aquifer (Figure 5D-10), the Upper Grand Rapids Aquifer (Figure 5D-14), the Lower Grand Rapids Aquifer (Figure 5D-16), the Lower Grand Rapids Aquifer/Aquitard (Figure 5D-17), Clearwater A Aquifer (Figure 5D-20) and the Basal McMurray Aquifer (Figure 5D-27) outcrop within the Clearwater, Christina and Athabasca River valleys, specified head values approximately equal to the river elevation were assigned. A constraint was placed on the specified head nodes to only allow flux out of the model at that boundary.

As described in Section 5.5.3.1, the Grosmont Aquifer acts as a drain for the McMurray Aquifer and thus lateral groundwater flow in the McMurray within the study area is predominantly towards the west. The influence of the Grosmont drain is represented in the numerical model by assigning a specified hydraulic head boundary condition of 350 masl along the west boundary of the Grosmont Aquifer (Figure 5D-29).

There is a component of flow in the undifferentiated McMurray to the east, specifically in the southeast portion of the model domain. This component of flow is likely the result of the Prairie Aquiclude being absent east of the model domain. To allow water in the McMurray to exit the model domain at the eastern boundary, a specified head ranging between 412 masl and 435 masl was assigned to the Basal McMurray Aquifer at the eastern edge of the model domain between Townships 69 and 78 (Figure 5D-27). A constraint was placed on the specified head nodes to only allow flux out of the model at that boundary.

As described in Section 5.5.3.1, regional groundwater flow in the Beaverhill Lake Aquifer/Aquitard is directed east beyond the zero edge of the Prairie Aquiclude where it drains into the Winnipegosis Aquifer. This influence of the Winnipegosis Aquifer is represented in the numerical model by assigning specified hydraulic heads at the base of the model on the eastern portion of the RSA where the Prairie Aquiclude is absent (Figure 5D-30). The specified hydraulic head values at the south are 440 masl and a constant gradient was applied up to the northern boundary where a specified head of 250 masl was assigned.

All other model boundary surfaces were assigned no-flow boundary conditions as it was assumed that the net groundwater flux across these surfaces is negligible compared to groundwater recharge, groundwater flow through the Wiau Channel, groundwater flow from the Viking, Grand Rapids, Clearwater and Basal McMurray aquifers to the Athabasca and Clearwater River valleys, groundwater flow towards the Grosmont Aquifer, and groundwater flow into the Winnipegosis Aquifer.

5D1.4 Model Calibration

The assigned hydraulic parameters of the hydrostratigraphic units were based on professional experience, the steady state calibration and knowledge gained from previous transient calibrations completed for the EnCana Foster Creek In-Situ Oil Sands Project (Matrix, 2005a), the ConocoPhillips Surmont Project (Gulf, 2001 and ConocoPhillips, 2006), the EnCana Christina Lake Project (Matrix, 2007 and 2007b), the Devon Jackfish 2 Project (Devon, 2006) and the Nexen/OPTI Long Lake South Project (Nexen/OPTI, 2006). Details concerning these transient calibrations are summarised in Table 5D-2.

Table 5D-2 Hydraulic Tests Data used in Previous Model Calibration

Project	Aquifer	Type of Test / Data	Average Pumping / Injection Rate	Duration of Test	Distance to Observation Well	Reference
Devon Jackfish 2	Lower Grand Rapids	Pumping	1,000 m^3/day	3 days	50 m	Devon, 2006
Devon Jackfish 2	Basal McMurray	Injection	1,000 m^3/day	3 days	N/A	Devon, 2006
ConocoPhillips Surmont	Lower Grand Rapids	Pumping	500 m^3/day	> 8 years	~1,100 m	ConocoPhillips, 2006
ConocoPhillips Surmont	Basal McMurray	Injection	45 m^3/day	> 12 years	~1,700 m	ConocoPhillips, 2006
EnCana Christina Lake Thermal	Basal McMurray	Injection	800 m^3/day	4 years	~400 m ~1,200 m ~2,400 m	Matrix, 2007a Matrix, 2007b
Nexen/OPTI Long Lake South	Lower Grand Rapids	Pumping	1,350 m^3/day	3 days	80 m	Nexen/OPTI, 2006
Nexen/OPTI Long Lake South	Clearwater A	Pumping	440 m^3/day	7 days	~1,000 m, 1,600 m	Nexen/OPTI, 2006
Nexen/OPTI Long Lake South	Basal McMurray	Pumping	730 m^3/day	4 days	80 m	Nexen/OPTI, 2006
EnCana Foster Creek	Lower Grand Rapids	Pumping	880 m^3/day	17 days	200 m 1,300 m	Matrix, 2005

5D1.4.1 Steady State Model Calibration

Once the mesh was constructed and boundary conditions specified, the steady state calibration was completed by adjusting the hydraulic properties assigned to each model hydrostratigraphic unit. Two types of steady state calibration targets were used:

- Simulated head distribution was compared to mapped and measured hydraulic heads in the Empress, Grand Rapids, Clearwater and the McMurray Formations.
- Simulated fluxes were compared to measured precipitation rates, estimates of groundwater recharge, and the estimated flux through the Wiau Aquifer.

5D1.4.1.1 Calibration to Hydraulic Heads

Simulated hydraulic head distributions and values were compared spatially and graphically to mapped (interpreted) hydraulic head distributions. The simulated hydraulic head distributions of the Empress, Grand Rapids, Clearwater and McMurray formations are presented in Figures 5D-31 through 5D-34 and are in reasonably close agreement with the mapped hydraulic head distributions (Figures 5D-35 through 5D-38).

The steady state calibration targets for the spatial distribution of the Empress Channel Aquifer hydraulic heads included:

- Flow from east to west in the Wiau Channel (Figure 5D-35);
- Flow to the hydraulic low in the Christina Channel in Township 75 Range 6 (Figure 5D-35);
- Flow from south to north in the Sunday Creek Channel (Figure 5D-35); and
- General magnitude and gradient of hydraulic heads in the Christina, Wiau and Sunday Creek Channels.

As presented in Figures 5D-31 and 5D-35, there is close agreement between the spatial distribution of simulated and observed hydraulic head with respect to each of the calibration targets.

The steady state calibration targets for the spatial distribution of the Grand Rapids hydraulic heads included:

- Flow to the west and north towards the Athabasca and Clearwater Rivers as presented in Figure 5D-36;
- Groundwater mounding in the Grand Rapids below the Christina, Sunday Creek and Christina Channels as presented in Figure 5D-36; and
- General magnitude and gradient of hydraulic heads in the RSA as presented in Figure 5D-36.

There is close agreement between the spatial distribution of the Grand Rapids simulated (Figure 5D-32) and observed hydraulic heads (Figure 5D-36) with respect to each of the calibration targets. The data density of the observed values is too sparse to resolve mounding of the simulated magnitude considering the limited extent of the simulated values (Figure 5D-36).

The steady state calibration targets for the spatial distribution of the Clearwater hydraulic heads included:

- Flow to the west and to the north towards the Athabasca and Clearwater Rivers as presented in Figure 5D-37;

- Groundwater mounding in the southern part of the RSA as presented in Figure 5D-37; and

- General magnitude and gradient of hydraulic heads in the RSA as presented in Figure 5D-37.

There is reasonable agreement between the spatial distribution of the Clearwater simulated (Figure 5D-33) and observed hydraulic heads (Figure 5D-37) with respect to the flow direction, groundwater mounding and the hydraulic gradients. The simulated hydraulic heads in the Clearwater are somewhat underestimated relative to the observed hydraulic heads.

The steady state calibration targets for the spatial distribution of the undifferentiated McMurray hydraulic heads included:

- Flow to the north towards the Athabasca and Clearwater Rivers as presented in Figure 5D-38;

- Flow to the west towards the Grosmont Formation as presented in Figure 5D-38;

- Flow to the east in the southeast portion of the RSA as presented in Figure 5D-38; and

- General magnitude and gradient of hydraulic heads in the RSA as presented in Figure 5D-38.

There is close agreement between the spatial distribution of the undifferentiated McMurray simulated (Figure 5D-34) and observed hydraulic heads (Figure 5D-38) with respect to each of the calibration targets.

Hydraulic head mapping was based on published hydraulic head values, and reported drill stem test (DST) pressures. Due to inherent uncertainties in the hydraulic head measurements obtained from DSTs, the interpreted hydraulic head maps for each aquifer is smoothed compared to the raw data. In order to better calibrate the model to interpreted head distributions, a representative data set of interpreted hydraulic head values was generated by sampling the contoured head surfaces in a grid pattern. This sampled data set offers a more evenly distributed calibration dataset compared to the clustered measured hydraulic head data. In addition to the representative data set, reported hydraulic head values from pumping, observation wells, source wells and injection wells in the RSA were used for a graphical comparison of the simulated versus observed heads. A plot of 359 simulated versus observed hydraulic head values is included as Figure 5D-39. As presented in Figure 5D-39, there is relatively close agreement between the simulated and observed hydraulic heads. The average difference between the observed hydraulic heads and simulated hydraulic heads was 8 m and the mean absolute difference was 26 m.

5D1.4.1.2 Calibration to Estimated Flux

Average annual precipitation in the vicinity of the Project is estimated to be 481 mm/year (Devon, 2003). Based on previous studies, the recharge rate to overburden aquifers is estimated to be 3 mm/year (EBA, 1999). In addition, a regional scale model constructed for the Husky Tucker Thermal Project estimated 3.5 mm/year recharge to the Manville aquifers (Husky, 2003). These constraints were used to develop a calibration target of between 1 mm/year to 5 mm/year. Once calibrated, the steady state model simulated a net vertical flux of 1.2 mm/year downward.

As reported by Stewart (2003), a series of springs discharge water from the Empress Channel Aquifer within the Wiau Channel into the Athabasca River valley. The total discharge from the springs was estimated to be 7,680 m^3/day (Stewart, 2003). Therefore, this represents the minimum flux within the Empress Channel Aquifer at the western boundary of the model. Based on the horizontal hydraulic gradient observed east of the discharge springs, the maximum flux at the western boundary within the Empress Channel Aquifer is estimated to be 27,000 m^3/day. Once calibrated, the simulated steady state net flux at the western boundary of the Empress Channel Aquifer was 19,490 m^3/day and is within the calibration target.

Simulation Sensitivity

Upon completion of the steady state calibration, an understanding of the simulation sensitivity was gained. With respect to the steady state calibration and on a regional scale, a major control on the magnitude and distribution of hydraulic heads was the vertical hydraulic conductivity of major aquitards including the La Biche, Joli Fou and the Clearwater Shale Aquitards. At a more local scale, in addition to the hydraulic parameters of the major aquitards, a major control on the magnitude and distribution of the steady state groundwater mounding observed in the Grand Rapids was the vertical hydraulic conductivity of the Upper Grand Rapids Aquifer. Because the stacked series of coarsening upward sequences of fine grain and coarse grain sediments within the Upper Grand Rapids, the hydrostratigraphic unit as a whole has a relatively low vertical hydraulic conductivity. With an assigned vertical hydraulic conductivity of 1×10^{-10} m/s, a close agreement between the simulated and observed groundwater mounding in the Upper Grand Rapids was obtained.

Based on previous transient calibrations, the simulation results are also sensitive to the hydraulic parameters assigned to the pumping/injection candidate aquifers.

5D1.5 Literature Cited

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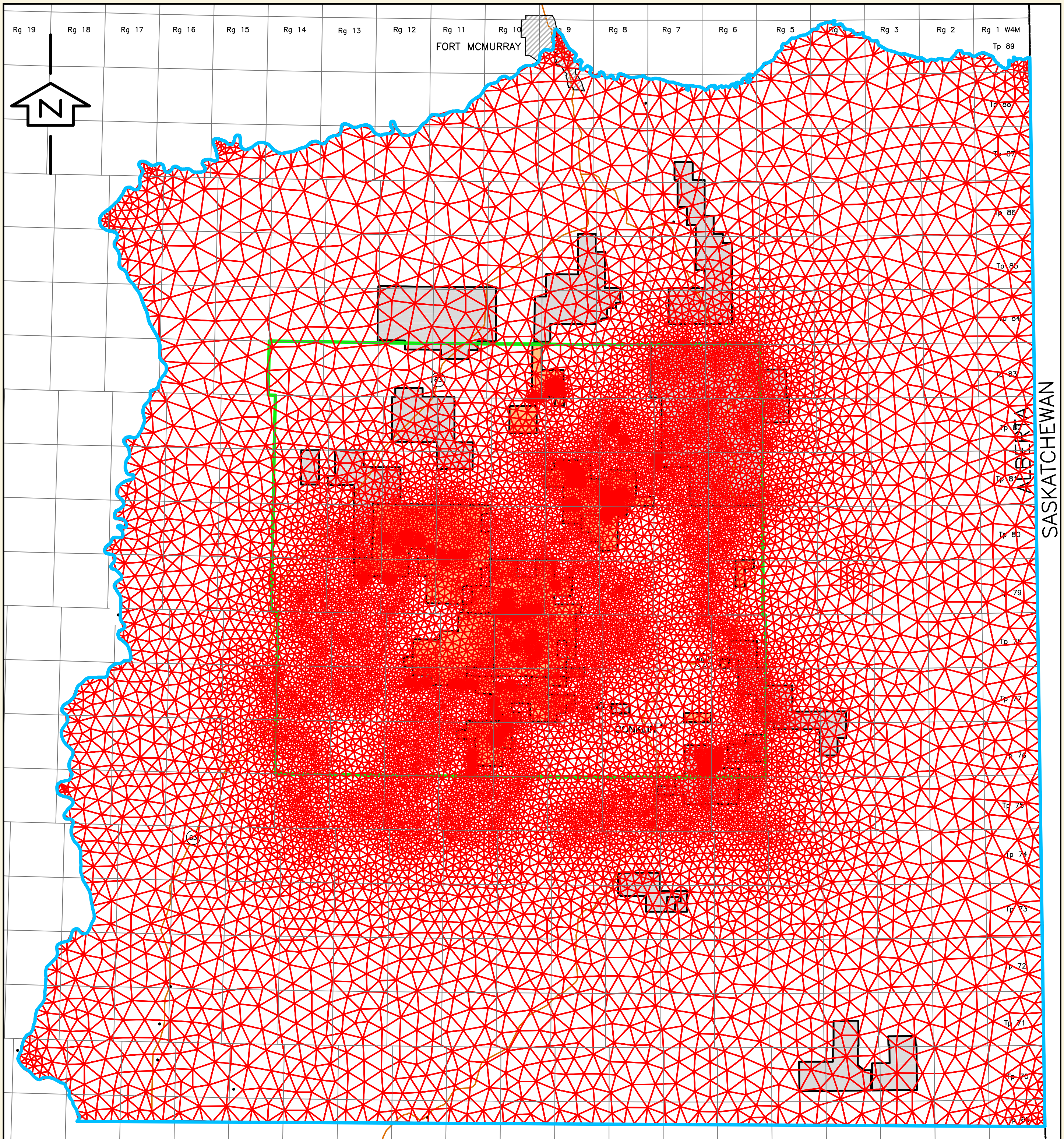

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- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- REGIONAL STUDY AREA (RSA)
- LOCAL STUDY AREA (LSA)

REFERENCE
ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

FINITE ELEMENT MESH
REGIONAL STUDY AREA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/06/14	
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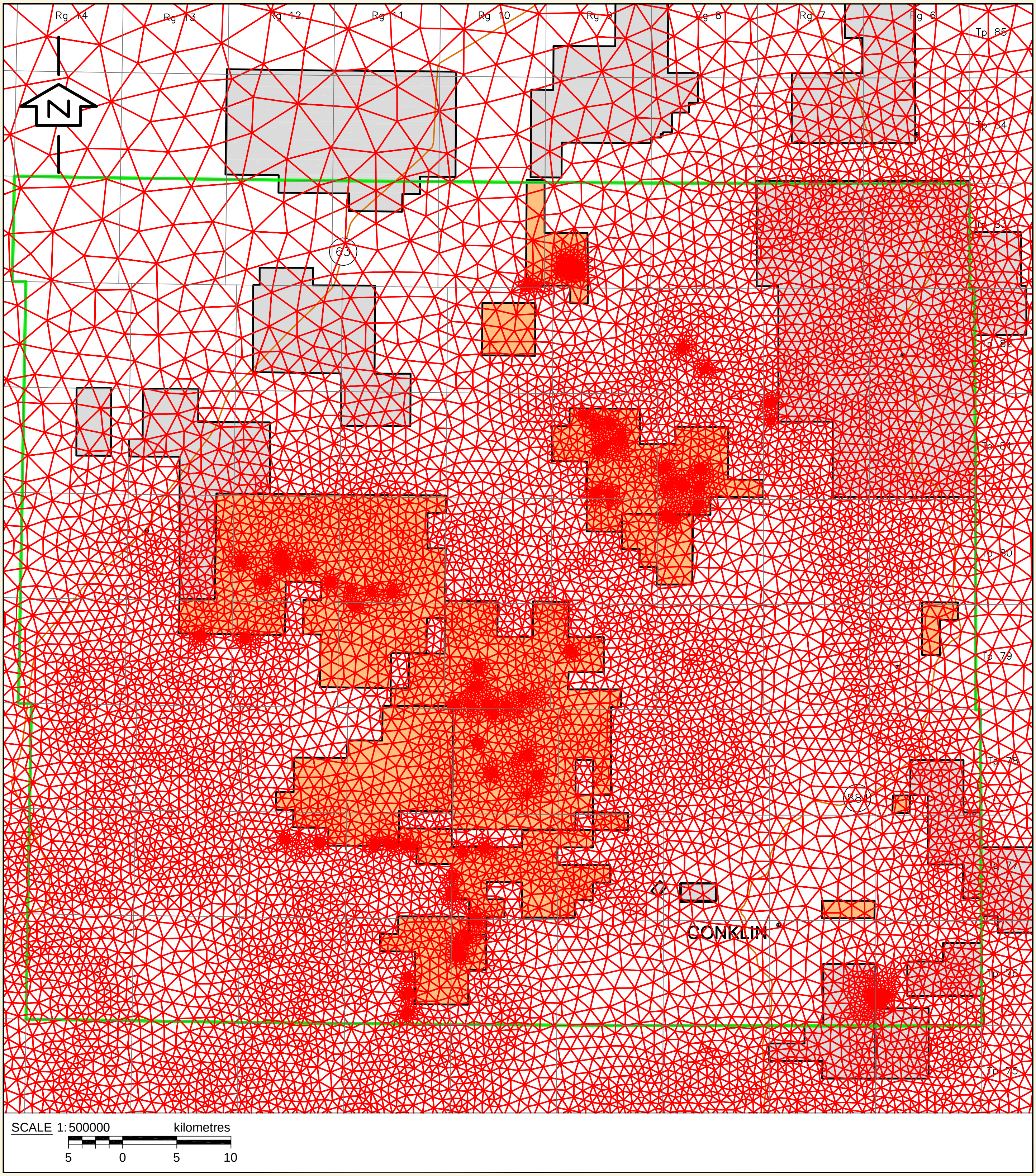

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- LOCAL STUDY AREA (LSA)

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SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

FINITE ELEMENT MESH
LOCAL STUDY AREA

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/06/14
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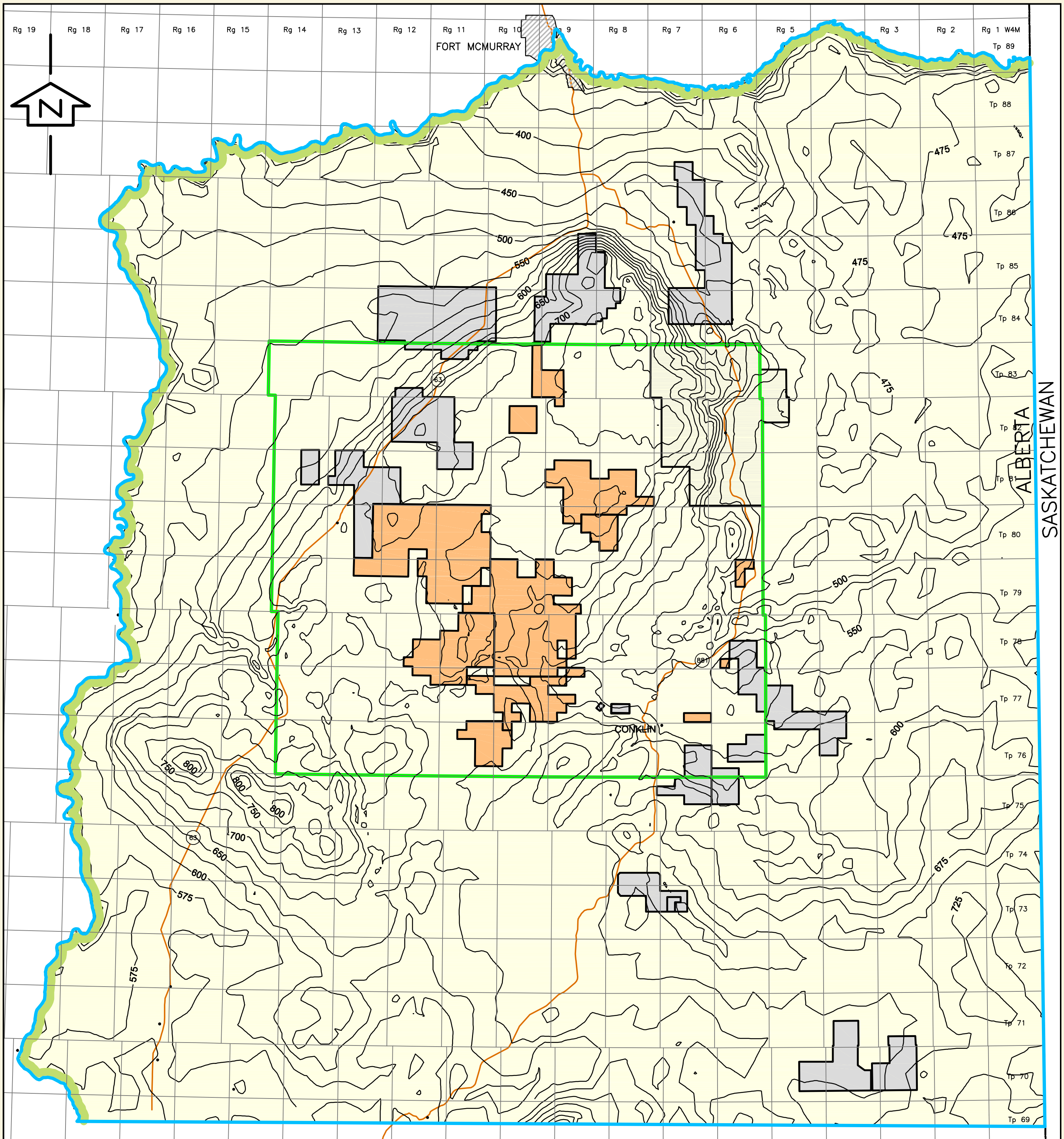

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- LOCAL STUDY AREA (LSA)
- CONSTANT HEAD NODE - ASSIGNED GROUND ELEVATION
- CONSTANT HEAD NODE - ASSIGNED RIVER ELEVATION
- – 450 – GROUND SURFACE ELEVATION (masl)

REFERENCE

ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

GROUND SURFACE (TOP SLICE) ELEVATION AND ASSIGNED BOUNDARY CONDITIONS

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/06/14
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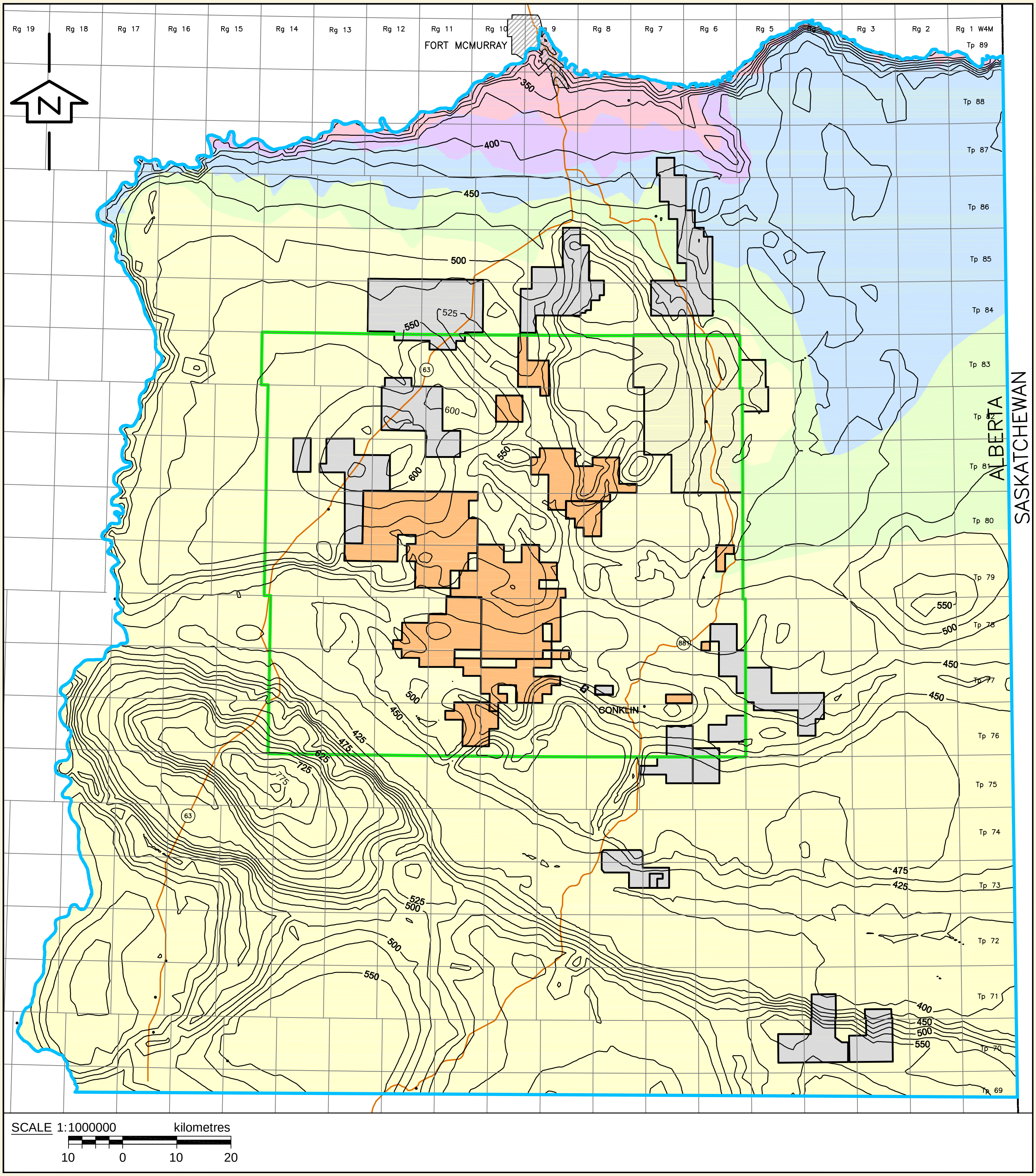

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- – 450 – BEDROCK SURFACE ELEVATION(masl)
- Labiche Subcroping Formation
- Joli Fou / Viking Subcroping Formation
- Upper Grand Rapids Subcroping Formation
- Lower Grand Rapids Subcroping Formation
- Clearwater Subcroping Formation

REFERENCE

ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
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DATUM: NAD 27 PROJECTIONS: UTM ZONE 12
ANDRIASHEK, L.D., 2003

Title:

TOP OF BEDROCK SURFACE AND SUBCROPPING FORMATIONS

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:
RP	07/06/14

File: 4455-IMPACTASSESSAPP-07.DWG

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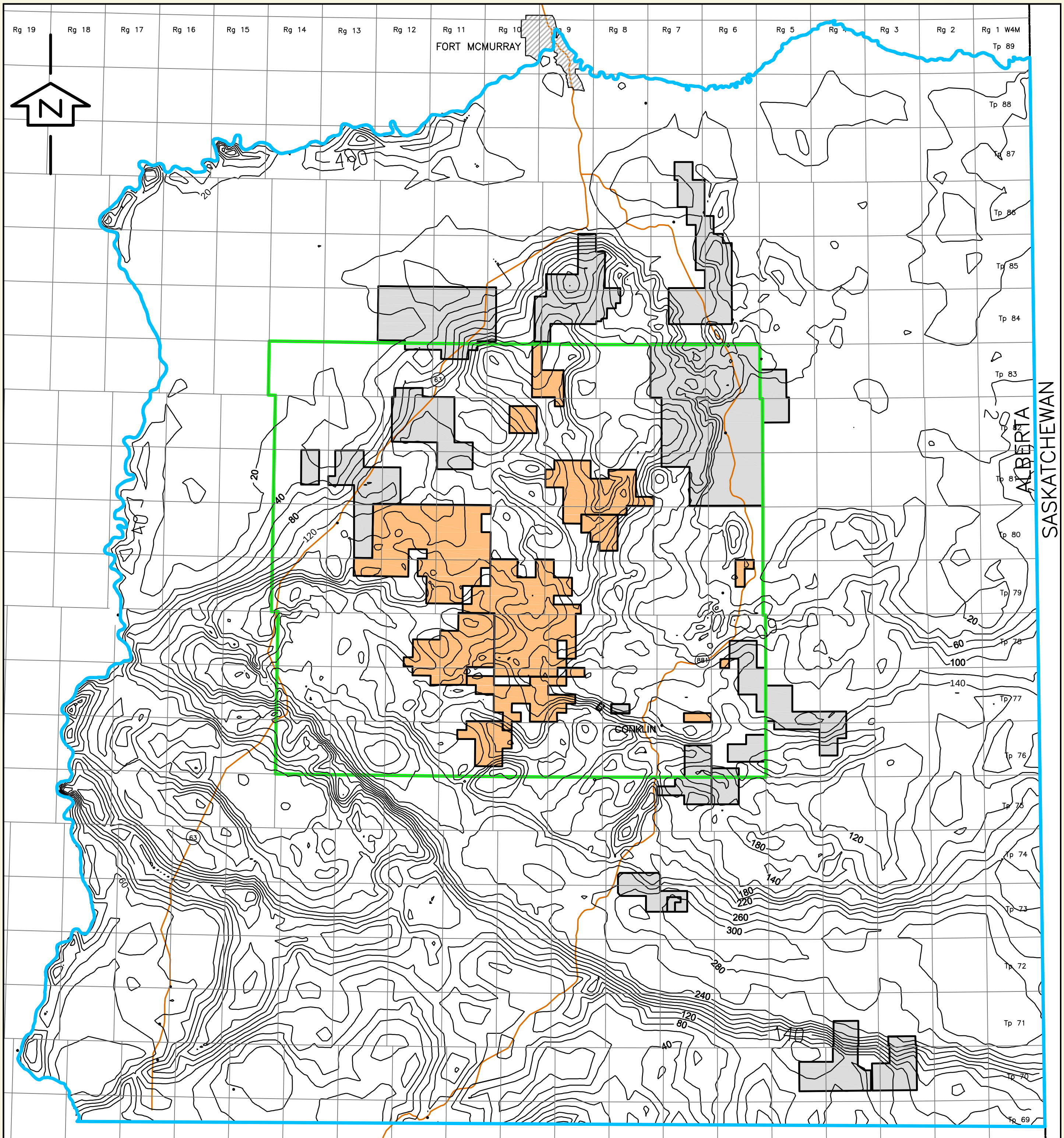

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- LOCAL STUDY AREA (LSA)
- **20** ISOPACH (m)

REFERENCE

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SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

OVERBURDEN AQUIFER/AQUITARD (TOP OF BEDROCK TO GROUND SURFACE) ISOPACH

NORTH AMERICAN OIL SANDS CORPORATION

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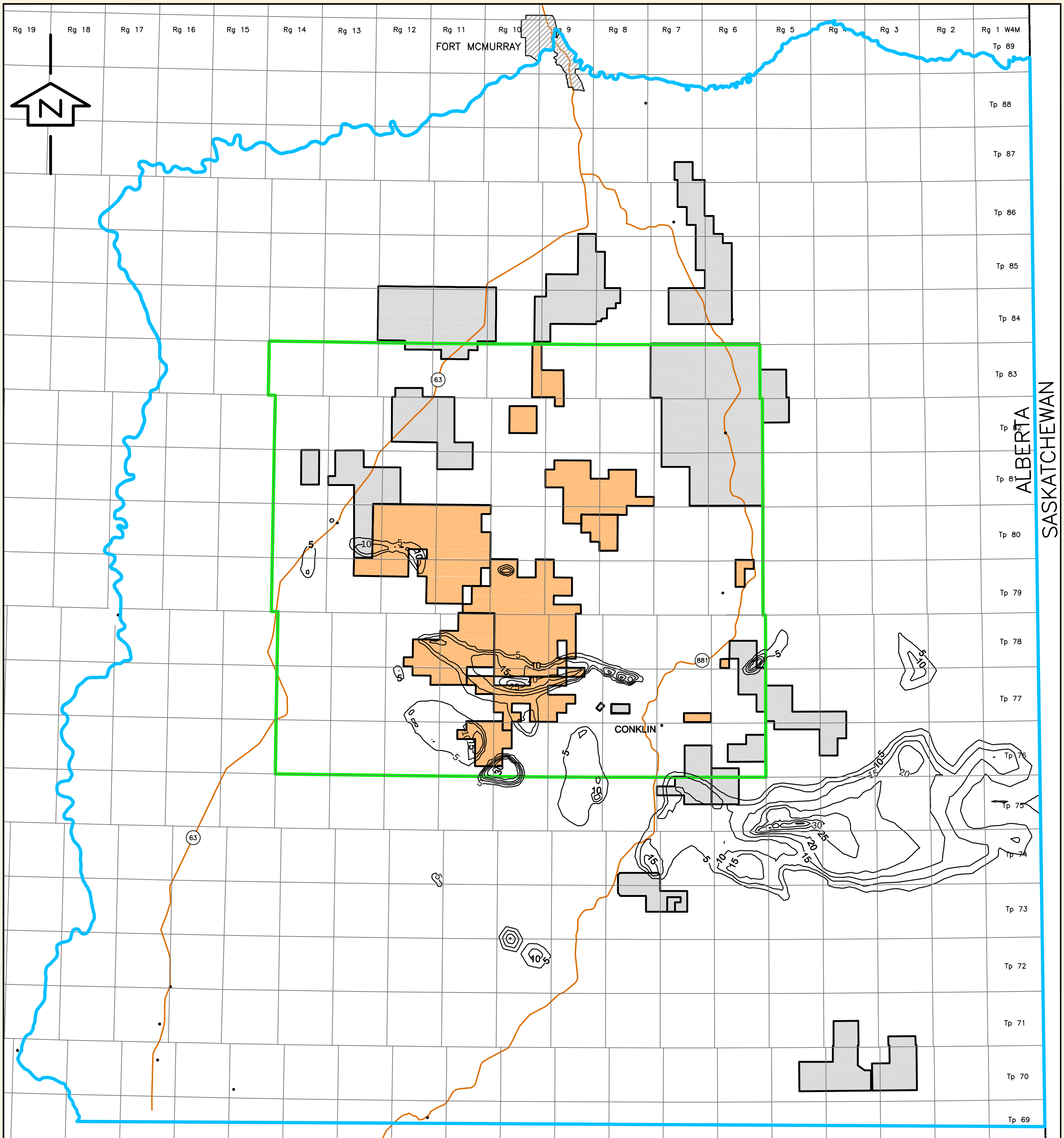

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- LOCAL STUDY AREA (LSA)
- 20 ISOPACH (m)

REFERENCE

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DATUM: NAD 27 PROJECTIONS: UTM ZONE 12
ANDRIASHEK, L.D., 2003

Title:

TERRACE SAND AQUIFER ISOPACH

NORTH AMERICAN OIL SANDS CORPORATION

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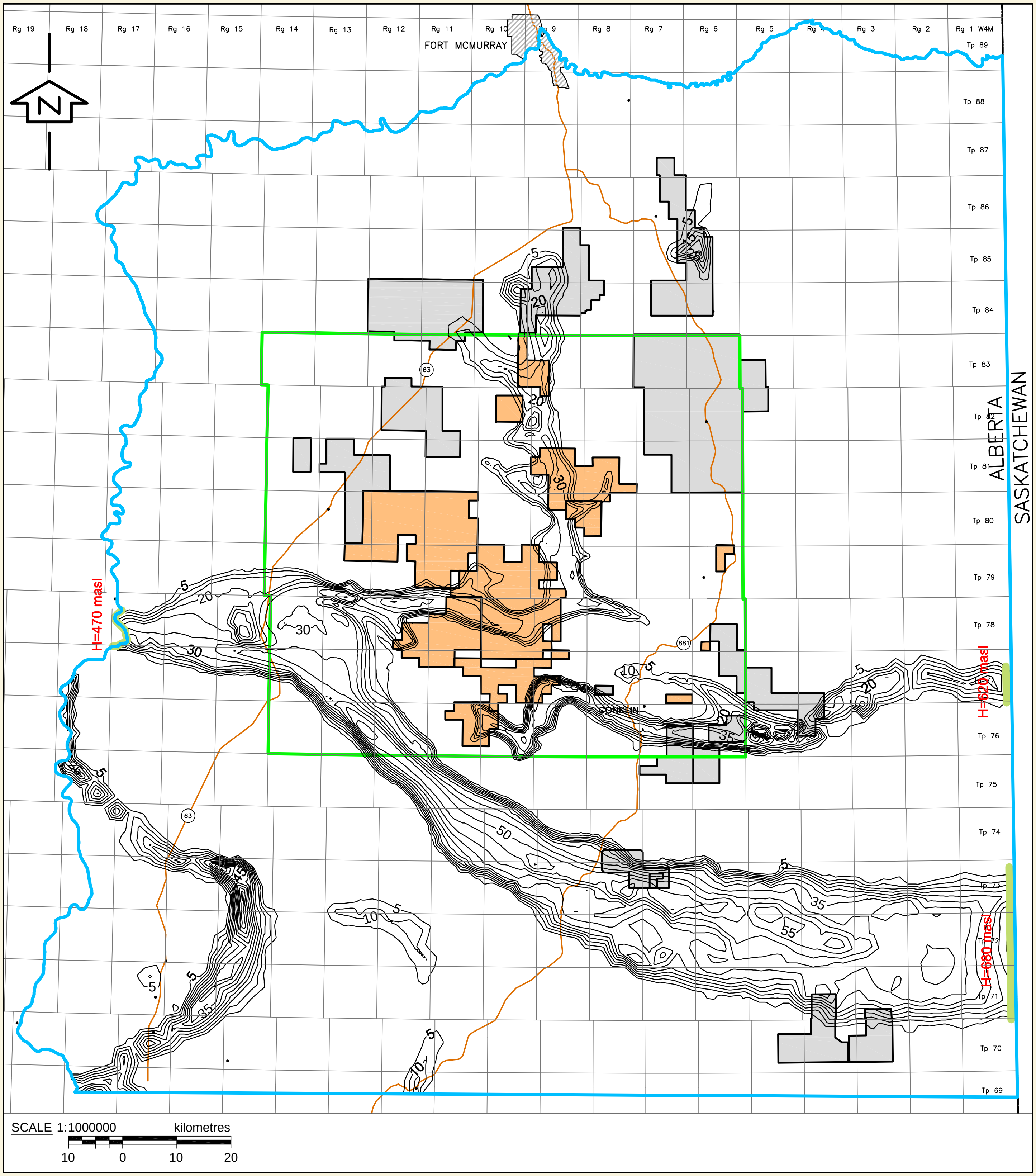

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- LOCAL STUDY AREA (LSA)
- CONSTANT HEAD NODES
- – **20** – ISOPACH (m)

REFERENCE

ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12
ANDRIASHEK, L.D., 2003

Title:

EMPRESS CHANNEL AQUIFER ISOPACH AND ASSIGNED BOUNDARY CONDITIONS

NORTH AMERICAN OIL SANDS CORPORATION

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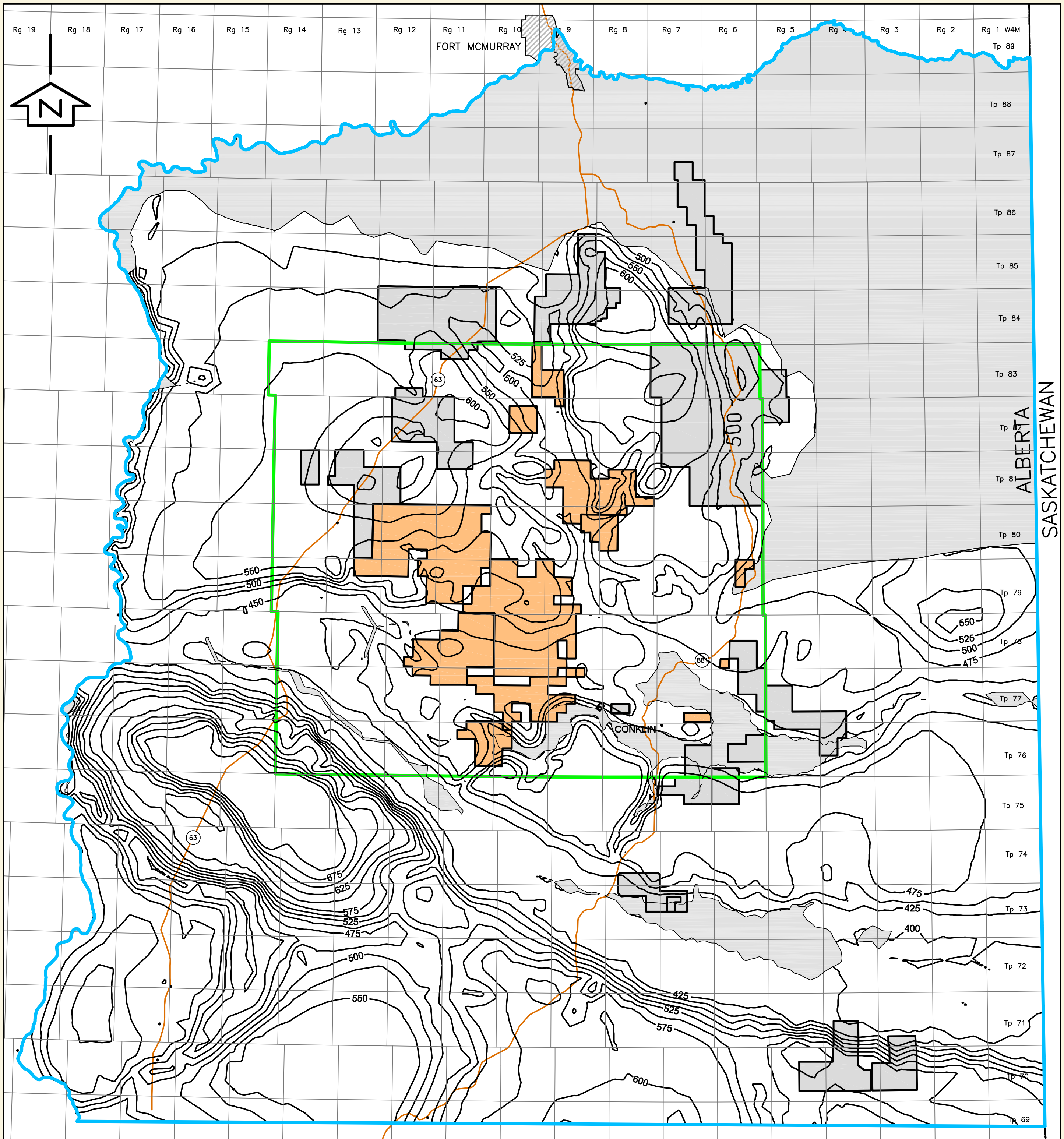

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- – 450 – AQUITARD STRUCTURE (masl)
- FORMATION ABSENT

REFERENCE

ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

LaBICHE AQUITARD STRUCTURE

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/06/14
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Fig. No.: 5D-8	

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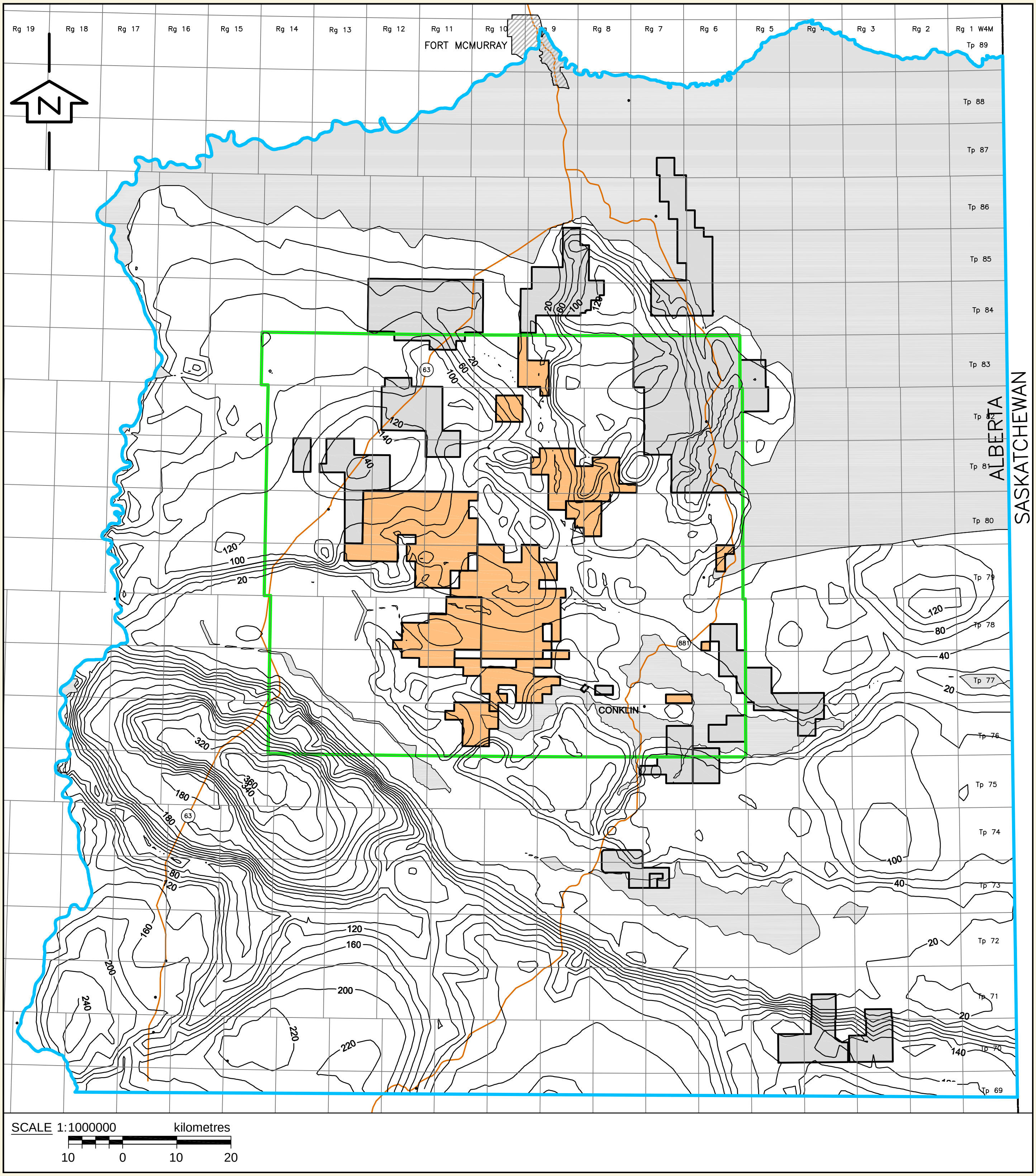

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- 20 ISOPACH (m)
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REFERENCE

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SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
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Title:

LaBICHE AQUITARD ISOPACH

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/06/14
File: 4455-IMPACTASSESSAPP-07.DWG	

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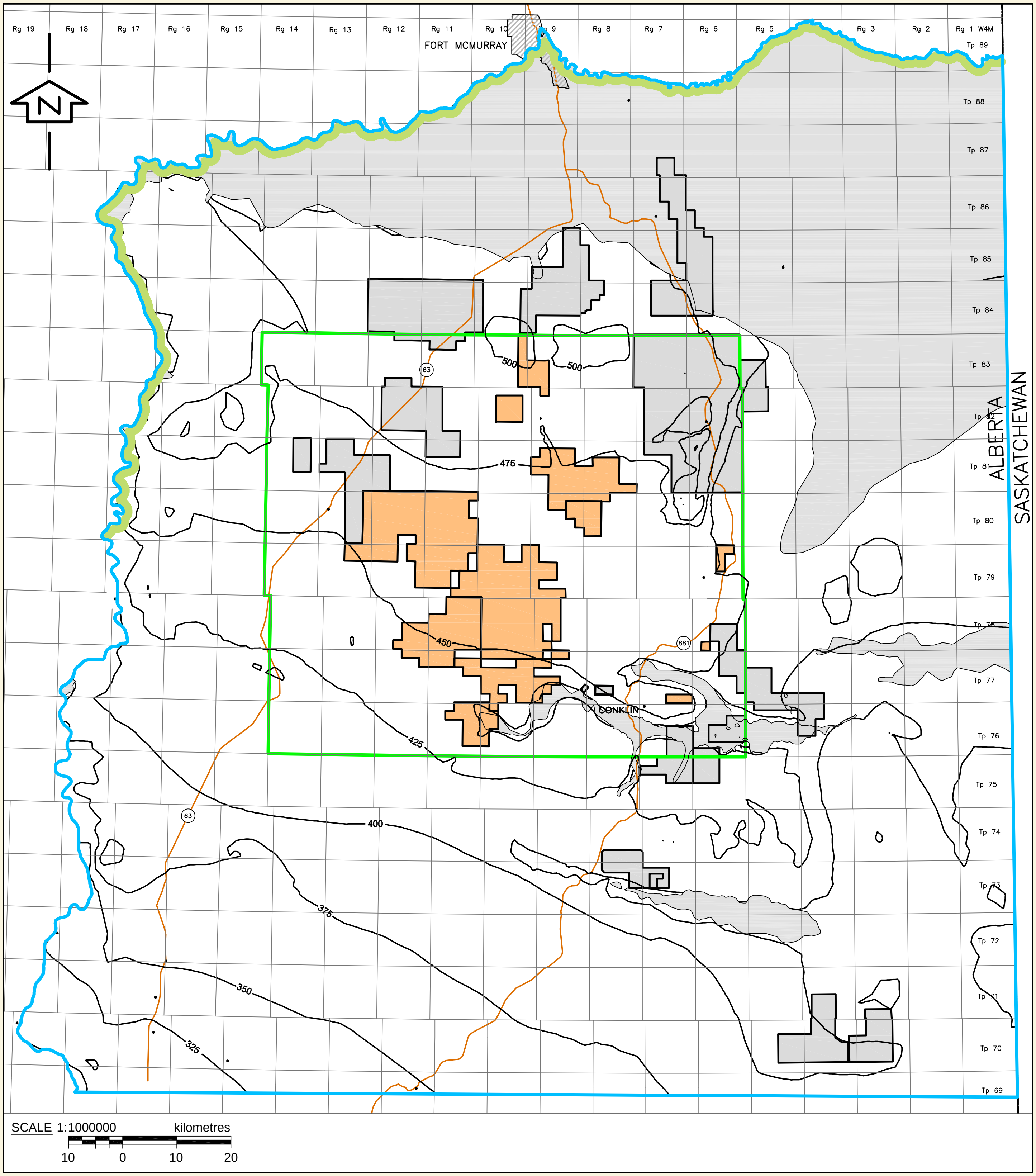

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- LOCAL STUDY AREA (LSA)
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- FORMATION ABSENT
- CONSTANT HEAD NODE - ASSIGNED RIVER ELEVATION

REFERENCE

ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

VIKING AQUIFER STRUCTURE AND ASSIGNED BOUNDARY CONDITIONS

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/06/14
File: 4455-IMPACTASSESSAPP-07.DWG	

Drawn by:	Checked:	Fig. No.:
ADF	BW	**5D-10**

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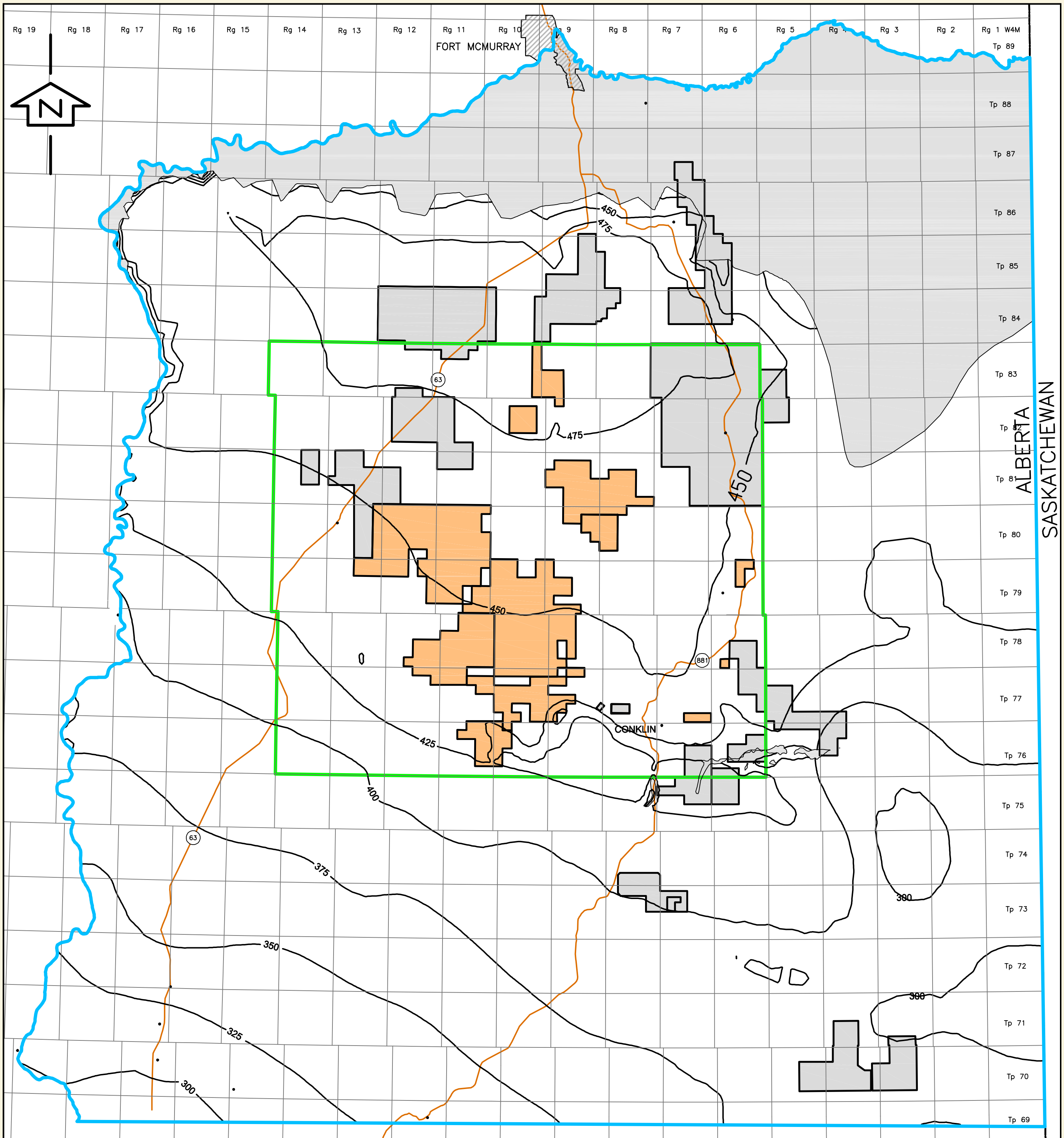

SCALE 1:1000000 kilometres

10 0 10 20

LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- REGIONAL STUDY AREA (RSA)
- LOCAL STUDY AREA (LSA)
- – 450 – AQUITARD STRUCTURE (masl)
- FORMATION ABSENT

REFERENCE

ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

JOLI FOU AQUITARD STRUCTURE

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/06/14
File: 4455-IMPACTASSESSAPP-07.DWG	

Drawn by: ADF	Checked: BW	Fig. No.: **5D-11**

*PLOT 1:1 = Letter (P)

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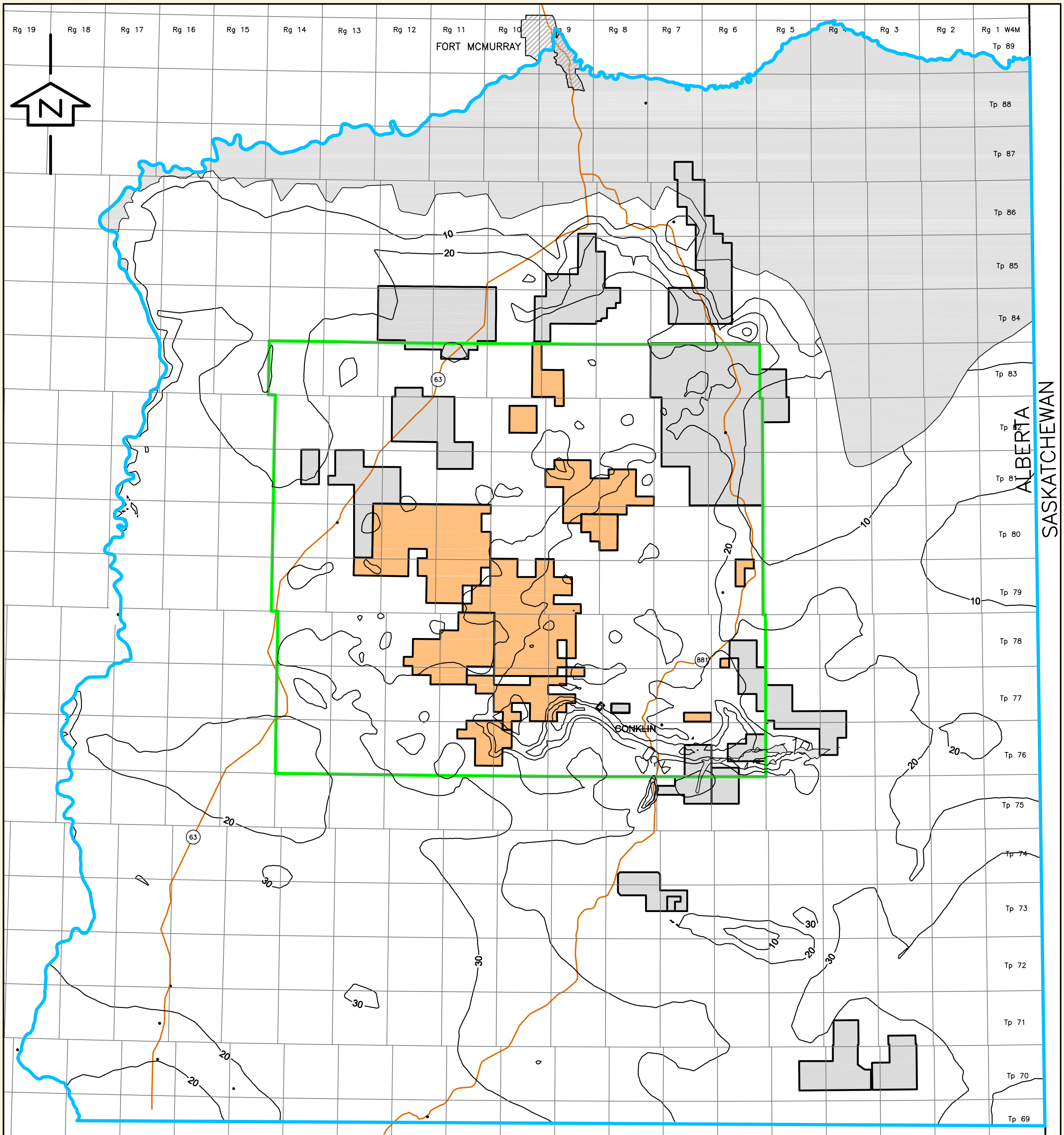


SCALE 1:1000000 kilometres

10 0 10 20

LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- REGIONAL STUDY AREA (RSA)
- LOCAL STUDY AREA (LSA)
- 20 – ISOPACH (m)
- FORMATION ABSENT

REFERENCE

ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

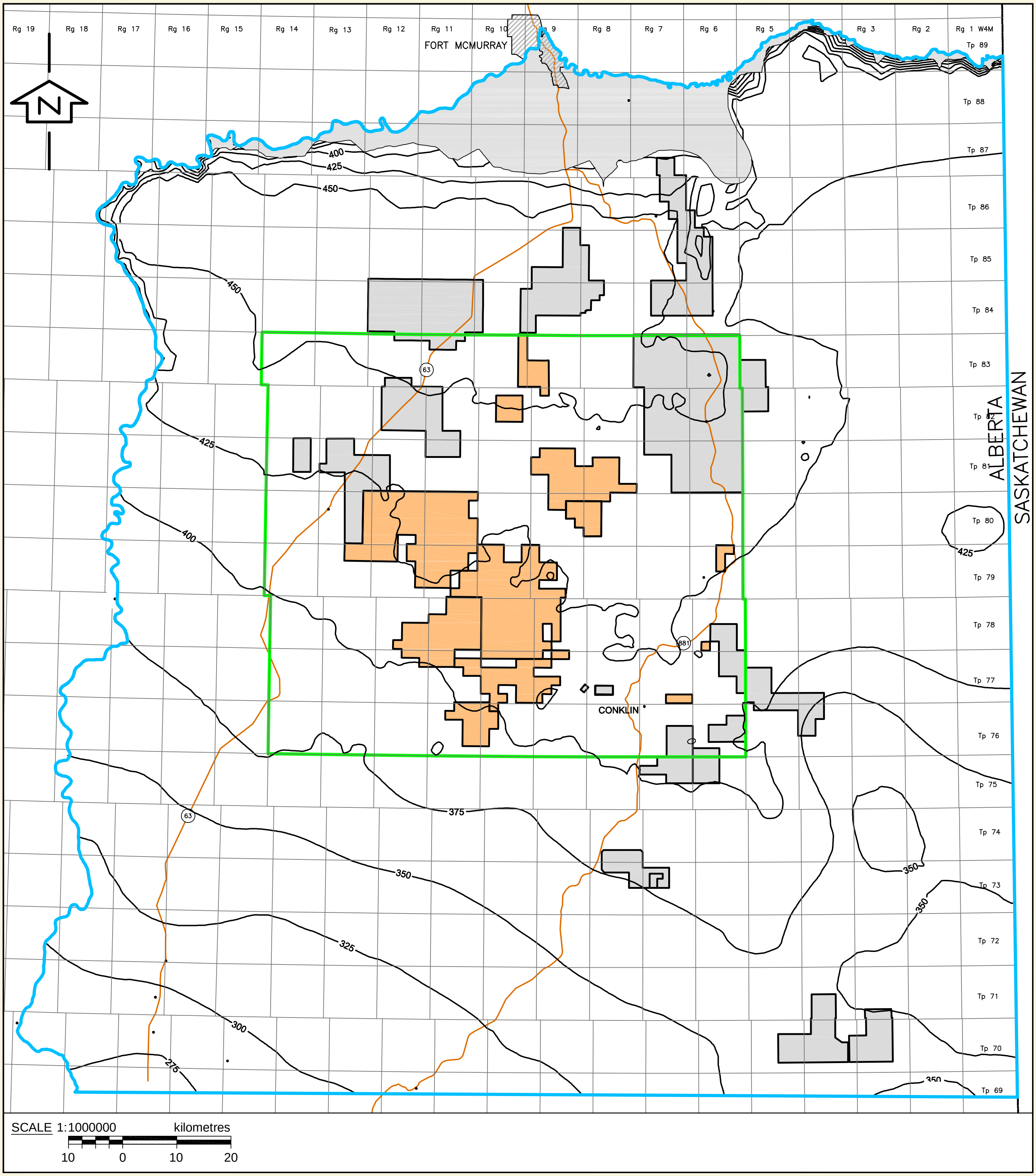
Title:

JOLI FOU AQUITARD ISOPACH

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/06/14
File: 4455-IMPACTASSESSAPP-07.DWG	

Drawn by:	Checked:	Fig. No.:
ADF	BW	5D-12



LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- REGIONAL STUDY AREA (RSA)
- LOCAL STUDY AREA (LSA)
- 450 AQUIFER STRUCTURE (masl)
- FORMATION ABSENT

REFERENCE

ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

UPPER GRAND RAPIDS AQUIFER STRUCTURE

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/06/14
File: 4455-IMPACTASSESSAPP-07.DWG	

Drawn by:	Checked:	Fig. No.:
ADF	BW	**5D-13**

*PLOT 1:1 = Letter (P)

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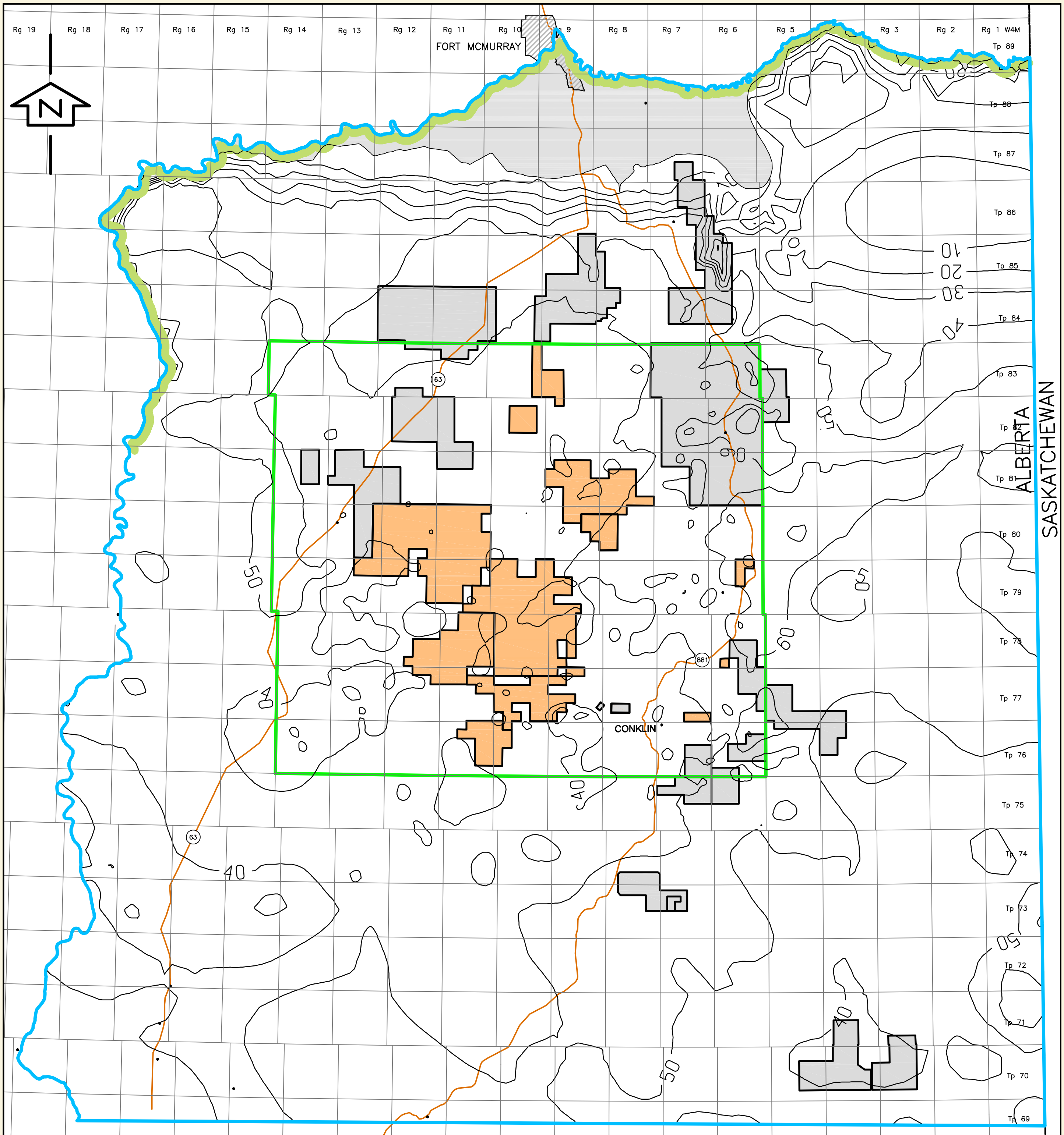


SCALE 1:1000000 kilometres

10 0 10 20

LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- REGIONAL STUDY AREA (RSA)
- LOCAL STUDY AREA (LSA)
- CONSTANT HEAD NODE - ASSIGNED RIVER ELEVATION
- **50** ISOPACH (m)
- FORMATION ABSENT

REFERENCE

ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

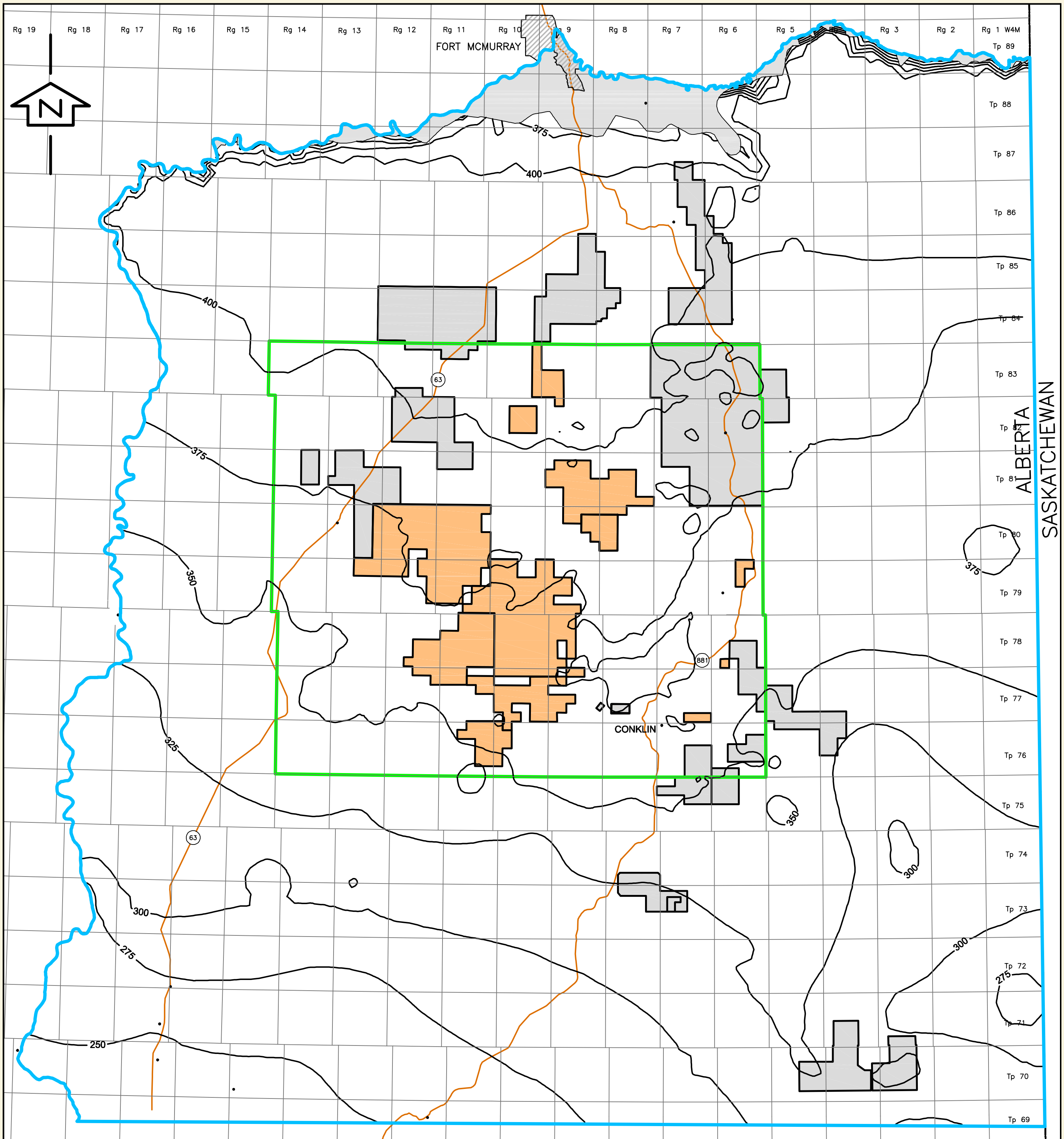
UPPER GRAND RAPIDS AQUIFER ISOPACH AND ASSIGNED BOUNDARY CONDITIONS

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/06/14
File: 4455-IMPACTASSESSAPP-07.DWG	

Drawn by:	Checked:	Fig. No.:
ADF	BW	5D-14

*PLOT 1:1 = Letter (P)



SCALE 1:1000000 kilometres

10 0 10 20

LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- REGIONAL STUDY AREA (RSA)
- LOCAL STUDY AREA (LSA)
- 450 AQUIFER STRUCTURE (masl)
- FORMATION ABSENT

REFERENCE

ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

LOWER GRAND RAPIDS AQUIFER STRUCTURE

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/06/14

File: 4455-IMPACTASSESSAPP-07.DWG

Drawn by:	Checked:	Fig. No.:
ADF	BW	5D-15

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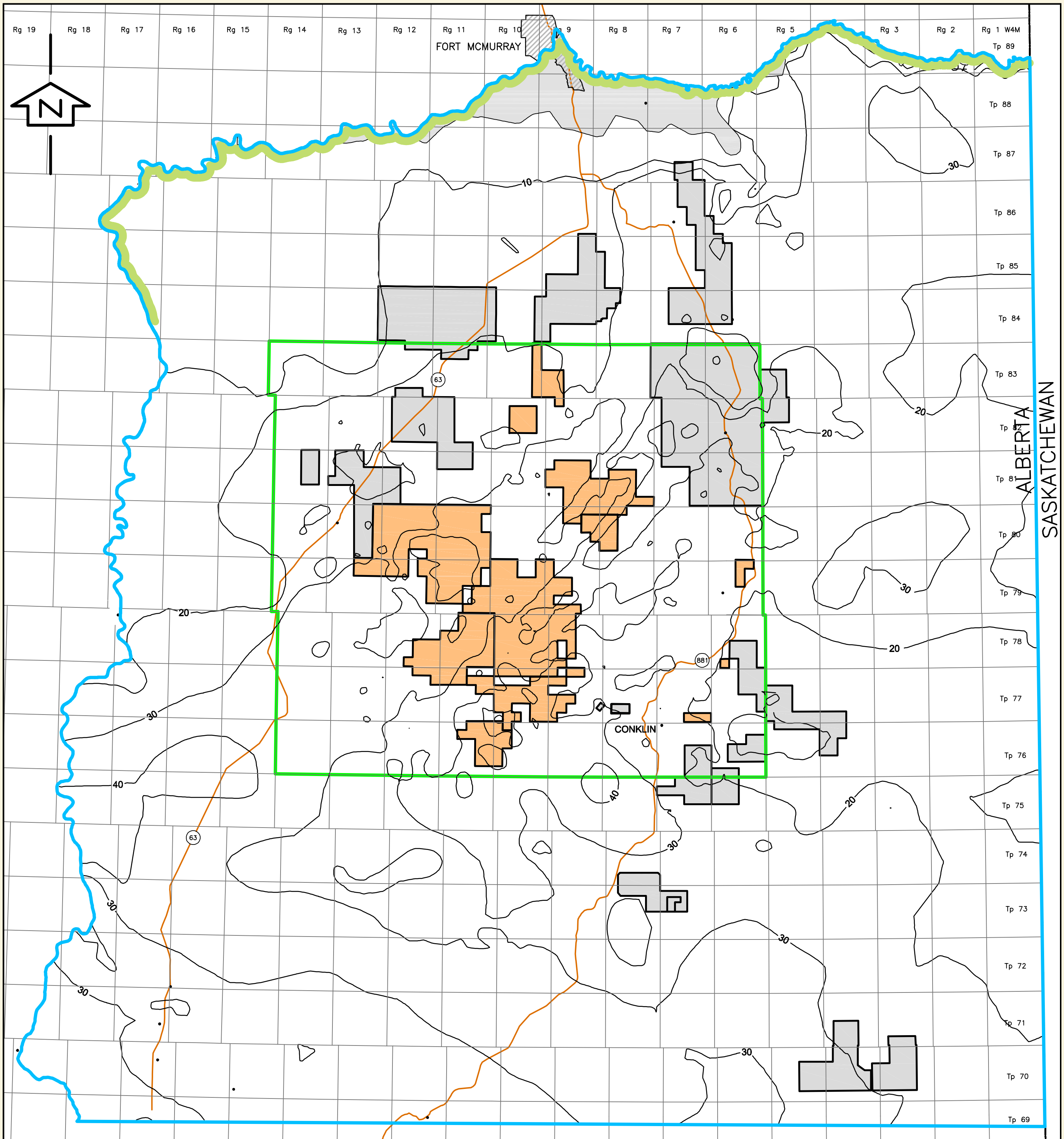


SCALE 1:1000000 kilometres

10 0 10 20

LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- REGIONAL STUDY AREA (RSA)
- LOCAL STUDY AREA (LSA)
- CONSTANT HEAD NODES - ASSIGNED RIVER ELEVATION
- 20 – ISOPACH (m)
- FORMATION ABSENT

REFERENCE

ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

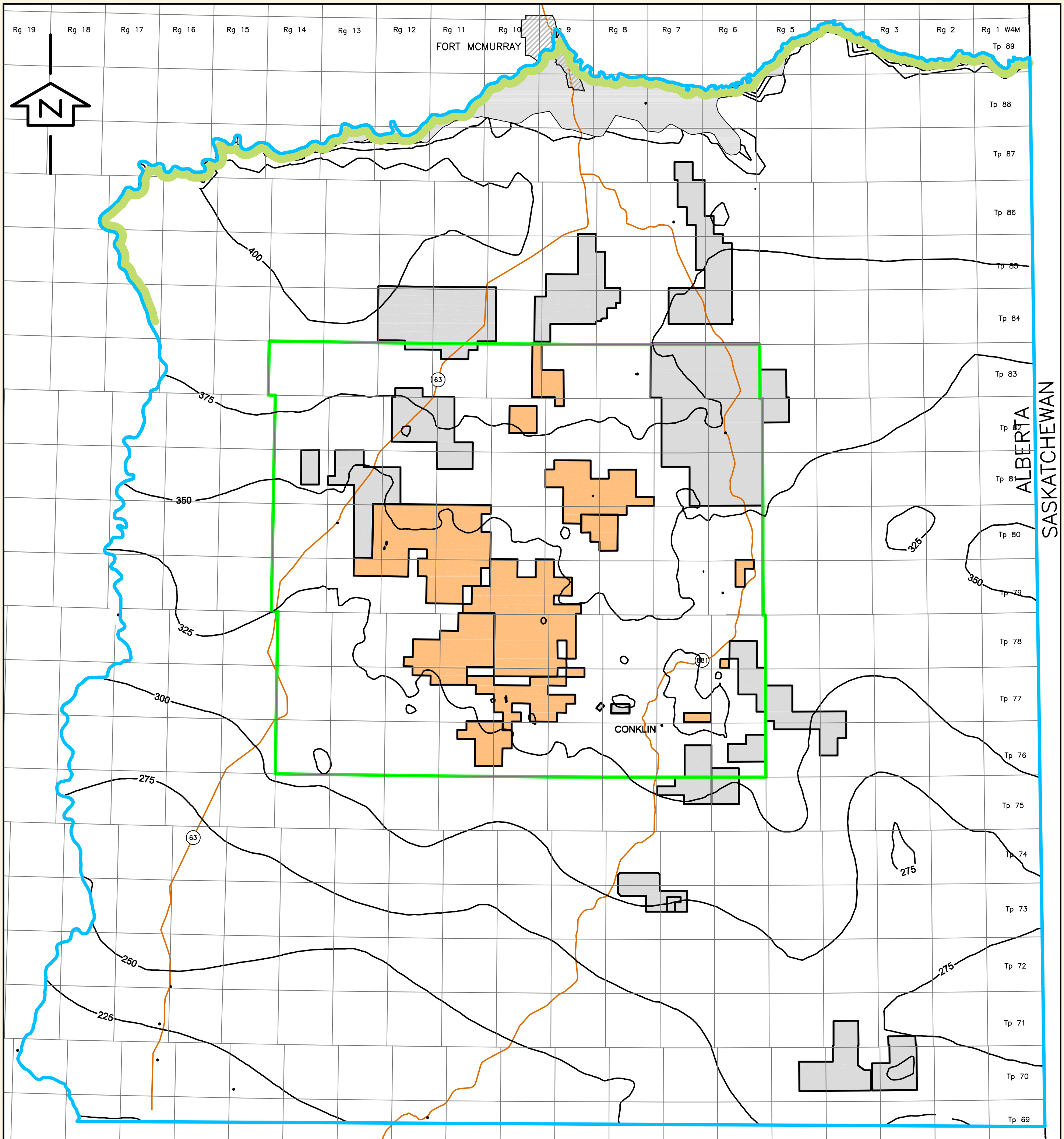
Title:

LOWER GRAND RAPIDS AQUIFER ISOPACH AND ASSIGNED BOUNDARY CONDITIONS

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/06/14	
File: 4455-IMPACTASSESSAPP-07.DWG		
Drawn by: ADF	Checked: BW	Fig. No.: **5D-16**

*PLOT 1:1 = Letter (P)



SCALE 1:1000000 kilometres

10 0 10 20

LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- REGIONAL STUDY AREA (RSA)
- LOCAL STUDY AREA (LSA)
- CONSTAND HEAD NODES - ASSIGNED RIVER ELEVATION
- 450 – AQUIFER/AQUITARD STRUCTURE (masl)
- FORMATION ABSENT

REFERENCE

ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

LOWER GRAND RAPIDS AQUIFER/AQUITARD STRUCTURE AND ASSIGNED BOUNDARY CONDITIONS

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/06/14
File: 4455-IMPACTASSESSAPP-07.DWG	

Drawn by:	Checked:	Fig. No.:
ADF	BW	5D-17

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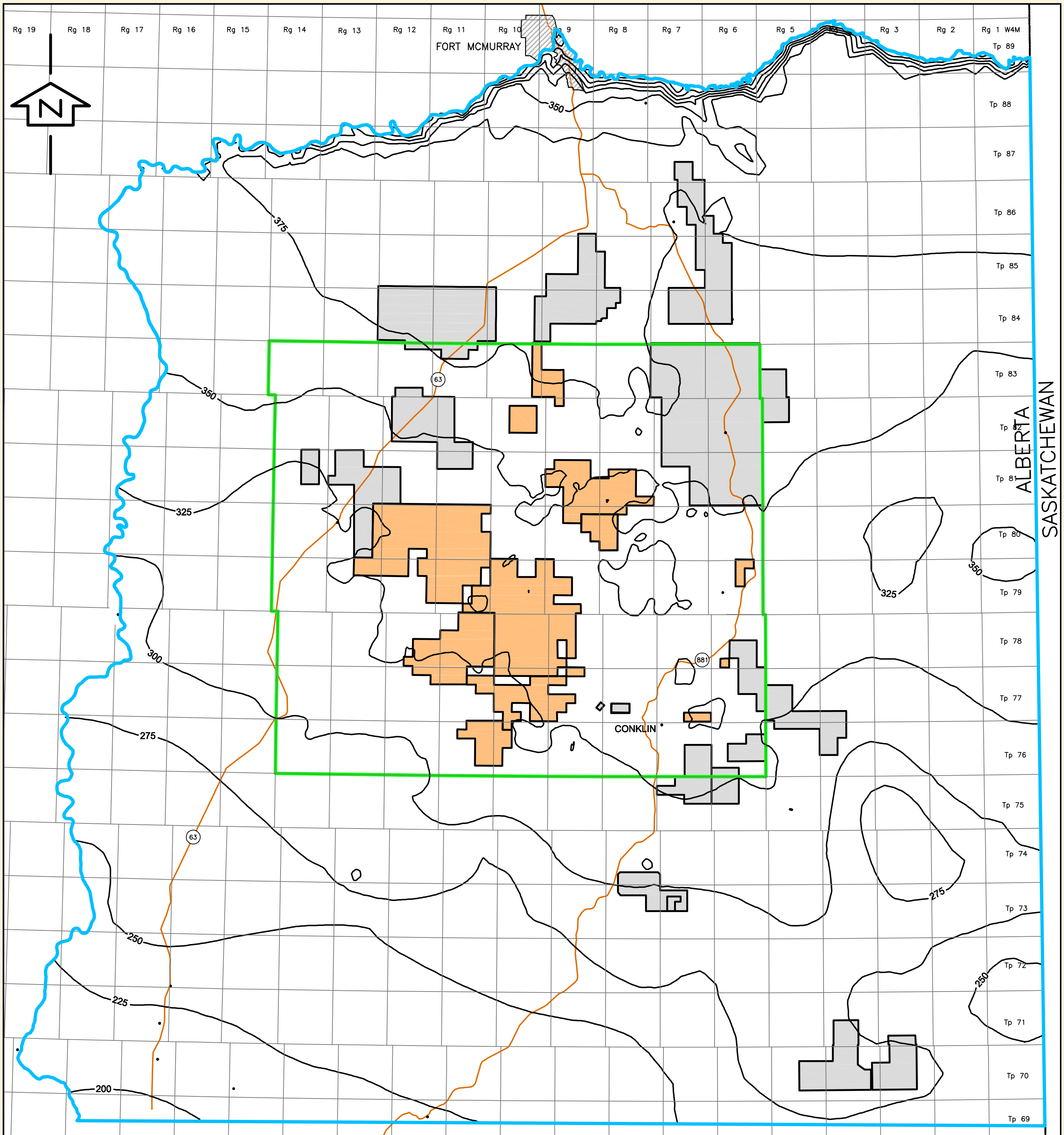

SCALE 1:1000000 kilometres

10 0 10 20

LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- REGIONAL STUDY AREA (RSA)
- LOCAL STUDY AREA (LSA)
- – 450 – AQUITARD STRUCTURE (masl)

REFERENCE

ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

CLEARWATER SHALE AQUITARD (TOP OF CLEARWATER FORMATION) STRUCTURE

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/06/14
File: 4455-IMPACTASSESSAPP-07.DWG	

Drawn by:	Checked:	Fig. No.:
ADF	BW	**5D-18**

*PLOT 1:1 = Letter (P)

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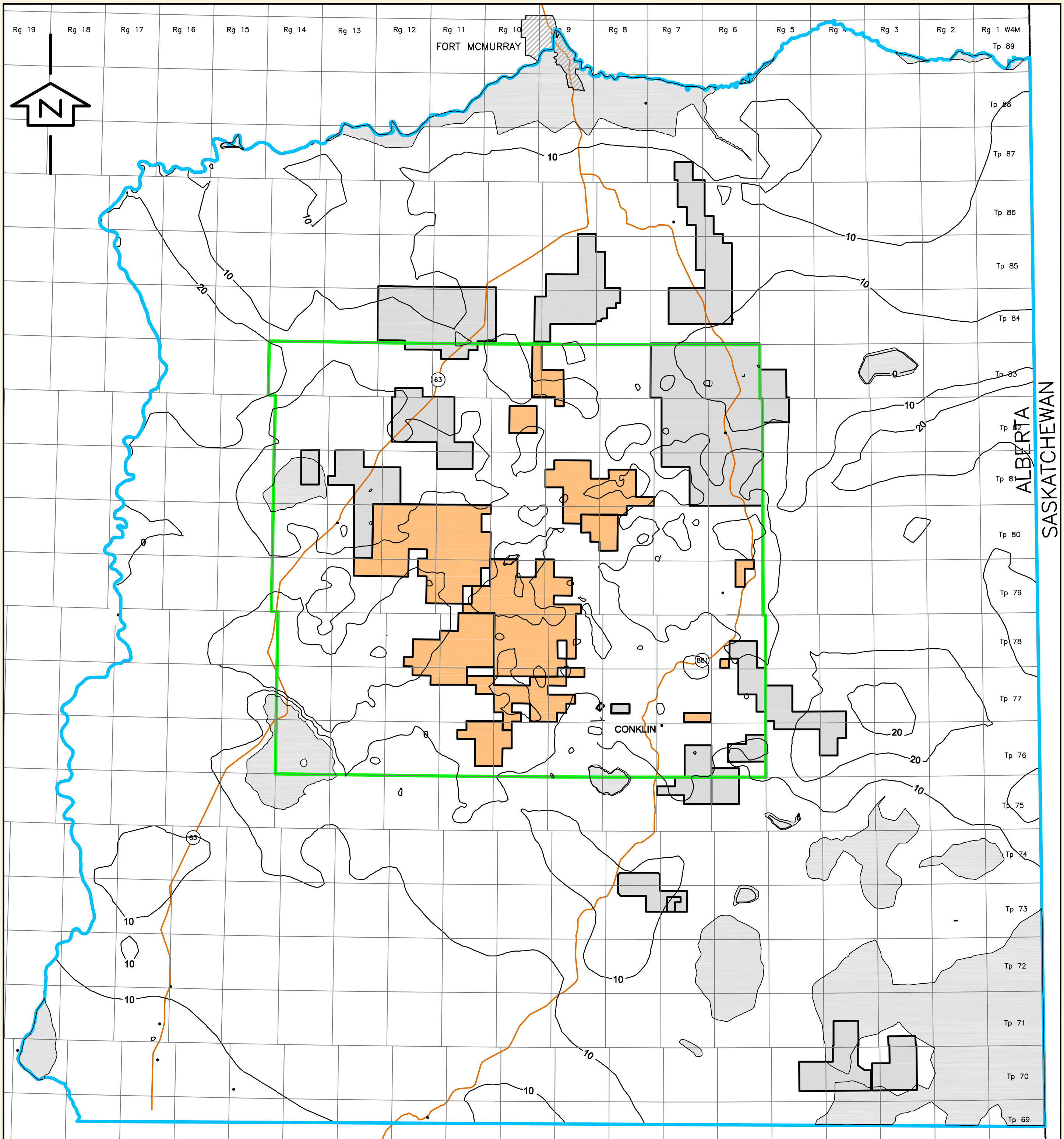


SCALE 1:1000000 kilometres

10 0 10 20

LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- REGIONAL STUDY AREA (RSA)
- LOCAL STUDY AREA (LSA)
- 20 ISOPACH (m)

REFERENCE

ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

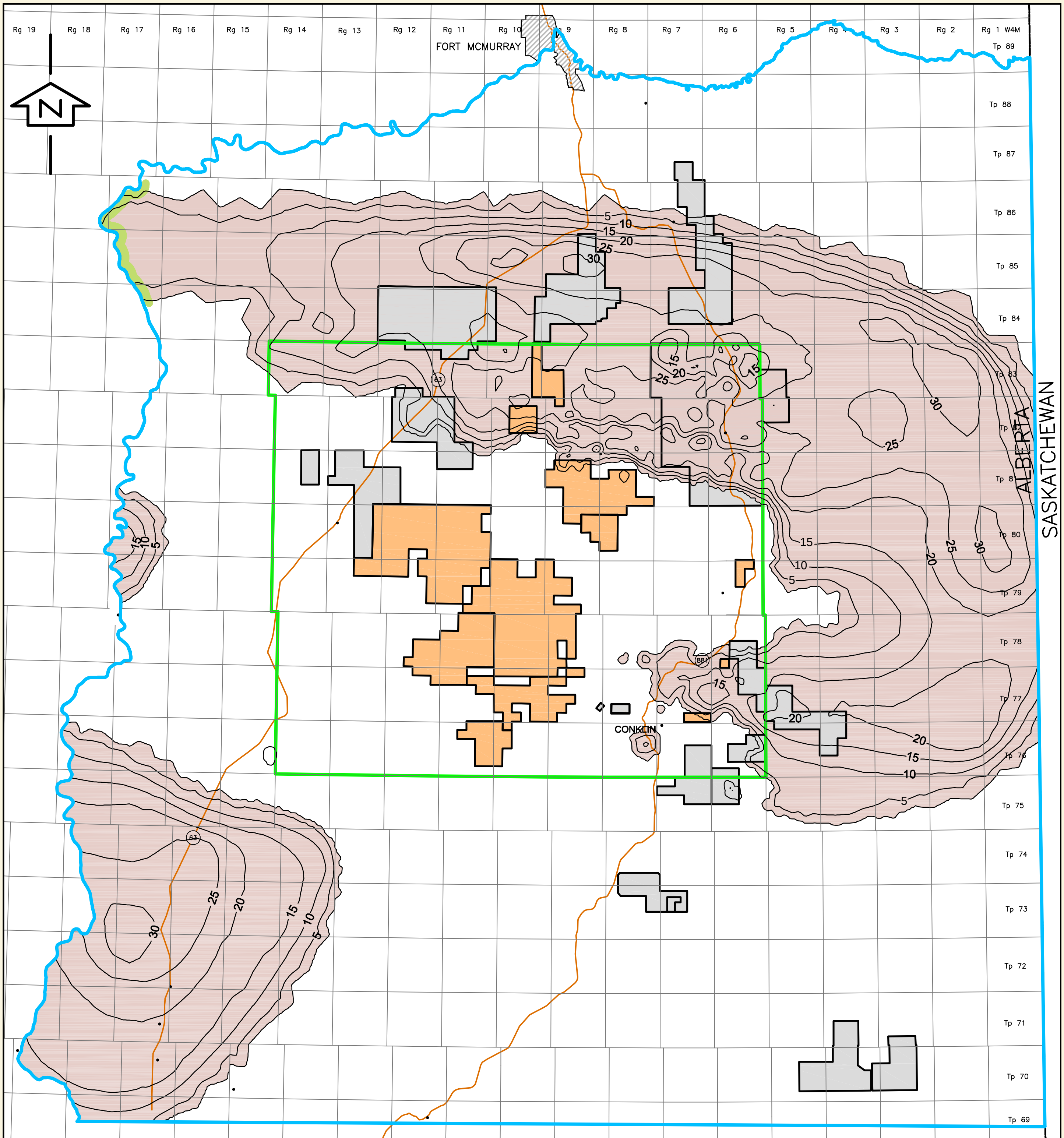
Title:

CLEARWATER SHALE AQUITARD ISOPACH

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/06/14
File: 4455-IMPACTASSESSAPP-07.DWG	

Drawn by:	Checked:	Fig. No.:
ADF	BW	**5D-19**



SCALE 1:1000000 kilometres

10 0 10 20

LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- REGIONAL STUDY AREA (RSA)
- LOCAL STUDY AREA (LSA)
- CONSTANT HEAD NODES - ASSIGNED RIVER ELEVATION
- – 20 – ISOPACH (m)
- CLEARWATER A AQUIFER

REFERENCE

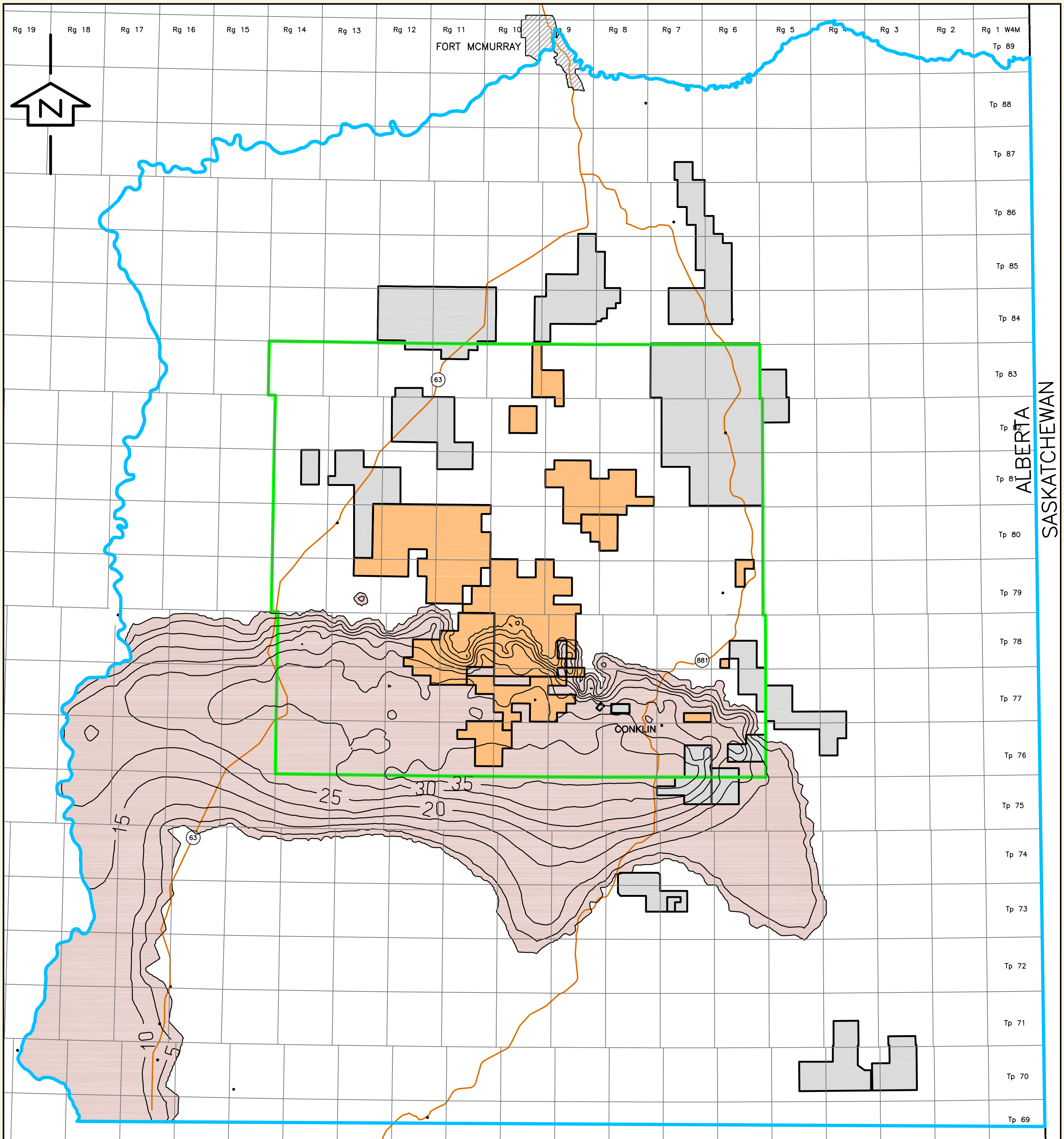
ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

CLEARWATER A AQUIFER ISOPACH

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/06/14	
File: 4455-IMPACTASSESSAPP-07.DWG		
Drawn by: ADF	Checked: BW	Fig. No.: **5D-20**



SCALE 1:1000000 kilometres

10 0 10 20

LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- REGIONAL STUDY AREA (RSA)
- LOCAL STUDY AREA (LSA)
- – **20** – ISOPACH (m)
- CLEARWATER B AQUIFER

REFERENCE

ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

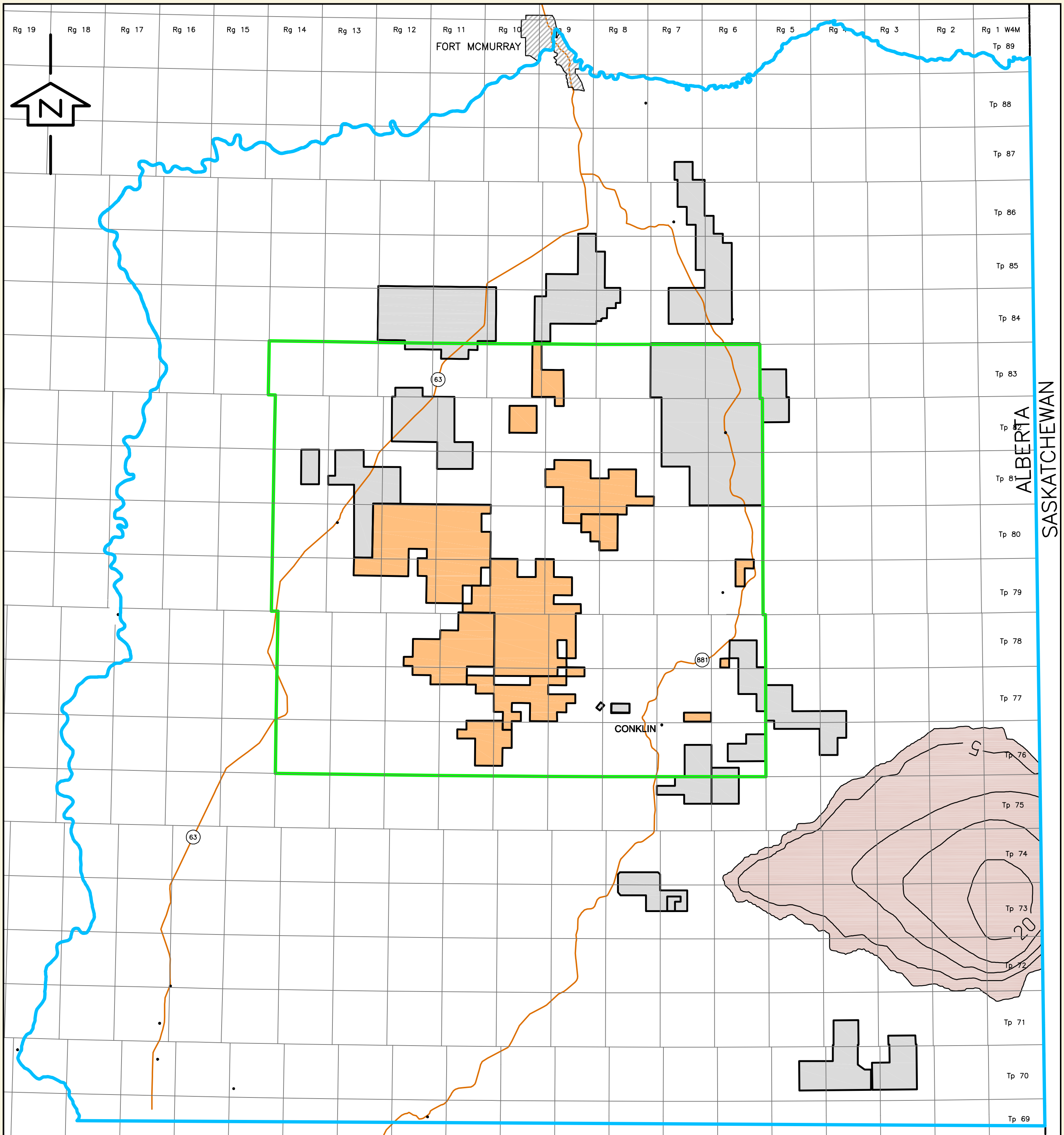
CLEARWATER B AQUIFER ISOPACH

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/06/14
File: 4455-IMPACTASSESSAPP-07.DWG	

Drawn by:	Checked:	Fig. No.:
ADF	BW	5D-21

*PLOT 1:1 = Letter (P)



SCALE 1:1000000 kilometres

10 0 10 20

LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- REGIONAL STUDY AREA (RSA)
- LOCAL STUDY AREA (LSA)
- – **20** – ISOPACH (m)
- CLEARWATER C AQUIFER

REFERENCE

ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

CLEARWATER C AQUIFER ISOPACH

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/06/14

File: 4455-IMPACTASSESSAPP-07.DWG

Drawn by:	Checked:	Fig. No.:
ADF	BW	5D-22

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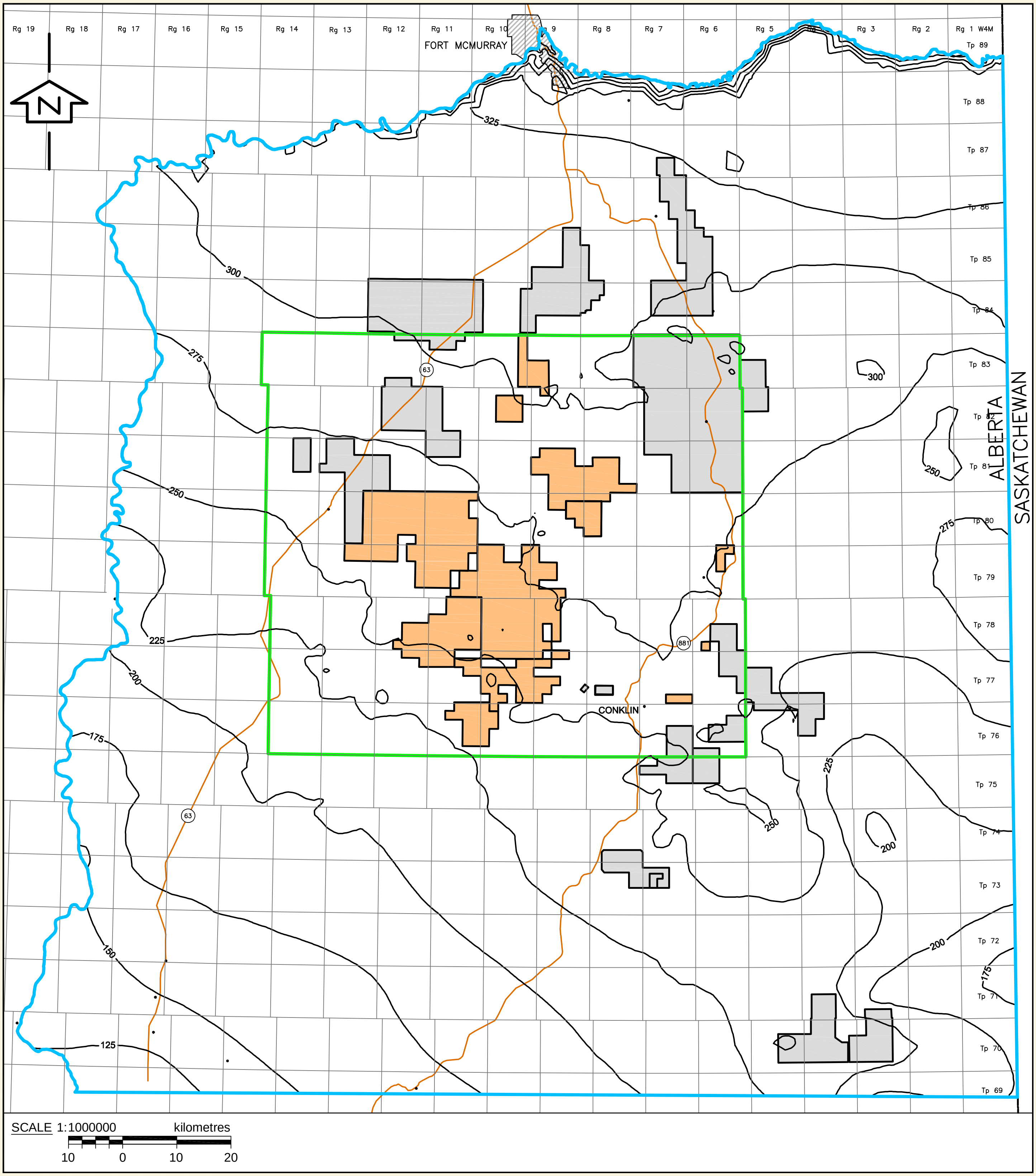


LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- REGIONAL STUDY AREA (RSA)
- LOCAL STUDY AREA (LSA)
- 450 AQUIFER STRUCTURE (masl)

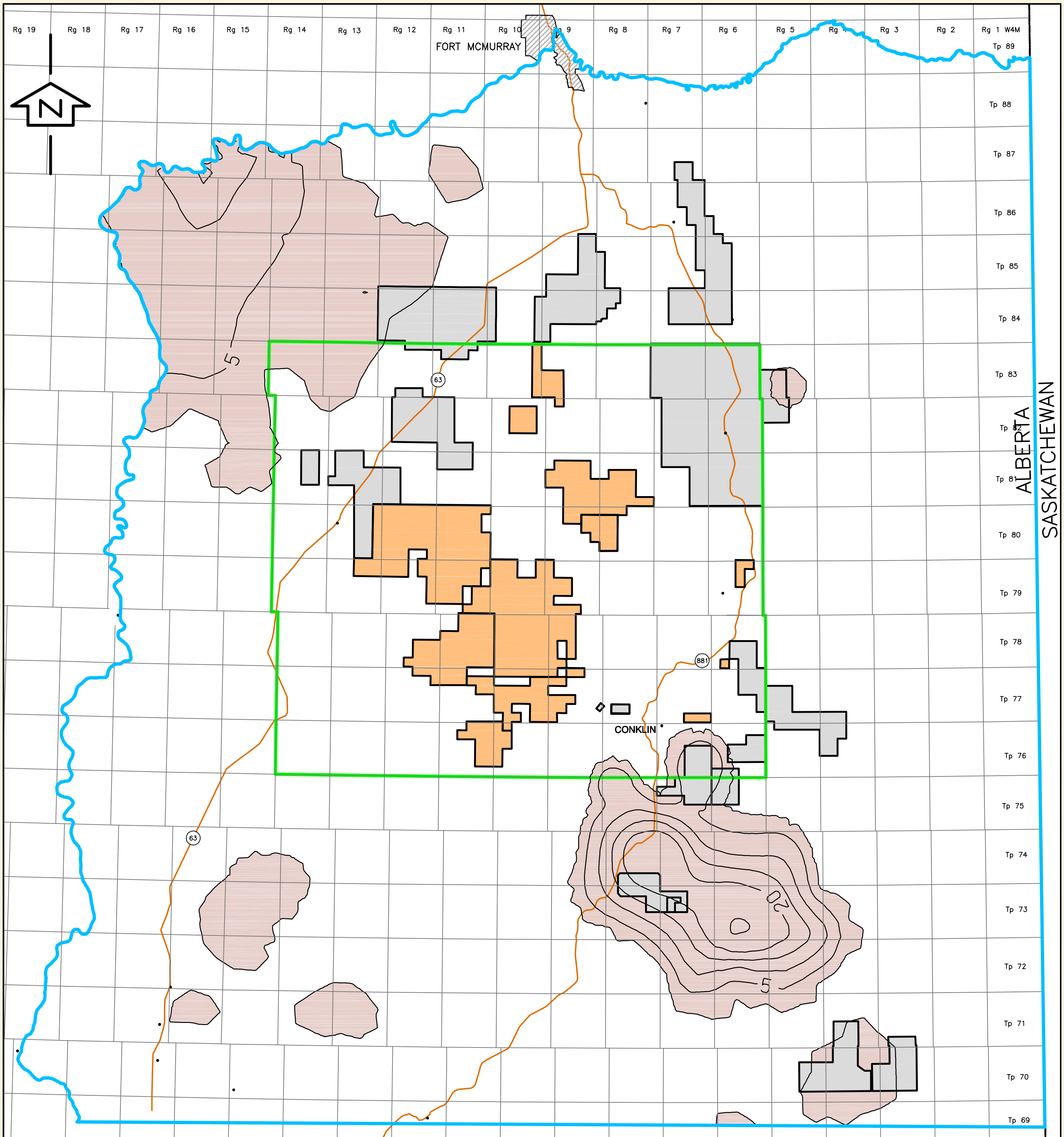
REFERENCE
ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

WABISKAW AQUIFER\AQUITARD STRUCTURE

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/06/14	
File: 4455-IMPACTASSESSAPP-07.DWG		
Drawn by: ADF	Checked: BW	Fig. No.: **5D-23**



SCALE 1:1000000 kilometres

10 0 10 20

LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- REGIONAL STUDY AREA (RSA)
- LOCAL STUDY AREA (LSA)
- – **20** – ISOPACH (m)
- WABISKAW BITUMEN AQUITARD

REFERENCE

ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12
WHITEMAN

Title:

WABISKAW BITUMEN AQUITARD ISOPACH

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/06/14	
File: 4455-IMPACTASSESSAPP-07.DWG		
Drawn by: ADF	Checked: BW	Fig. No.: **5D-24**

*PLOT 1:1 = Letter (P)

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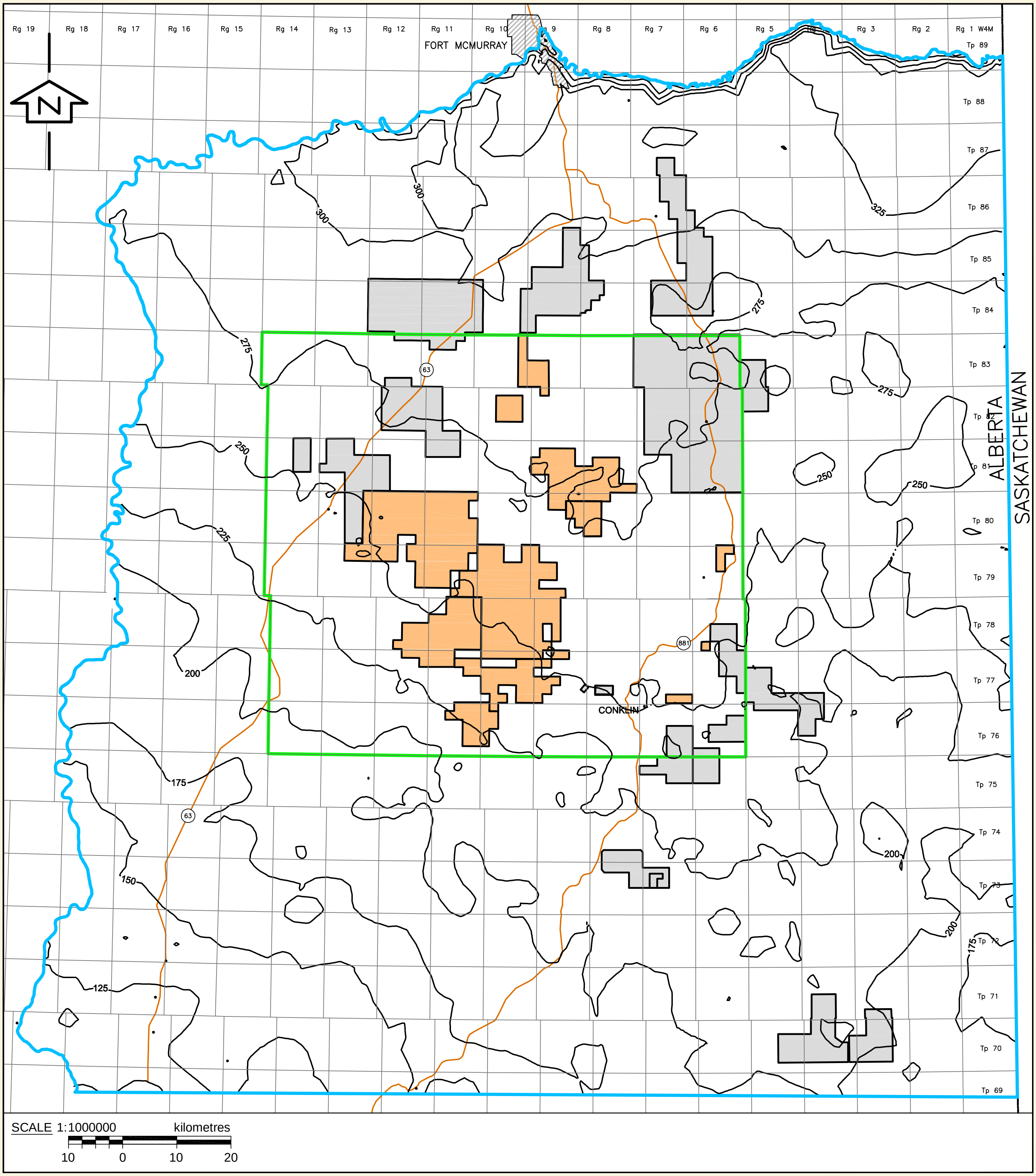


LEGEND
- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- REGIONAL STUDY AREA (RSA)
- LOCAL STUDY AREA (LSA)
- **450** AQUIFER STRUCTURE (masl)

REFERENCE
ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

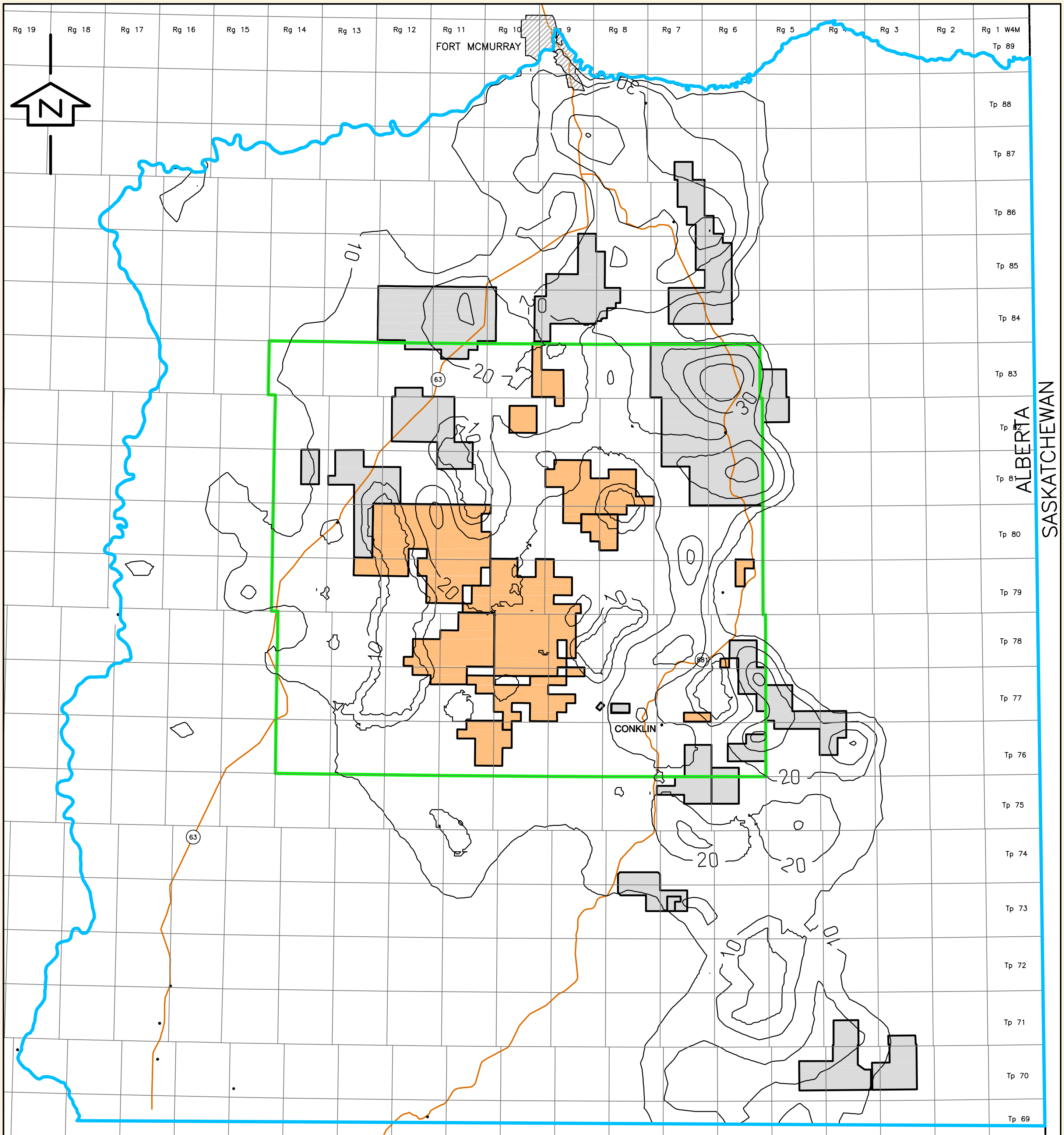
Title:

McMURRAY AQUIFER/AQUITARD STRUCTURE

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/06/14
File: 4455-IMPACTASSESSAPP-07.DWG	
Drawn by: ADF	Checked: BW
Fig. No.: 5D-25	

*PLOT 1:1 = Letter (P)



SCALE 1:1000000 kilometres

10 0 10 20

LEGEND
KAI KOS DEHSEH PROJECT
ADJACENT *INSITU* OIL SANDS PROJECT
REGIONAL STUDY AREA (RSA)
LOCAL STUDY AREA (LSA)
– **20** – ISOPACH (m)

REFERENCE
ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12
WHITEMAN

Title:

McMURRAY BITUMEN AQUITARD ISOPACH

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/06/14

File: 4455-IMPACTASSESSAPP-07.DWG

Drawn by:	Checked:	Fig. No.:
ADF	BW	**5D-26**

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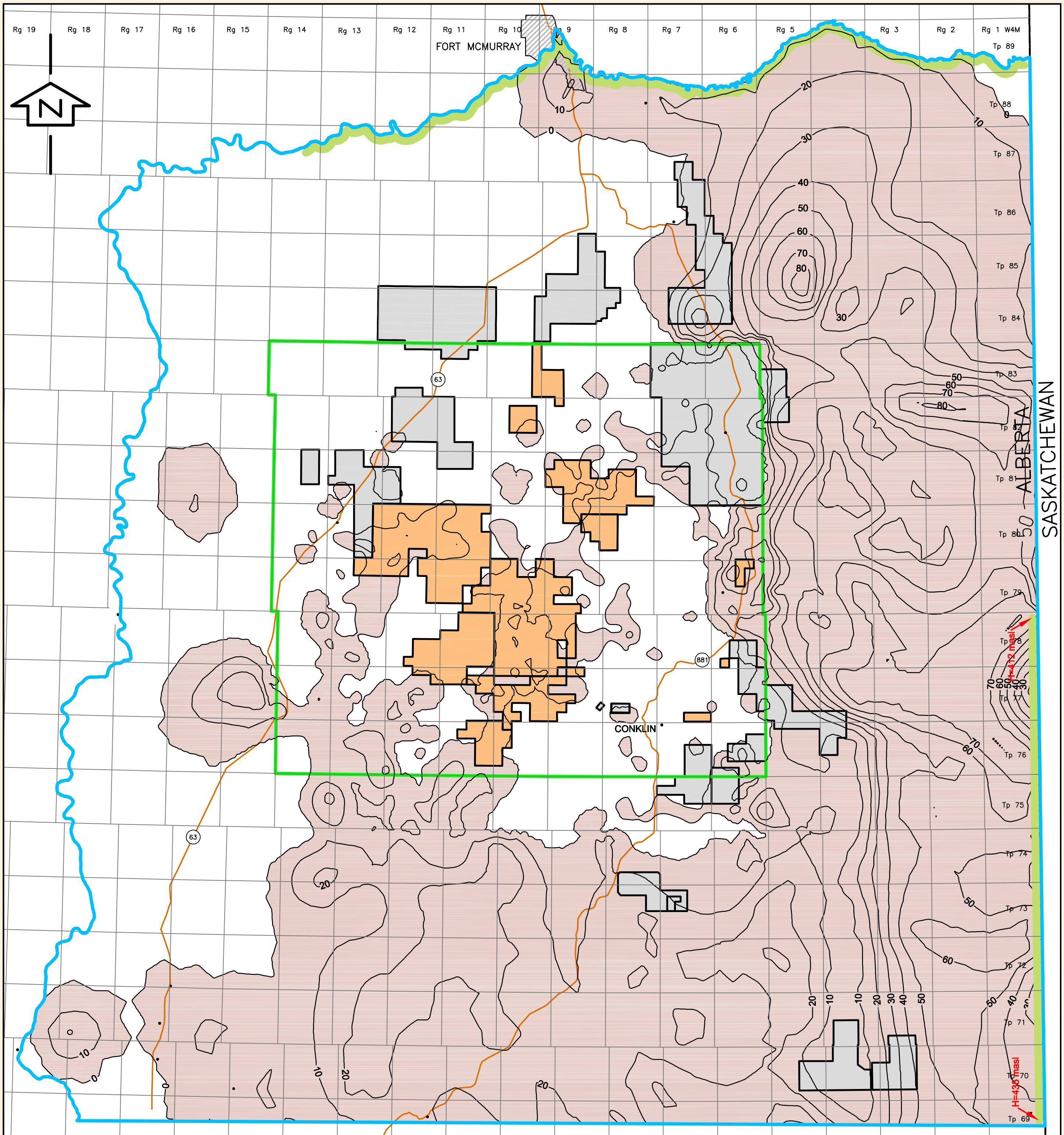


SCALE 1:1000000 kilometres

10 0 10 20

LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- REGIONAL STUDY AREA (RSA)
- LOCAL STUDY AREA (LSA)
- CONSTANT HEAD NODE - ASSIGNED RIVER ELEVATION
- 20 ISOPACH (m)
- BASAL McMURRAY AQUIFER

REFERENCE

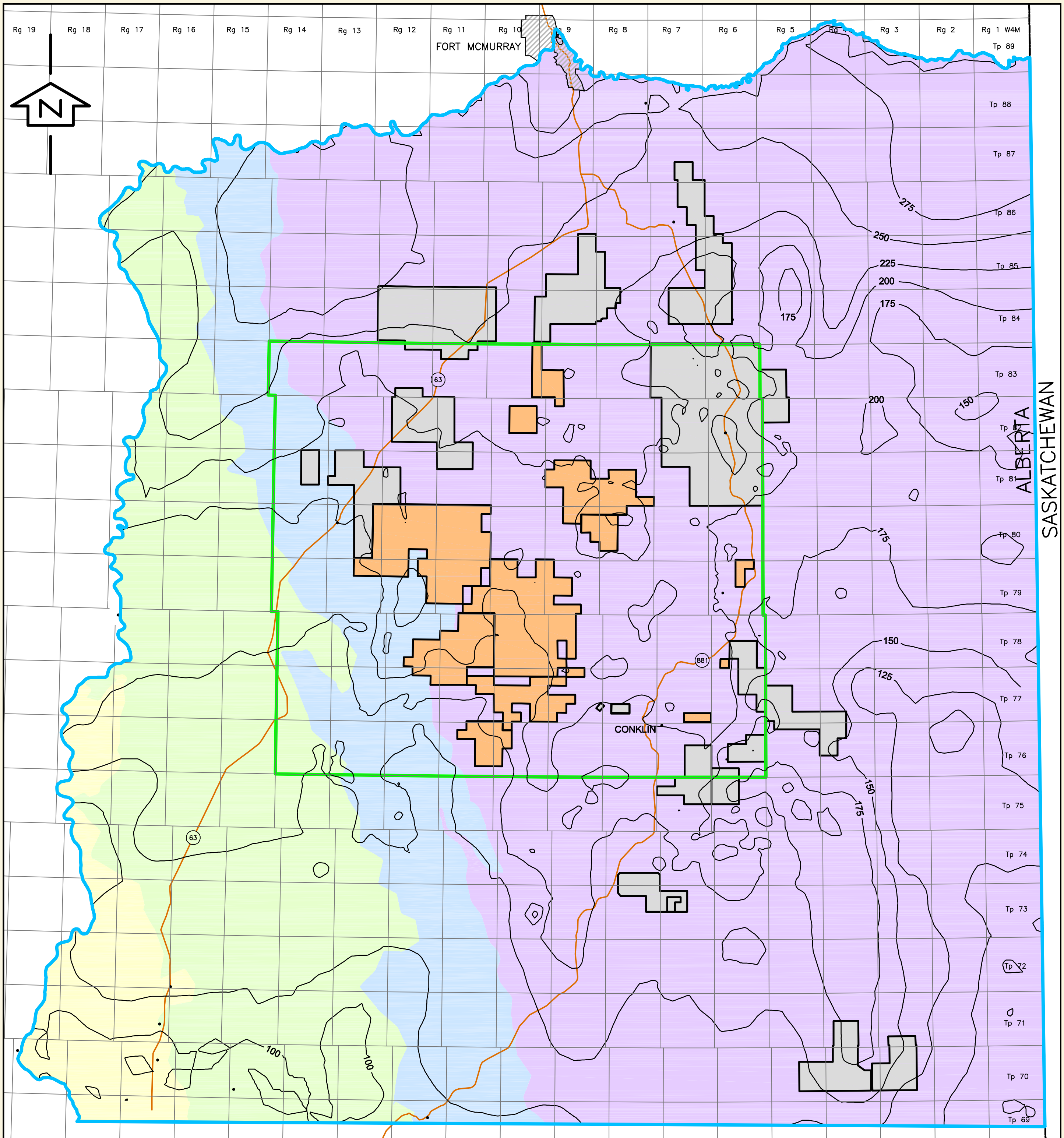
ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

BASAL McMURRAY AQUIFER ISOPACH AND ASSIGNED BOUNDARY CONDITIONS

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/06/14	
File: 4455-IMPACTASSESSAPP-07.DWG		
Drawn by: ADF	Checked: BW	Fig. No.: **5D-27**



SCALE 1:1000000 kilometres

10 0 10 20

LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- REGIONAL STUDY AREA (RSA)
- LOCAL STUDY AREA (LSA)
- −450− STRUCTURE (masl)
- Winterburn Subcroping Formation
- Grosmont Subcroping Formation
- Ireton Subcroping Formation
- Beaverhill Lake / Cooking Lake Subcroping Formation

REFERENCE

ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

TOP OF DEVONIAN STRUCTURE AND SUBCROPPING FORMATIONS

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/06/14

File: 4455-IMPACTASSESSAPP-07.DWG

Drawn by:	Checked:	Fig. No.:
ADF	BW	5D-28

*PLOT 1:1 = Letter (P)

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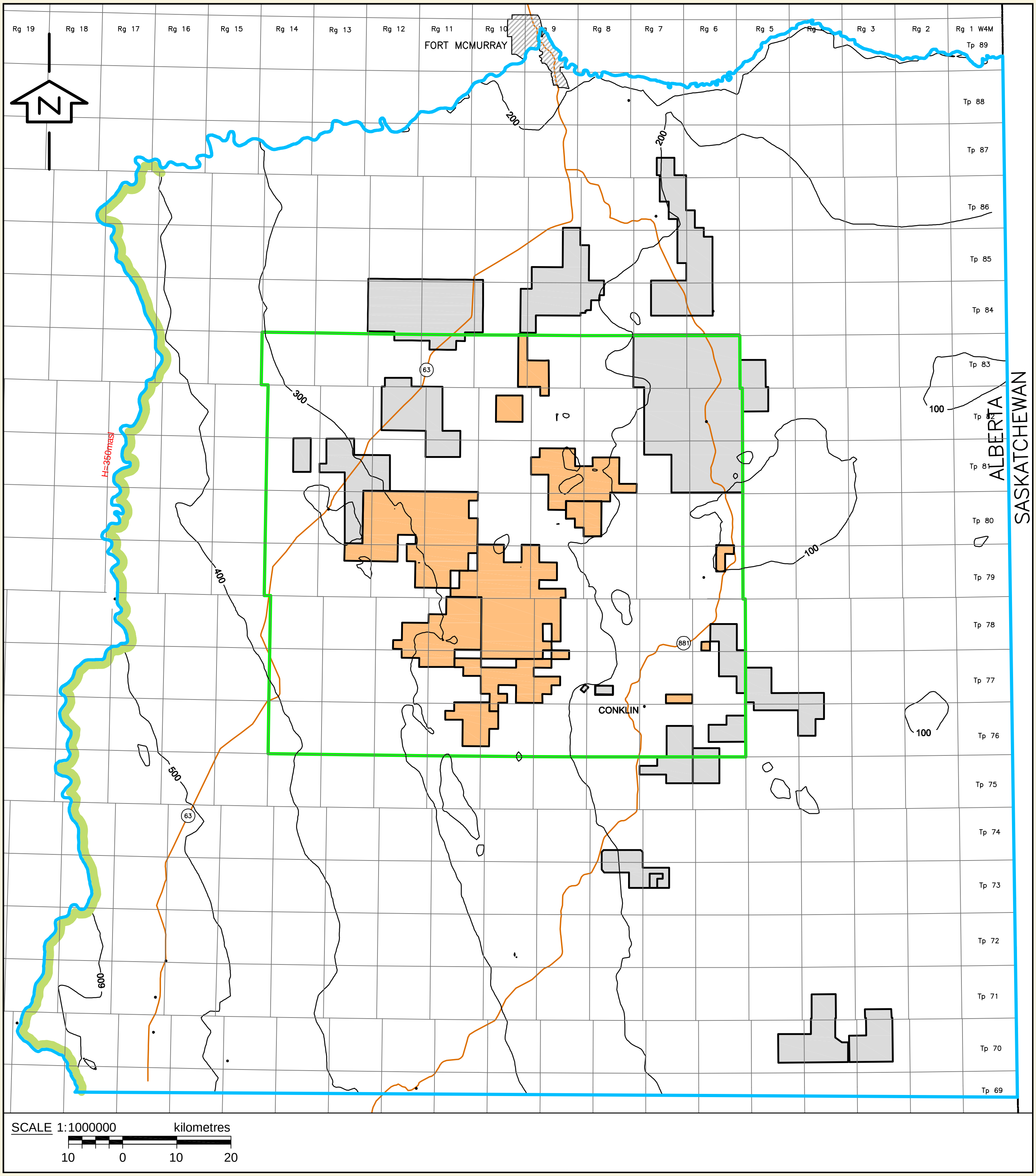

LEGEND

KAI KOS DEHSEH PROJECT

ADJACENT *INSITU* OIL SANDS PROJECT

REGIONAL STUDY AREA (RSA)

LOCAL STUDY AREA (LSA)

CONSTANT HEAD NODE - ASSIGNED TO GROSMONT ONLY

– 20 – ISOPACH(m)

REFERENCE

ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

UNDIFFERENTIATED DEVONIAN ISOPACH AND ASSIGNED BOUNDARY CONDITIONS

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/06/14
File: 4455-IMPACTASSESSAPP-07.DWG	

Drawn by:	Checked:	Fig. No.:
ADF	BW	5D-29

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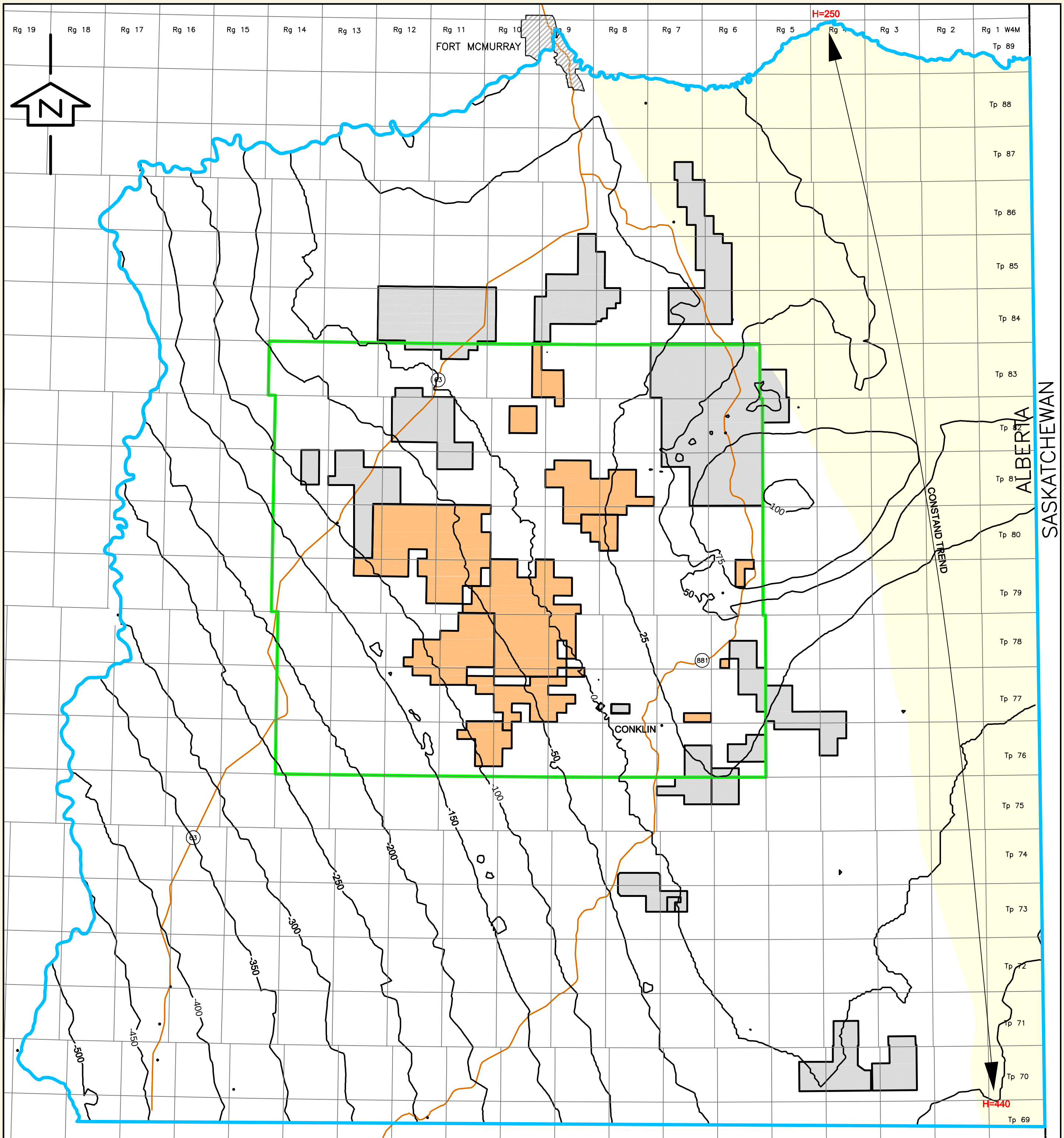
*PLOT 1:1 = Letter (P)



SCALE 1:1000000 kilometres

10 0 10 20

LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- REGIONAL STUDY AREA (RSA)
- LOCAL STUDY AREA (LSA)
- 450 — STRUCTURE (masl)
- CONSTANT HEAD NODE - ASSIGNED WHERE PRAIRIE AQUICLUDE ABSENT

REFERENCE

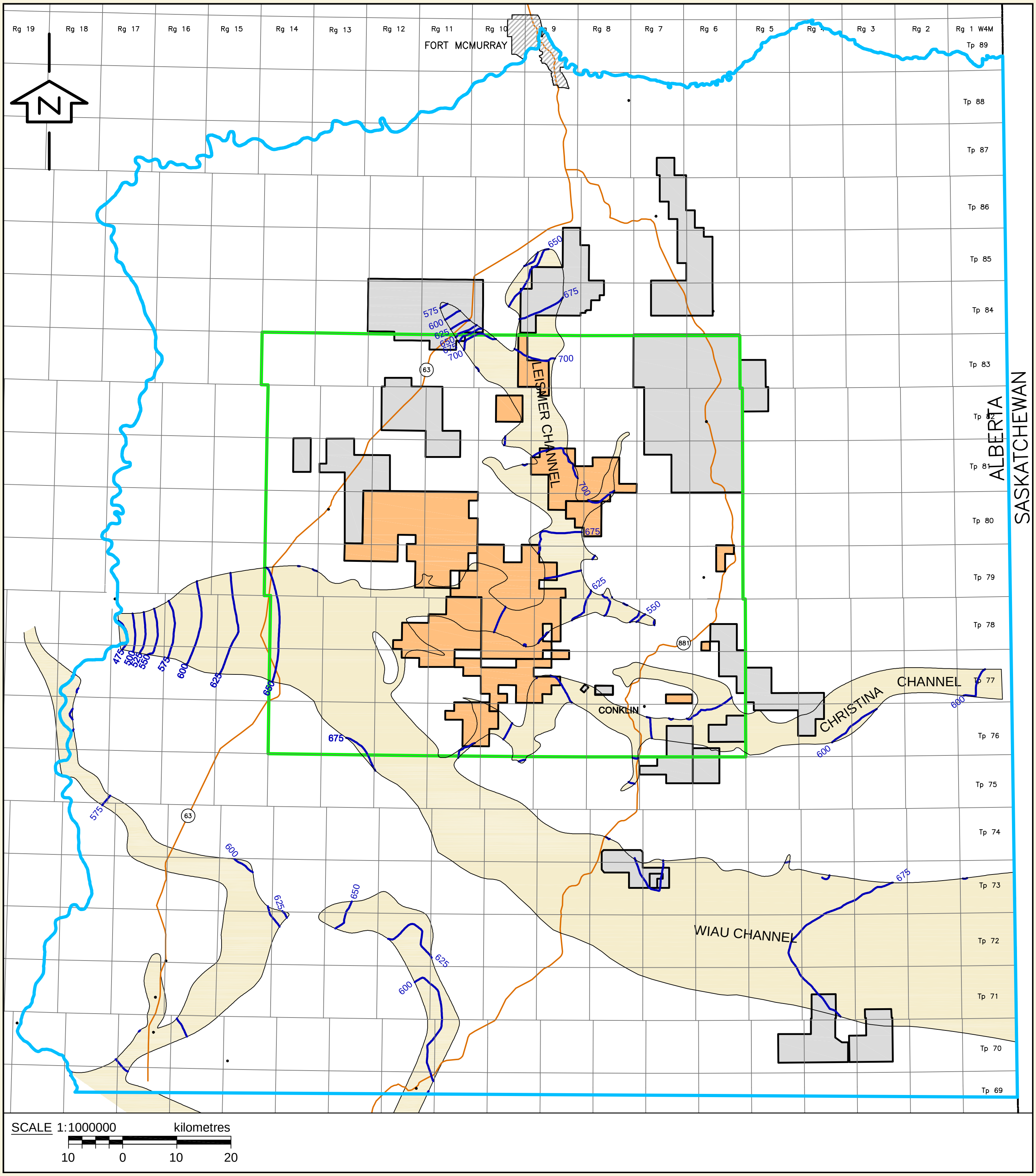
ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

PRAIRIE AQUICLUDE STRUCTURE (BASE OF MODEL) AND ASSIGNED BOUNDARY CONDITIONS

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/06/14	
File: 4455-IMPACTASSESSAPP-07.DWG		
Drawn by: ADF	Checked: BW	Fig. No.: 5D-30



LEGEND
- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- REGIONAL STUDY AREA (RSA)
- LOCAL STUDY AREA (LSA)
- 450 HYDRAULIC HEAD (masl)
- AQUIFER

REFERENCE
ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

EMPRESS CHANNEL AQUIFER SIMULATED STEADY STATE HYDRAULIC HEAD MAP

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/06/14
File: 4455-IMPACTASSESSAPP-07.DWG	

Drawn by:	Checked:	Fig. No.:
ADF	BW	5D-31

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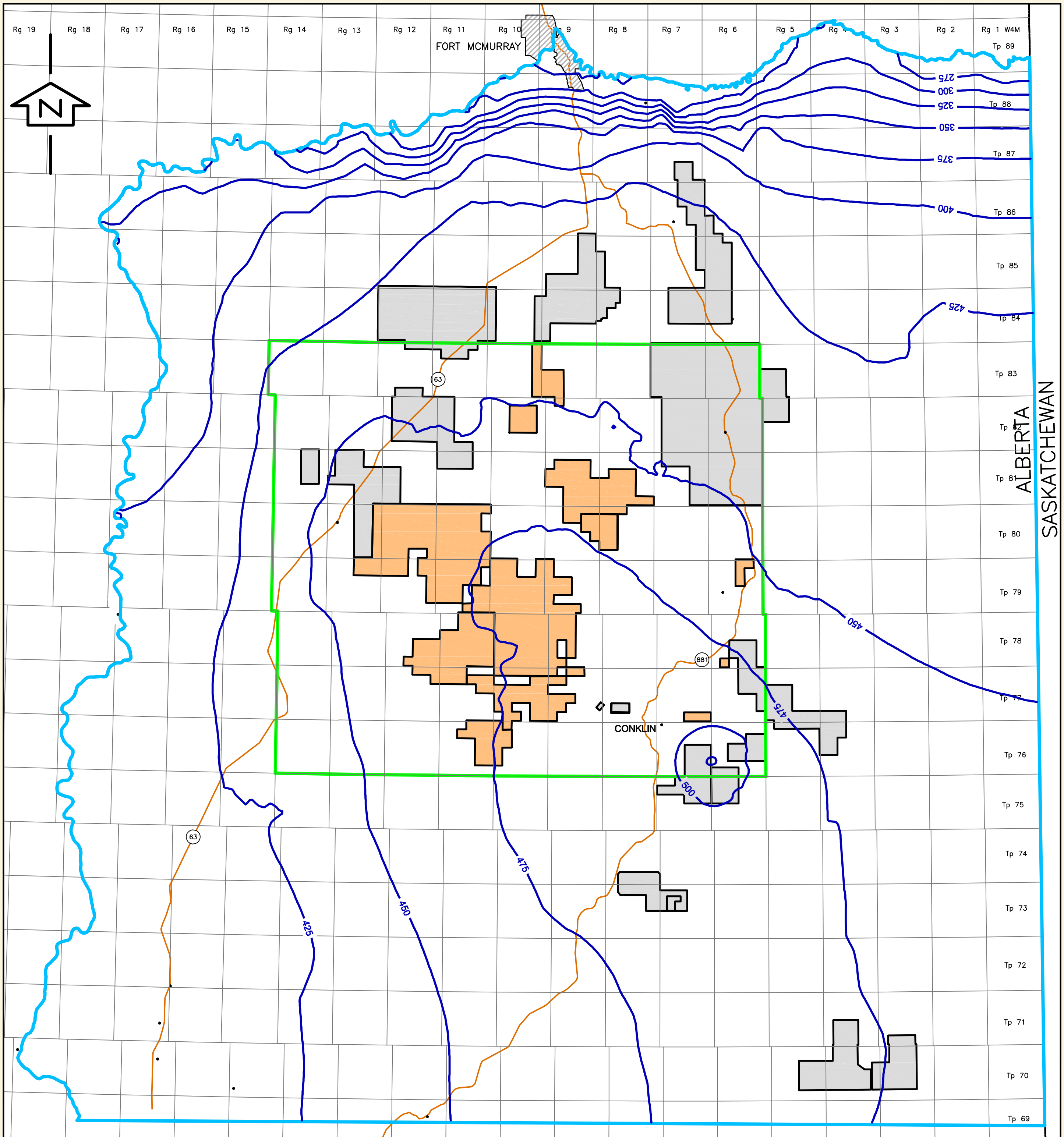


SCALE 1:1000000 kilometres

10 0 10 20

LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- REGIONAL STUDY AREA (RSA)
- LOCAL STUDY AREA (LSA)
- 450 HYDRAULIC HEAD (masl)

REFERENCE

ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

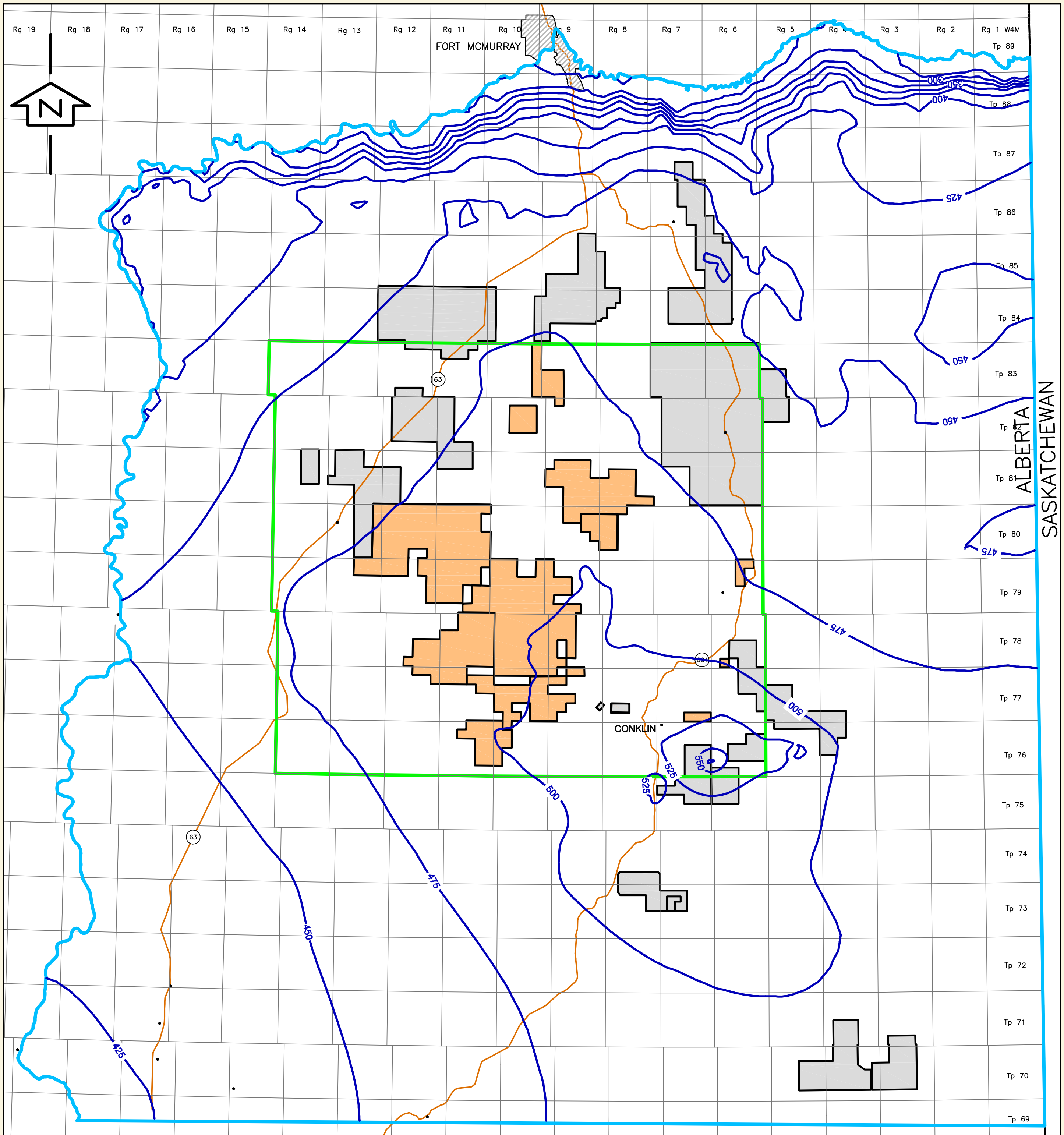
UNDIFFERENTIATED CLEARWATER SIMULATED STEADY STATE HYDRAULIC HEAD MAP

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:
RP	07/06/14

File: 4455-IMPACTASSESSAPP-07.DWG

Drawn by:	Checked:	Fig. No.:
ADF	BW	**5D-33**



SCALE 1:1000000 kilometres

10 0 10 20

LEGEND

KAI KOS DEHSEH PROJECT

ADJACENT *INSITU* OIL SANDS PROJECT

REGIONAL STUDY AREA (RSA)

LOCAL STUDY AREA (LSA)

450 HYDRAULIC HEAD (masl)

REFERENCE

ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

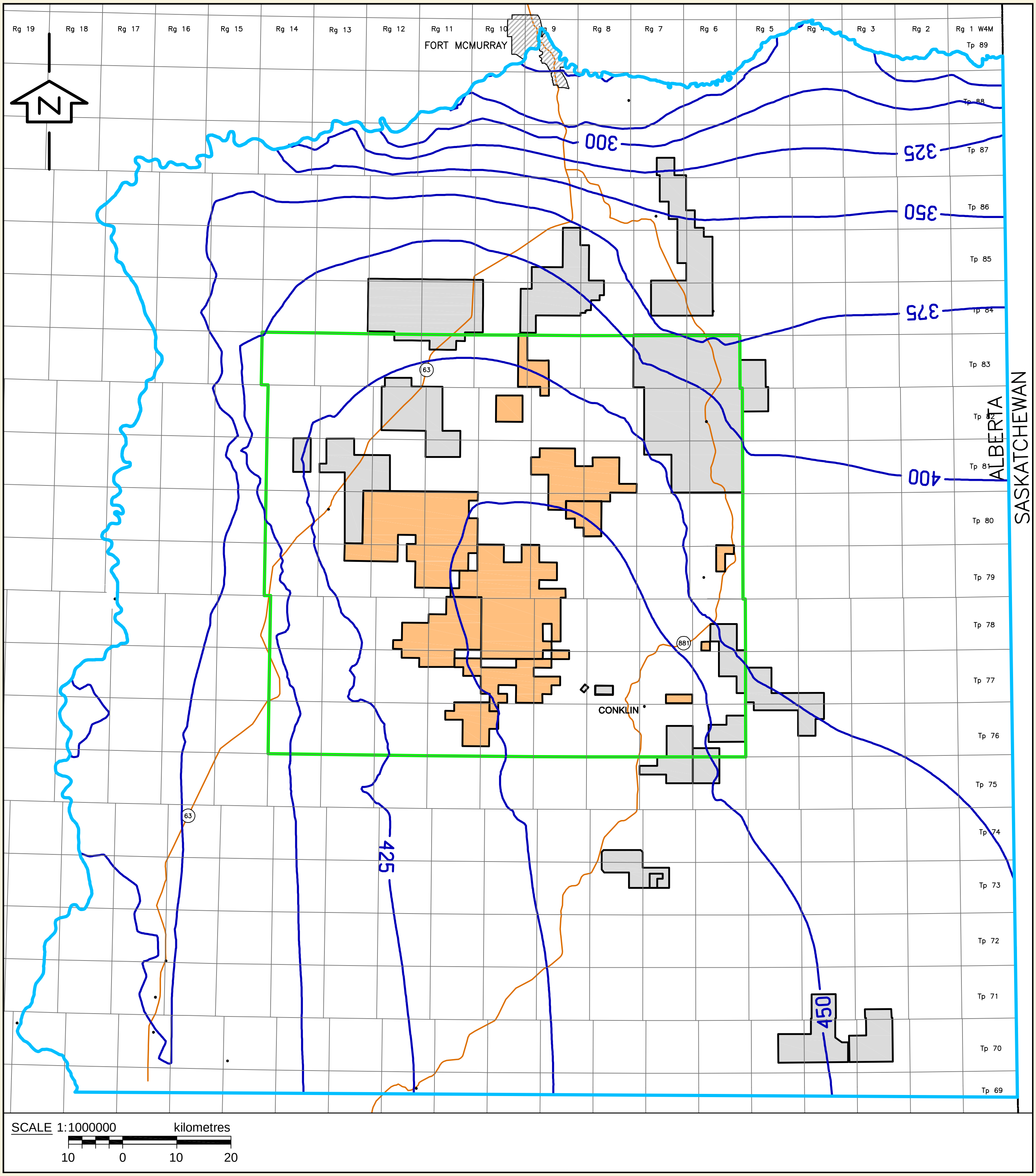
UNDIFFERENTIATED GRAND RAPIDS SIMULATED STEADY STATE HYDRAULIC HEAD MAP

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:
RP	07/06/14

File: 4455-IMPACTASSESSAPP-07.DWG

Drawn by:	Checked:	Fig. No.:
ADF	BW	5D-32



LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- REGIONAL STUDY AREA (RSA)
- LOCAL STUDY AREA (LSA)
- 450 HYDRAULIC HEAD (masl)

REFERENCE

ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

UNDIFFERENTIATED McMURRAY SIMULATED STEADY STATE HYDRAULIC HEAD MAP

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/06/14
File: 4455-IMPACTASSESSAPP-07.DWG	

Drawn by:	Checked:	Fig. No.:
ADF	BW	**5D-34**

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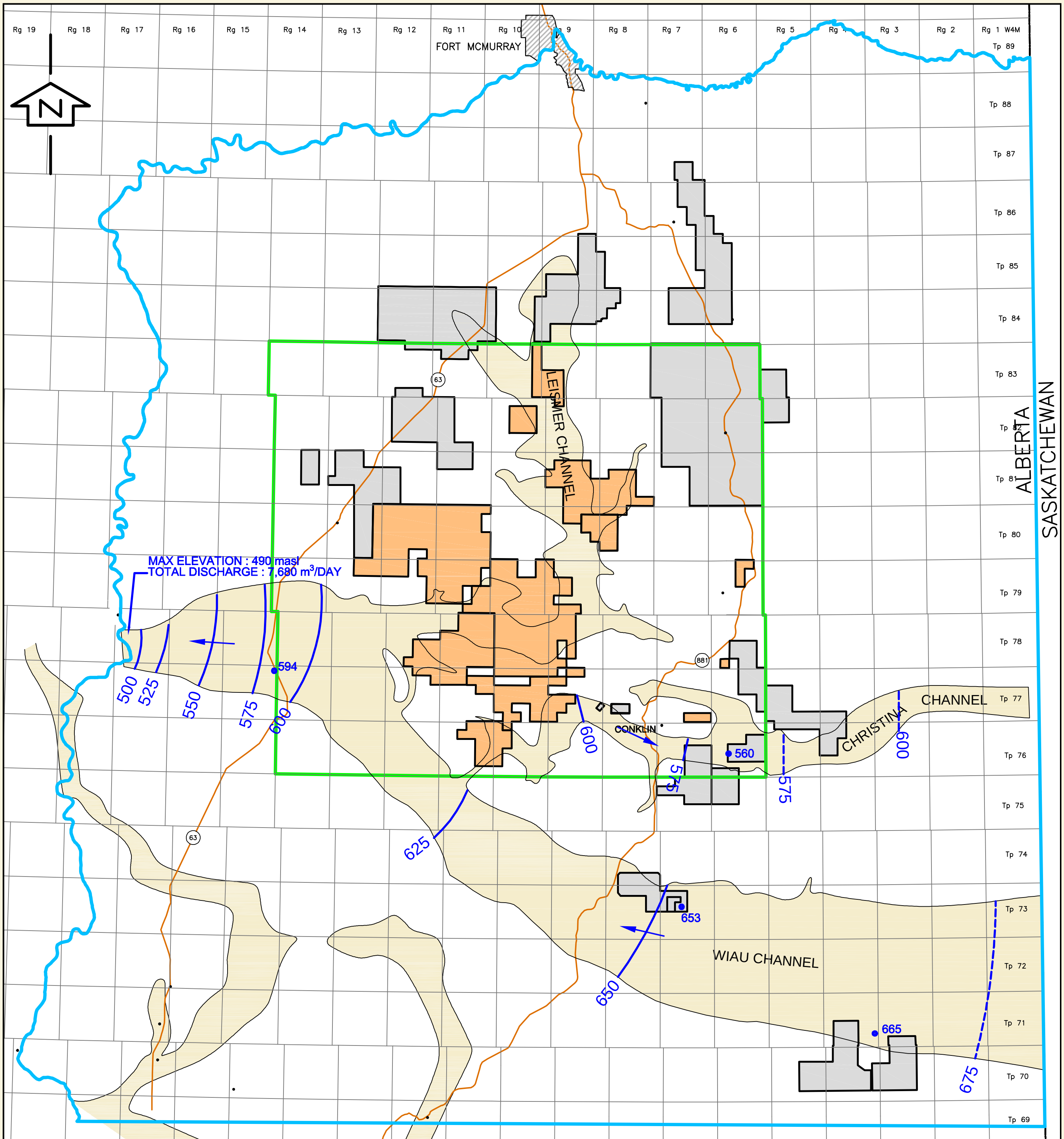
*PLOT 1:1 = Letter (P)



SCALE 1:1000000 kilometres

10 0 10 20

LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- REGIONAL STUDY AREA (RSA)
- LOCAL STUDY AREA (LSA)
- 450 HYDRAULIC HEAD (masl)
- AQUIFER

REFERENCE

ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

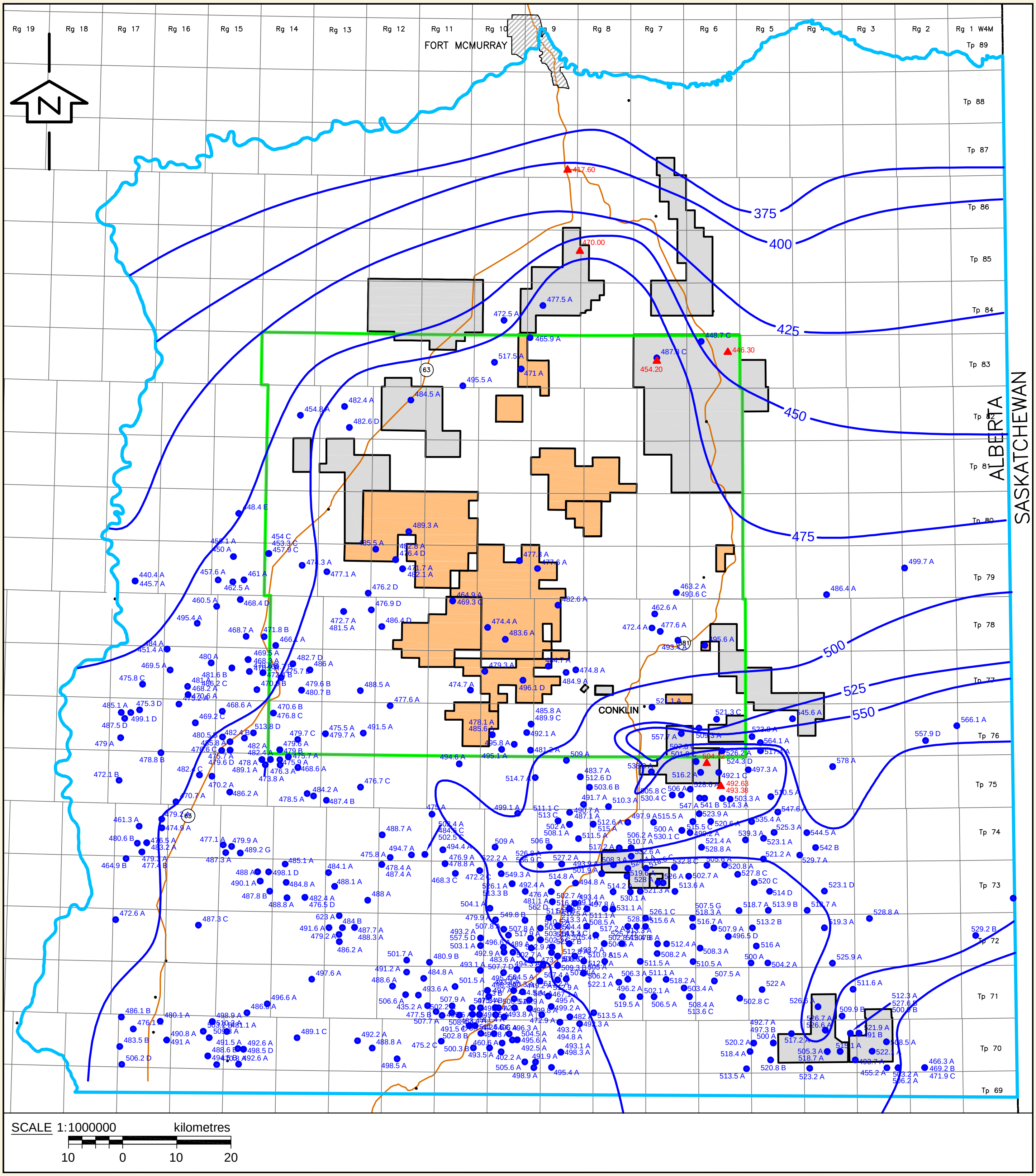
Title:

EMPRESS CHANNEL AQUIFER HYDRAULIC HEAD MAP

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/06/14
File: 4455-IMPACTASSESSAPP-07.DWG	

Drawn by:	Checked:	Fig. No.:
ADF	BW	5D-35



LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- REGIONAL STUDY AREA (RSA)
- LOCAL STUDY AREA (LSA)
- 450 HYDRAULIC HEAD (masl)
- 487.3 C Equivalent Hydraulic Head (masl), Quality Control Code
- 470.00 Reported Hydraulic Head Values (masl)

REFERENCE

ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

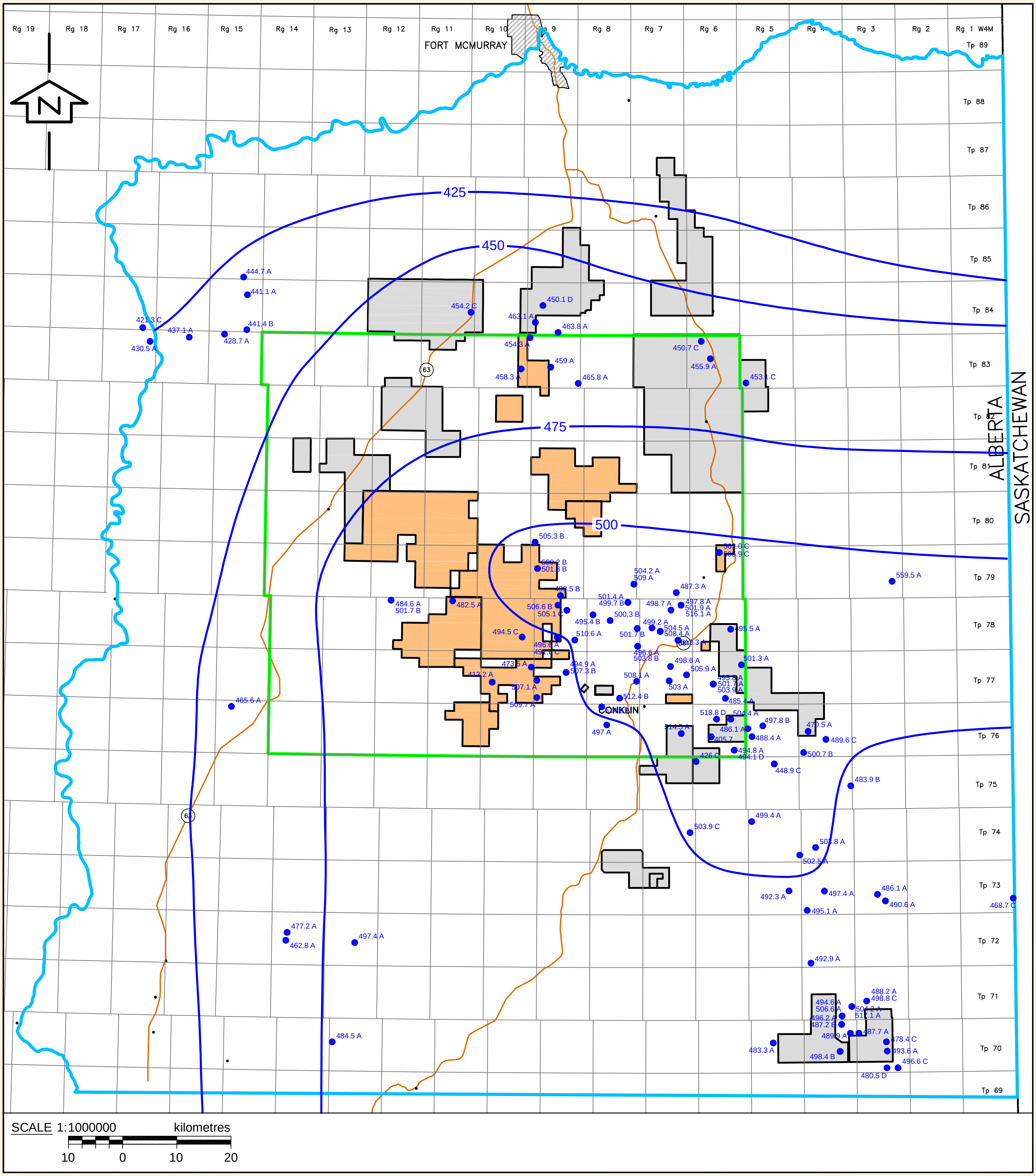
GRAND RAPIDS UNDIFFERENTIATED HYDRAULIC HEAD MAP

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:
RP	07/06/14

File: 4455-IMPACTASSESSAPP-07.DWG

Drawn by:	Checked:	Fig. No.:
ADF	BW	5D-36



LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- REGIONAL STUDY AREA (RSA)
- LOCAL STUDY AREA (LSA)
- 450 HYDRAULIC HEAD (masl)
- 487.3 C Equivalent Hydraulic Head (masl), Quality Control Code

REFERENCE
ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

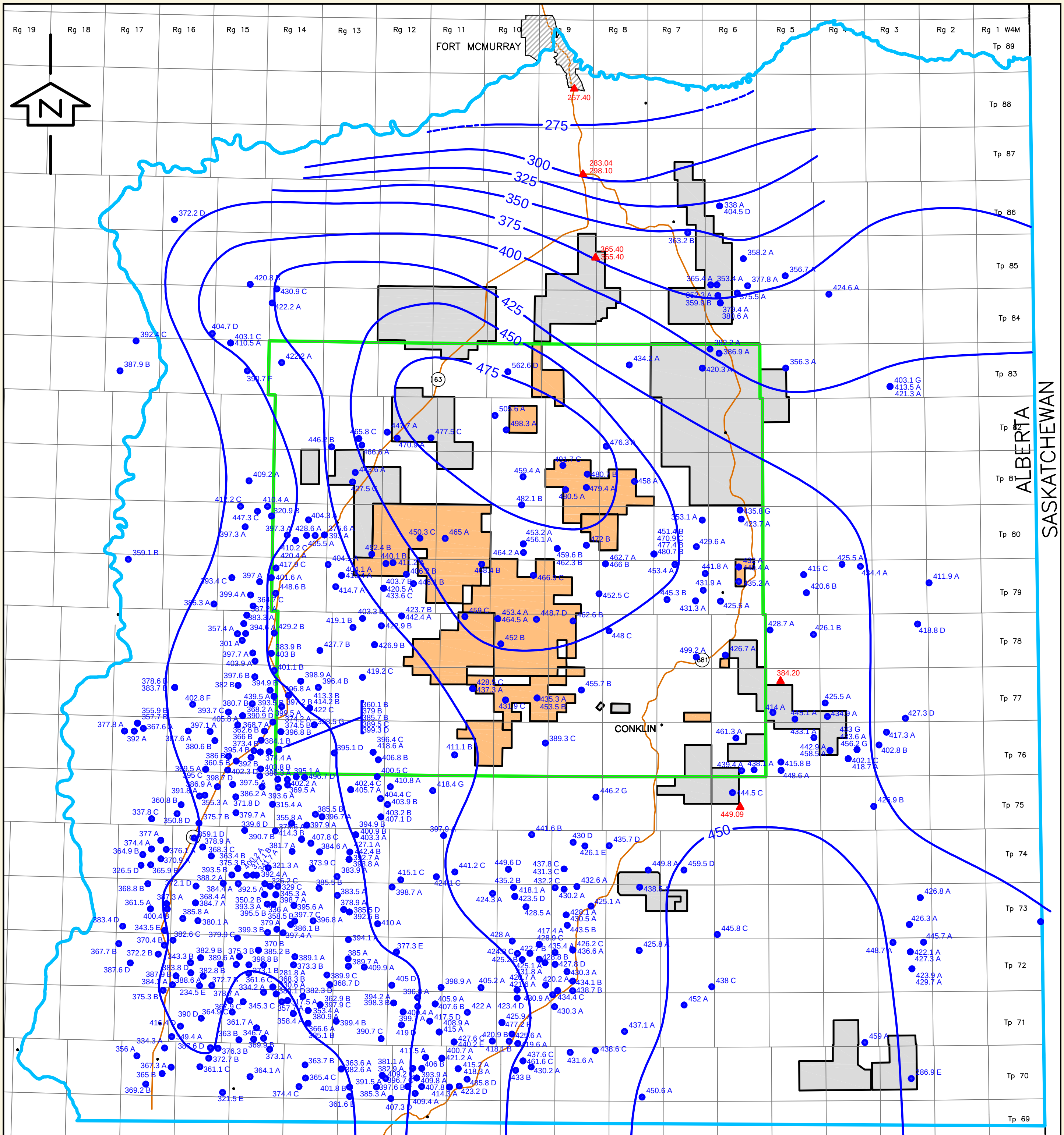
Title:

UNDIFFERENTIATED CLEARWATER HYDRAULIC HEAD MAP

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/06/14
File: 4455-IMPACTASSESSAPP-07.DWG	

Drawn by:	Checked:	Fig. No.:
ADF	BW	5D-37



SCALE 1:1000000 kilometres

10 0 10 20

LEGEND

- KAI KOS DEHSEH PROJECT
- ADJACENT *INSITU* OIL SANDS PROJECT
- REGIONAL STUDY AREA (RSA)
- LOCAL STUDY AREA (LSA)
- 450 HYDRAULIC HEAD (masl)
- 487.3 C Equivalent Hydraulic Head (masl), Quality Control Code
- 470.00 Reported Hydraulic Head Values (masl)

REFERENCE

ALBERTA NTDB DIGITAL OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 27 PROJECTIONS: UTM ZONE 12

Title:

McMURRAY HYDRAULIC HEAD MAP

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/06/14
File: 4455-IMPACTASSESSAPP-07.DWG	

Drawn by: ADF	Checked: BW	Fig. No.: 5D-38

*PLOT 1:1 = Letter (P)

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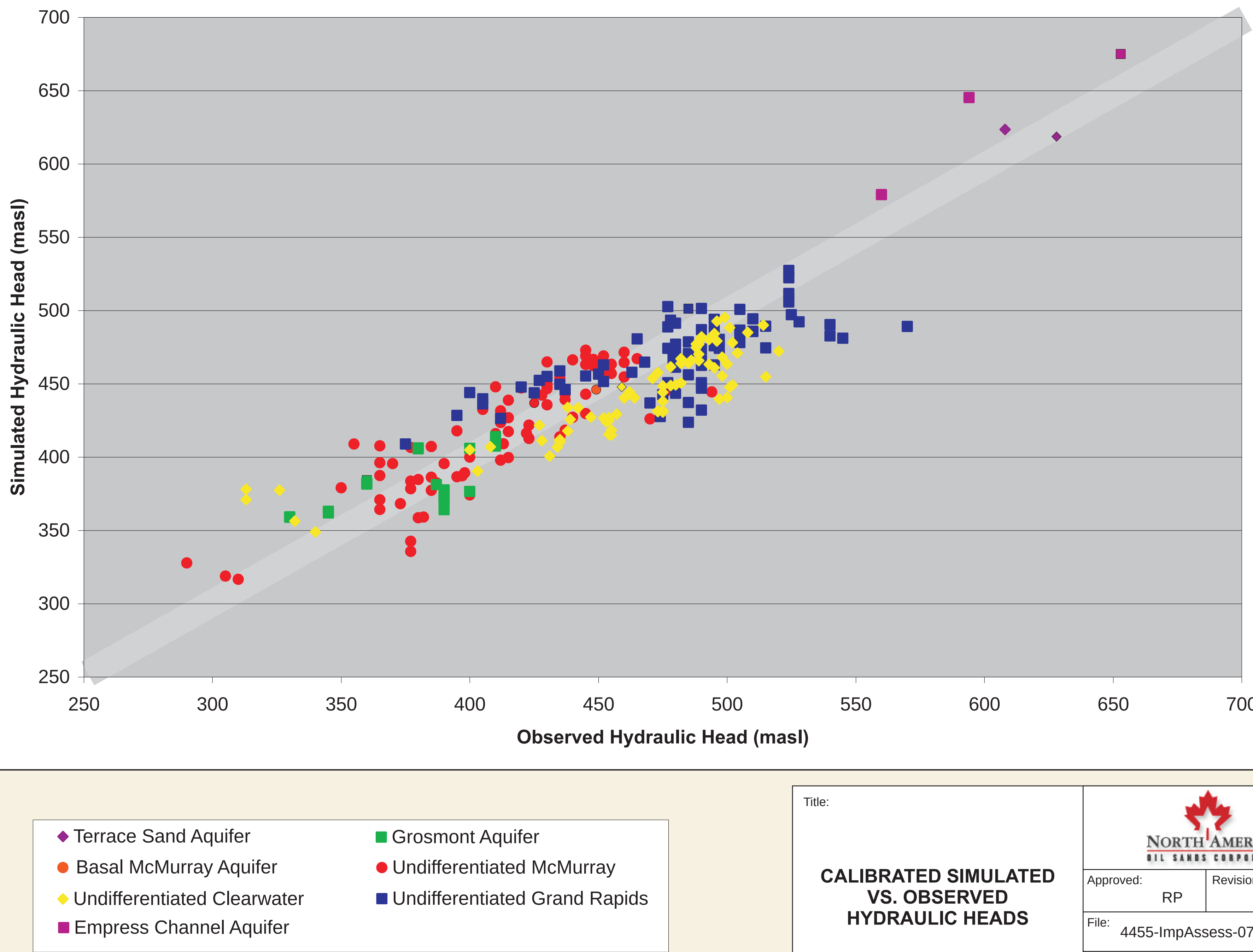

Title:

CALIBRATED SIMULATED VS. OBSERVED HYDRAULIC HEADS

NORTH AMERICAN OIL SANDS CORPORATION

Approved: RP	Revision Date: 07/06/02	
File: 4455-ImpAssess-07.cdr		
Drawn by: GDE	Checked: BW	Fig. No.: **5D-39**

Table 7A-1 Water Quality in the Hangingstone Lease

Sample Site		WCH1	WCH2				WCH3				WCH4				WCH5				
Date	**Unit**	04-May-06	04-May-06	01-Oct-05	07-Feb-06	07-Aug-05	04-May-06	30-Sep-05	09-Feb-06	09-Feb-06	04-May-06	03-Oct-05	06-Aug-05	06-Aug-05	05-May-06	03-Oct-05	10/3/2005 dupl	06-Aug-05	20-Aug-06
Field Parameters																			
Temperature	°C	4.6	5.7	5.1	5.2	16.0	3.0	5.5	0.1	--	4.4	1.5	17.1	--	4.7	2.6	--	17.1	14.6
pH		--	--	***9.6***	***5.4***	***9.2***	***3.5***	***9.6***	***5.1***	--	***6.2***	***9.6***	***5.8***	--	***4.4***	***9.6***	--	***9.2***	***2.5***
Conductivity (EC)	uS/cm	103	30	60	419	108	26	50	84	--	92	760	37	--	30	570	--	59	42
Dissolved oxygen (DO)	mg/L	11.9	13.0	11.9	--	9.7	22.2	12.3	11.3	--	12.0	10.5	***4.4***	--	11.1	14.2	--	13.6	7.0
Conventional Parameters																			
pH		--	--	***6.0***	7.2	***6.2***	--	--	***6.0***	***6.0***	--	6.9	***5.9***	6.7	--	***4.7***	***4.5***	--	***4.4***
Conductivity (EC)	uS/cm	--	--	23	150	27	--	--	44	44	--	38	28	36	--	27	27	--	28
Hardness ($CaCO_3$)	mg/L	--	--	12.0	76.0	15.0	--	--	21.0	21.0	--	21.0	15.0	21.0	--	6.5	7.0	--	5.3
Alkalinity ($CaCO_3$)	mg/L	--	--	3.6	72.1	5.6	--	--	8.5	9.4	--	11.9	4.5	10.3	--	< 0.5	< 0.5	--	< 0.5
Total Dissolved Solids	mg/L	--	--	< 10.0	80.0	11.0	--	--	20.0	21.0	--	17.0	11.0	16.0	--	< 10.0	< 10.0	--	< 10.0
Total Suspended Solids	mg/L	--	13.0	11.0	5.0	2.0	7.0	--	4.0	1.0	5.0	7.0	4.0	1.0	11.0	1.0	8.0	--	15.0
Turbidity	NTU	2.9	1.6	8.1	16.5	--	2.8	10.7	9.2	--	--	--	2.4	--	1.8	--	--	2.6	1.4
Major Ions																			
Carbonate (CO_3)	mg/L	--	--	< 0.5	< 0.5	< 0.5	--	--	< 0.5	< 0.5	--	< 0.5	< 0.5	< 0.5	--	< 0.5	< 0.5	--	< 0.5
Bicarbonate (HCO_3 ($CaCO_3$))	mg/L	--	--	4.4	87.9	6.8	--	--	10.3	11.5	--	14.5	5.4	12.6	--	< 0.5	< 0.5	--	< 0.5
Sodium (Na)	mg/L	--	--	< 0.5	1.7	< 0.5	--	--	0.8	0.8	--	0.9	< 0.5	0.7	--	< 0.5	< 0.5	--	< 0.5
Potassium (K)	mg/L	--	--	< 0.3	0.7	< 0.3	--	--	0.5	0.5	--	< 0.3	< 0.3	< 0.3	--	< 0.3	< 0.3	--	< 0.3
Calcium (Ca)	mg/L	--	--	3.5	21.8	4.1	--	--	5.9	5.8	--	5.8	4.1	5.6	--	1.7	1.9	--	1.4
Magnesium (Mg)	mg/L	--	--	0.9	5.3	1.1	--	--	1.5	1.4	--	1.7	1.2	1.8	--	0.5	0.6	--	0.4
Chloride (Cl)	mg/L	--	--	1.3	2.1	1.5	--	--	3.0	2.7	--	1.2	1.8	1.5	--	< 0.5	< 0.5	--	1.9
Sulphate (SO_4)	mg/L	--	--	< 0.5	2.5	< 5.0	--	--	1.0	1.4	--	< 0.5	< 10.0	< 10.0	--	< 0.5	< 0.5	--	2.8
Nutrients																			
Nitrite (NO_2-N)	mg/L	--	--	< 0.003	< 0.003	< 0.003	--	--	< 0.003	< 0.003	--	< 0.003	< 0.003	0.005	--	0.007	0.008	--	< 0.003
Nitrate (NO_3 -N)	mg/L	--	--	0.006	0.003	0.006	--	--	0.031	0.055	--	0.006	0.015	0.018	--	< 0.003	< 0.003	--	0.008
Nitrate + nitrite (NO_3 + NO_2 -N)	mg/L	--	--	0.006	0.003	0.006	--	--	***0.031***	***0.055***	--	0.006	0.015	***0.023***	--	0.007	0.008	--	0.008
Nitrogen - Ammonia (NH_4-N)	mg/L	--	0.02	< 0.01	0.17	0.01	0.04	--	0.31	0.33	0.03	0.04	0.01	0.02	0.04	0.06	0.03	--	0.04
Nitrogen - Kjeldahl (TKN)	mg/L	--	0.93	0.61	1.07	0.60	0.80	--	1.77	2.34	0.88	0.84	0.84	0.63	1.00	0.61	0.64	--	1.03
Total nitrogen (TKN+NO_3 + NO_2)	mg/L	--	0.93	0.62	***1.07***	0.61	--	--	***9.87***	***2.40***	0.88	0.85	0.86	0.65	1.00	0.62	0.65	--	***1.04***
Phosphorus, total	mg/L	--	0.039	0.023	***0.080***	0.030	0.032	--	***0.085***	***0.085***	0.019	0.024	***0.090***	0.013	0.033	0.023	0.026	--	0.023
Total Metals																			
Aluminum (Al)	ug/L	--	***213***	***291***	***137***	***141***	***211***	--	***426***	***403***	64	98	***279***	***102***	***193***	***226***	***242***	--	***426***
Antimony (Sb)	ug/L	--	< 0.2	< 0.2	< 0.2	< 0.2	0.3	--	< 0.2	< 0.2	0.3	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	--	< 0.2
Arsenic (As)	ug/L	--	< 0.2	0.4	0.6	0.5	< 0.2	--	0.4	0.3	5.9	0.4	1.0	< 0.2	< 0.2	0.4	0.4	--	0.5
Barium (Ba)	ug/L	--	14.1	11.9	40.0	12.8	8.7	--	21.1	20.8	6.6	11.2	20.6	11.7	7.8	9.3	9.3	--	13.3
Beryllium (Be)	ug/L	--	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	--	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	--	< 0.2
Boron (B)	ug/L	--	< 10	< 10	20	< 10	10	--	10	< 10	10	< 10	< 10	< 10	10	< 10	< 10	--	< 10
Cadmium (Cd)	ug/L	--	0.01	0.02	< 0.01	0.19	0.23	--	< 0.01	< 0.01	0.13	0.02	0.18	0.17	0.19	0.06	0.07	--	0.02
Chromium (Cr)	ug/L	--	1	< 1	< 1	1	2	--	< 1	< 1	2	< 1	2	1	2	1	2	--	2
Cobalt (Co)	ug/L	--	< 0.3	< 0.3	< 0.3	0.5	< 0.3	--	0.4	0.3	< 0.3	0.5	0.8	0.5	< 0.3	0.5	0.5	--	0.7
Copper (Cu)	ug/L	--	0.3	0.3	< 0.2	0.4	< 0.2	--	< 0.2	< 0.2	< 0.2	< 0.2	0.7	< 0.2	< 0.2	< 0.2	0.3	--	0.9
Iron (Fe)	ug/L	--	--	***880***	***2150***	***870***	--	--	***2030***	***1890***	--	***600***	***1500***	***540***	--	***870***	***980***	--	***870***
Lead (Pb)	ug/L	--	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	--	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	--	0.3
Lithium (Li)	ug/L	--	< 4	< 4	5	< 4	< 4	--	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	4	--	< 4
Manganese (Mn)	ug/L	--	--	52	186	70	--	--	177	176	--	58	96	25	--	55	60	--	44
Mercury (Hg) (ug/L)	ug/L	--	< 0.0006	< 0.0006	< 0.0006	< 0.0006	--	--	< 0.0006	< 0.0006	< 0.0006	< 0.0006	0.001	< 0.0006	< 0.0006	0.0015	< 0.0006	--	< 0.0006
Molybdenum (Mo)	ug/L	--	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	--	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	--	< 0.2
Nickel (Ni)	ug/L	--	0.6	0.7	< 0.5	1.1	1.3	--	0.9	0.9	1.2	1	1.6	1.3	1	1	1.1	--	6.8
Selenium (Se)	ug/L	--	< 0.2	< 0.2	< 0.2	0.2	< 0.2	--	< 0.2	< 0.2	< 0.2	< 0.2	0.2	< 0.2	< 0.2	< 0.2	< 0.2	--	0.3
Silicon (Si)	ug/L	--	1330	2220	3840	1400	850	--	3350	3420	830	2240	1580	1690	700	1330	1290	--	1100
Silver (Ag)	ug/L	--	< 0.1	< 0.1	< 0.1	***1.6***	***0.4***	--	< 0.1	< 0.1	***0.3***	< 0.1	***3.6***	***2***	***0.8***	< 0.1	< 0.1	--	< 0.1
Strontium (Sr)	ug/L	--	22	17	83	20	8	--	28	28	14	24	20	26	7	10	10	--	12
Sulphur (S)	ug/L	--	700	300	1400	400	700	--	800	800	500	300	400	300	500	400	400	--	400
Thallium (Tl)	ug/L	--	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	--	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	--	0.2
Tin (Sn)	ug/L	--	< 1	1	< 1	< 1	< 1	--	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	--	< 1
Titanium (Ti)	ug/L	--	3	4	2	3	4	--	5	4	2	1	5	2	3	3	3	--	4
Uranium (U)	ug/L	--	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	--	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	--	< 0.4
Vanadium (V)	ug/L	--	< 1	< 1	< 1	< 1	1	--	< 1	< 1	< 1	< 1	1	< 1	< 1	< 1	< 1	--	1
Zinc (Zn)	ug/L	--	6.5	***32.8***	12.2	12.5	12.9	--	15.6	19.3	11.6	6.9	14.3	10	***37.2***	7.6	8.7	--	***52.8***
Zirconium (Zr)	ug/L	--	0.5	0.3	< 0.2	< 0.2	2	--	< 0.2	< 0.2	< 1	0.2	0.4	< 0.2	< 1	0.3	0.3	--	0.5
Polycyclic Aromatic Hydrocarbons																			
Naphthalene	ug/L	--	--	< 0.1	< 0.1	< 0.1	--	--	< 0.1	< 0.1	--	< 0.1	< 0.1	< 0.1	--	< 0.1	< 0.1	< 0.1	--
Acenaphthylene	ug/L	--	--	< 0.1	< 0.1	< 0.1	--	--	< 0.1	< 0.1	--	< 0.1	< 0.1	< 0.1	--	< 0.1	< 0.1	< 0.1	--
Acenaphthene	ug/L	--	--	< 0.1	< 0.1	< 0.1	--	--	< 0.1	< 0.1	--	< 0.1	< 0.1	< 0.1	--	< 0.1	< 0.1	< 0.1	--
Fluorene	ug/L	--	--	< 0.05	< 0.05	< 0.05	--	--	< 0.05	< 0.05	--	< 0.05	< 0.05	< 0.05	--	< 0.05	< 0.05	< 0.05	--
Phenanthrene	ug/L	--	--	< 0.05	< 0.05	< 0.05	--	--	< 0.05	< 0.05	--	< 0.05	< 0.05	< 0.05	--	< 0.05	< 0.05	< 0.05	--
Anthracene	ug/L	--	--	< 0.01	< 0.01	< 0.01	--	--	< 0.01	< 0.01	--	< 0.01	< 0.01	< 0.01	--	< 0.01	< 0.01	< 0.01	--
Acridine	ug/L	--	--	< 0.2	< 0.2	< 0.2	--	--	< 0.2	< 0.2	--	< 0.2	< 0.2	< 0.2	--	< 0.2	< 0.2	< 0.2	--
Fluoranthene	ug/L	--	--	< 0.04	< 0.04	< 0.04	--	--	< 0.04	< 0.04	--	< 0.04	< 0.04	< 0.04	--	< 0.04	< 0.04	< 0.04	--
Pyrene	ug/L	--	--	< 0.02	< 0.02	< 0.02	--	--	0.02	< 0.02	--	< 0.02	< 0.02	< 0.02	--	< 0.02	< 0.02	< 0.02	--
Benz[a]anthracene	ug/L	--	--	< 0.01	< 0.01	< 0.05	--	--	***0.02***	< 0.01	--	< 0.01	< 0.05	< 0.05	--	< 0.01	< 0.01	< 0.05	--
Chrysene	ug/L	--	--	< 0.05	< 0.05	< 0.05	--	--	< 0.05	< 0.05	--	< 0.05	< 0.05	< 0.05	--	< 0.05	< 0.05	< 0.05	--
Benzo[b]fluoranthene	ug/L	--	--	< 0.1	< 0.1	< 0.1	--	--	< 0.1	< 0.1	--	< 0.1	< 0.1	< 0.1	--	< 0.1	< 0.1	< 0.1	--
Benzo[k]fluoranthene	ug/L	--	--	< 0.1	< 0.05	< 0.05	--	--	< 0.05	< 0.05	--	< 0.1	< 0.05	< 0.05	--	< 0.1	< 0.1	< 0.05	--
Benzo[a]pyrene	ug/L	--	--	< 0.01	< 0.01	< 0.05	--	--	0.01	< 0.01	--	< 0.01	< 0.05	< 0.05	--	< 0.01	< 0.01	< 0.05	--
Indeno[1,2,3-cd]pyrene	ug/L	--	--	< 0.1	< 0.1	< 0.1	--	--	< 0.1	< 0.1	--	< 0.1	< 0.1	< 0.1	--	< 0.1	< 0.1	< 0.1	--
Dibenz[a,h]anthracene	ug/L	--	--	< 0.05	< 0.05	< 0.05	--	--	< 0.05	< 0.05	--	< 0.05	< 0.05	< 0.05	--	< 0.05	< 0.05	< 0.05	--
Quinoline	ug/L	--	--	< 0.2	< 0.2	< 0.2	--	--	< 0.2	< 0.2	--	< 0.2	< 0.2	< 0.2	--	< 0.2	< 0.2	< 0.2	--
Benzo[g,h,i]perylene	ug/L	--	--	< 0.05	< 0.05	< 0.05	--	--	< 0.05	< 0.05	--	< 0.05	< 0.05	< 0.05	--	< 0.05	< 0.05	< 0.05	--
CCME B(a)P Equivalent	ug/L	--	--	< 0.0078	< 0.0078	< 0.008	--	--	< 0.0078	< 0.0078	--	< 0.0078	< 0.008	< 0.008	--	< 0.0078	< 0.0078	< 0.008	--

Notes:

--- - not analyzed
NS - not specified
^ - Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME, 2006)
* - Alberta Environment Surface Water Quality Guidelines for use in Alberta (AENV, 1999)
CC - continuous concentration guideline, National Recommended Water Quality Criteria (USEPA, 2006)
MC - maximum concentration guideline, National Recommended Water Quality Criteria (USEPA, 2006)
*** - National Recommended Water Quality Criteria (USEPA, 2006)
^^ - indicates value for Inorganic Mercury
1 - value if pH <6.5, Ca <4.0, DOC <2
2 - value if pH ≥6.5, Ca ≥4.0, DOC ≥2
3 - refer to CCME summary table for DO guideline breakdown
4 - refer to USEPA summary table for Ammonia criteria calculations
A - Acute aquatic life guideline
AA - 1 day minimum, acute guideline
a - value if pH>6.5, Ca>4.0, DOC>2
b - dependent on hardness value
C - Chronic Aquatic Life guideline
H - dependent on hardness value
*** - value denotes NO_2-N guideline concentration
Italics - indicates that values exceed specified guideline

Table 7A-1 Water Quality in the Hangingstone Lease

Sample Site		WCH6			LH1					LH3					AENV Freshwater Aquatic Life*	CCME Water Quality Guidelines - Freshwater^	EPA Freshwater Water Quality***
Date	**Unit**	05-May-06	29-Sep-05	06-Aug-05	05-May-06	07-Aug-05	19-Aug-06	03-Oct-05	07-Feb-06	04-May-06	07-Aug-05	01-Oct-05	08-Feb-06	08-Feb-06			
Field Parameters																	
Temperature	°C	7.0	6.2	16.3	8.1	16.9	18.2	6.5	0.8	6.6	17.9	5.1	0.7	--	NS	NS	NS
pH		*6.4*	7.2	*5.4*	*4.1*	*4.5*	6.5	*5.3*	*5.0*	*5.6*	*4.5*	*5.3*	*4.7*	--	6.5-8.5	6.5-9.0	6.5-9^{CC}
Conductivity (EC)	uS/cm	30	60	27	15	15	16	--	23	--	18	--	--	--	NS	NS	NS
Dissolved oxygen (DO)	mg/L	10.5	11.4	6.1	18.0	9.6	9.7	13.0	13.1	16.6	8.9	13.2	15.9	--	5.0^{AA}	5.5-9.5^{3}	NS
Conventional Parameters																	
pH		--	7.5	*5.9*	--	6.7	6.8	*6.3*	6.6	--	--	6.7	*6.4*	*6.4*	6.5-9	6.5-9.0	6.5-9^{CC}
Conductivity (EC)	uS/cm	--	61	28	--	16	17	20	27	--	--	18	32	31	NS	NS	NS
Hardness ($CaCO_3$)	mg/L	--	34.0	15.0	--	8.6	5.9	8.6	11.0	--	--	7.0	16.0	16.0	NS	NS	NS
Alkalinity ($CaCO_3$)	mg/L	--	28.1	4.8	--	3.7	4.0	3.3	6.0	--	--	3.4	5.8	6.2	NS	NS	20^{CC}
Total Dissolved Solids	mg/L	--	34.0	12.0	--	< 10.0	< 10.0	< 10.0	< 10.0	--	--	< 10.0	13.0	14.0	NS	NS	NS
Total Suspended Solids	mg/L	19.0	8.0	3.0	3.0	3.0	3.0	4.0	2.0	5.0	--	4.0	1.0	3.0	NS	NS	NS
Turbidity	NTU	4.9	7.8	2.6	2.2	3.5	1.8	--	0.8	3.2	4.0	--	1.4	--	NS	NS	NS
Major Ions																	
Carbonate (CO_3)	mg/L	--	< 0.5	< 0.5	--	< 0.5	< 0.5	< 0.5	< 0.5	--	--	< 0.5	< 0.5	< 0.5	NS	NS	NS
Bicarbonate (HCO_3 ($CaCO_3$))	mg/L	--	34.3	5.8	--	4.5	4.8	4.0	7.3	--	--	4.1	7.1	7.5	NS	NS	NS
Sodium (Na)	mg/L	--	1.2	< 0.5	--	< 0.5	0.5	< 0.5	0.5	--	--	< 0.5	0.6	0.6	NS	NS	NS
Potassium (K)	mg/L	--	0.3	< 0.3	--	0.4	< 0.3	< 0.3	0.7	--	--	0.3	0.4	0.4	NS	NS	NS
Calcium (Ca)	mg/L	--	9.6	4.2	--	2.5	1.6	2.3	3.1	--	--	2.0	4.3	4.4	NS	NS	NS
Magnesium (Mg)	mg/L	--	2.3	1.1	--	0.6	0.5	0.7	0.9	--	--	0.5	1.2	1.2	NS	NS	NS
Chloride (Cl)	mg/L	--	1.2	1.8	--	0.6	0.9	< 0.5	1.0	--	--	< 0.5	1.8	1.9	230**	NS	860^{MC}/230^{CC}
Sulphate (SO_4)	mg/L	--	-0.5	< 10.0	--	1.0	3.8	< 0.5	< 0.5	--	--	1.0	0.8	1.2	NS	NS	NS
Nutrients																	
Nitrite (NO_2-N)	mg/L	--	< 0.003	< 0.003	--	*0.026*	< 0.003	< 0.003	< 0.003	--	--	< 0.003	< 0.003	< 0.003	0.018	0.018	NS
Nitrate (NO_3-N)	mg/L	--	0.009	0.007	--	0.151	< 0.003	0.011	0.005	--	--	< 0.003	0.032	0.032	NS	2.9	NS
Nitrate + nitrite (NO_3 + NO_2 -N)	mg/L	--	0.009	0.007	--	*0.177*	< 0.003	0.011	0.005	--	--	< 0.003	*0.032*	*0.032*	0.018***	NS	NS
Nitrogen - Ammonia (NH_4-N)	mg/L	0.04	0.04	0.02	0.03	< 0.01	0.14	0.01	0.08	0.03	--	0.01	0.05	0.04	1.37 to 2.20	0.015	NS^{4}
Nitrogen - Kjeldahl (TKN)	mg/L	0.88	0.70	0.81	0.59	0.34	0.60	0.71	0.72	0.67	--	0.50	1.08	0.96	NS	NS	NS
Total nitrogen (TKN+NO_3 + NO_2)	mg/L	0.88	0.71	0.82	0.59	0.52	0.60	0.72	0.73	0.67	--	0.50	*1.11*	0.99	1.0^{C}	NS	NS
Phosphorus, total	mg/L	*0.066*	*0.071*	*0.086*	0.019	0.016	0.013	0.025	0.013	0.022	--	0.011	0.030	0.030	0.05^{C}	NS	NS
Total Metals																	
Aluminum (Al)	ug/L	*315*	*279*	*279*	27	66	42	*92*	46	*102*	--	57	*176*	*155*	5^^{1}/100^^{2}	100^{a}	750^{MC}/87^{CC}
Antimony (Sb)	ug/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	--	< 0.2	< 0.2	< 0.2	NS	NS	NS
Arsenic (As)	ug/L	5.3	0.6	1.0	< 0.2	< 0.2	0.2	0.6	< 0.2	< 0.2	--	0.7	< 0.2	< 0.2	5.0^	5	340^{MC}/150^{CC}
Barium (Ba)	ug/L	22.3	30.6	21.0	10.9	11.7	15.8	10.9	14.5	21.9	--	11.3	20.9	17.2	NS	NS	NS
Beryllium (Be)	ug/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	--	< 0.2	< 0.2	< 0.2	NS	NS	NS
Boron (B)	ug/L	10	10	< 10	< 10	< 10	10	< 10	20	< 10	--	< 10	< 10	< 10	NS	NS	NS
Cadmium (Cd)	ug/L	0.26	0.03	0.22	0.16	0.21	< 0.01	0.03	< 0.01	0.32	--	0.03	< 0.01	< 0.01	Hardness^{H}^	0.017^{b}	20^{MC,H}/0.25^{CC,H}
Chromium (Cr)	ug/L	2	< 1	2	1	1	< 1	< 1	< 1	1	--	< 1	< 1	1	8.9^	8.9	570^{MC,H}/74^{CC,H}
Cobalt (Co)	ug/L	0.4	0.4	0.8	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	--	< 0.3	< 0.3	< 0.3	NS	NS	NS
Copper (Cu)	ug/L	< 0.2	0.7	0.6	< 0.2	0.8	0.6	0.6	< 0.2	< 0.2	--	2.7	< 0.2	0.2	Hardness^{H}	2^{b}	13^{MC,H}/9^{CC,H}
Iron (Fe)	ug/L	--	*1970*	*1530*	--	60	40	*400*	110	--	--	60	*530*	*550*	300	300	1000CC
Lead (Pb)	ug/L	< 0.3	< 0.3	< 0.3	< 0.3	1.8	< 0.3	1.2	< 0.3	< 0.3	--	2.7	< 0.3	< 0.3	Hardness^{H}^	2^{b}	65^{MC,H}/2.5^{CC,H}
Lithium (Li)	ug/L	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	--	< 4	< 4	< 4	NS	NS	NS
Manganese (Mn)	ug/L	--	64	94	--	< 4	< 4	41	16	--	--	9	67	67	NS	NS	NS
Mercury (Hg) (ug/L)	ug/L	< 0.0006	< 0.0006	< 0.0006	< 0.0006	< 0.0006	--	< 0.0006	< 0.0006	< 0.0006	0.0009	< 0.0006	< 0.0006	< 0.0006	0.013^{A}/0.005^{C}	0.026^^	1.4^{MC,H}/0.77^{CC,H}
Molybdenum (Mo)	ug/L	0.2	0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	--	< 0.2	< 0.2	< 0.2	73^	73	NS
Nickel (Ni)	ug/L	0.8	1	1.6	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1	--	< 0.5	< 0.5	< 0.5	Hardness^{H}^	65^{b}	470^{MC,H}/52^{CC,H}
Selenium (Se)	ug/L	< 0.2	< 0.2	< 0.2	< 0.2	0.2	0.3	< 0.2	0.4	< 0.2	--	0.4	0.2	0.2	1.0^	1	5^{CC}
Silicon (Si)	ug/L	1450	2730	1600	50	250	180	250	100	220	--	150	300	190	NS	NS	NS
Silver (Ag)	ug/L	*0.9*	< 0.1	*4.2*	*0.3*	*1.1*	*2.7*	< 0.1	< 0.1	*0.4*	--	< 0.1	< 0.1	< 0.1	0.1^	0.1	3.2^{MC,H}
Strontium (Sr)	ug/L	19	40	20	8	8	10	10	12	9	--	9	5	15	NS	NS	NS
Sulphur (S)	ug/L	500	400	400	500	500	500	400	800	400	--	500	700	600	NS	NS	NS
Thallium (Tl)	ug/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	--	< 0.2	< 0.2	< 0.2	0.8^	0.8	NS
Tin (Sn)	ug/L	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	--	< 1	< 1	< 1	NS	NS	NS
Titanium (Ti)	ug/L	6	5	5	< 1	1	< 1	1	< 1	1	--	< 1	< 1	< 1	NS	NS	NS
Uranium (U)	ug/L	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	--	< 0.4	< 0.4	< 0.4	NS	NS	NS
Vanadium (V)	ug/L	< 1	< 1	1	< 1	< 1	< 1	< 1	< 1	< 1	--	< 1	< 1	< 1	NS	NS	NS
Zinc (Zn)	ug/L	11.6	8.5	14.4	5.6	11.9	*35.3*	6.1	23.4	28.6	--	20.8	*34.6*	28	30^	30	120^{M,H}/120^{CC,H}
Zirconium (Zr)	ug/L	9	0.4	0.5	2.4	< 0.2	< 0.2	0.3	< 0.2	9.2	--	0.2	< 0.2	< 0.2	NS	NS	NS
Polycyclic Aromatic Hydrocarbons																	
Naphthalene	ug/L	--	< 0.1	< 0.1	--	< 0.1	--	< 0.1	< 0.1	--	< 0.1	< 0.1	< 0.1	< 0.1	1.1^	1.1	NS
Acenaphthylene	ug/L	--	< 0.1	< 0.1	--	< 0.1	--	< 0.1	< 0.1	--	< 0.1	< 0.1	< 0.1	< 0.1	NS	NS	NS
Acenaphthene	ug/L	--	< 0.1	< 0.1	--	< 0.1	--	< 0.1	< 0.1	--	< 0.1	< 0.1	< 0.1	< 0.1	5.8^	5.8	NS
Fluorene	ug/L	--	< 0.05	< 0.05	--	< 0.052	--	< 0.05	< 0.05	--	< 0.05	< 0.05	< 0.05	< 0.05	3^	3	NS
Phenanthrene	ug/L	--	< 0.05	< 0.05	--	< 0.052	--	< 0.05	< 0.05	--	< 0.05	< 0.05	< 0.05	< 0.05	0.4^	0.4	NS
Anthracene	ug/L	--	< 0.01	< 0.01	--	< 0.01	--	< 0.01	< 0.01	--	< 0.01	< 0.01	< 0.01	< 0.01	0.012^	0.012	NS
Acridine	ug/L	--	< 0.2	< 0.2	--	< 0.21	--	< 0.2	< 0.2	--	< 0.2	< 0.2	< 0.2	< 0.2	4.4^	NS	NS
Fluoranthene	ug/L	--	< 0.04	< 0.04	--	< 0.042	--	< 0.04	< 0.04	--	< 0.04	< 0.04	< 0.04	< 0.04	0.04^	0.04	NS
Pyrene	ug/L	--	< 0.02	< 0.02	--	< 0.021	--	< 0.02	< 0.02	--	< 0.02	< 0.02	< 0.02	< 0.02	0.025^	0.025	NS
Benz[a]anthracene	ug/L	--	< 0.01	< 0.05	--	< 0.05	--	< 0.01	< 0.01	--	< 0.05	< 0.01	< 0.01	< 0.01	0.018^	0.018	NS
Chrysene	ug/L	--	< 0.05	< 0.05	--	< 0.05	--	< 0.05	< 0.05	--	< 0.05	< 0.05	< 0.05	< 0.05	NS	NS	NS
Benzo[b]fluoranthene	ug/L	--	< 0.1	< 0.1	--	< 0.1	--	< 0.1	< 0.1	--	< 0.1	< 0.1	< 0.1	< 0.1	NS	NS	NS
Benzo[k]fluoranthene	ug/L	--	< 0.1	< 0.05	--	< 0.05	--	< 0.1	< 0.05	--	< 0.05	< 0.1	< 0.05	< 0.05	NS	NS	NS
Benzo[a]pyrene	ug/L	--	< 0.01	< 0.05	--	< 0.05	--	< 0.01	< 0.01	--	< 0.05	< 0.01	< 0.01	< 0.01	0.015^	0.015	NS
Indeno[1,2,3-cd]pyrene	ug/L	--	< 0.1	< 0.1	--	< 0.1	--	< 0.1	< 0.1	--	< 0.1	< 0.1	< 0.1	< 0.1	NS	NS	NS
Dibenz[a,h]anthracene	ug/L	--	< 0.05	< 0.05	--	< 0.05	--	< 0.05	< 0.05	--	< 0.05	< 0.05	< 0.05	< 0.05	NS	NS	NS
Quinoline	ug/L	--	< 0.2	< 0.2	--	< 0.21	--	< 0.2	< 0.2	--	< 0.2	< 0.2	< 0.2	< 0.2	NS	NS	NS
Benzo[g,h,i]perylene	ug/L	--	< 0.05	< 0.05	--	< 0.052	--	< 0.05	< 0.05	--	< 0.05	< 0.05	< 0.05	< 0.05	NS	NS	NS
CCME B(a)P Equivalent	ug/L	--	< 0.0078	< 0.008	--	< 0.008	--	< 0.0078	< 0.0078	--	< 0.008	< 0.0078	< 0.0078	< 0.0078	NS	NS	NS

Notes:

--- - not analyzed
NS - not specified
^ - Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME, 2006)
* - Alberta Environment Surface Water Quality Guidelines for use in Alberta (AENV, 1999)
CC - continuous concentration guideline, National Recommended Water Quality Criteria (USEPA, 2006
MC - maximum concentration guideline, National Recommended Water Quality Criteria (USEPA, 2006)
*** - National Recommended Water Quality Criteria (USEPA, 2006)
^^ - indicates value for Inorganic Mercury
1 - value if pH <6.5, Ca <4.0, DOC <2
2 - value if pH $\geq$6.5, Ca $\geq$4.0, DOC $\geq$2
3 - refer to CCME summary table for DO guideline breakdown
4 - refer to USEPA summary table for Ammonia criteria calculations
A - Acute aquatic life guideline
A A - 1 day minimum, acute guideline
a - value if pH>6.5, Ca>4.0, DOC>2
b - dependent on hardness value
C - Chronic Aquatic Life guideline
H - dependent on hardness value
*** - value denotes NO_2-N guideline concentration
Italics - indicates that values exceed specified guideline

Table 7A-2 Water Quality in the Corner Lease

Sample Site		WCC1					WCC2	WCC3				LC1						LC2			AENV Freshwater Aquatic Life*	CCME Water Quality Guidelines - Freshwater^	EPA Freshwater Water Quality***
Date	Unit	05-May-06	06-Aug-05	20-Aug-06	20-Aug-06	29-Sep-05	05-May-06	05-May-06	05-Aug-05	29-Sep-05	09-Feb-06	05-May-06	05-May-06	06-Aug-05	19-Aug-06	01-Oct-05	10-Feb-06	07-May-06	06-Aug-05	03-Oct-05			
Field Parameters																							
Temperature	°C	5.6	15.4	12.7	--	5.1	10.5	8.1	17.1	6.2	0.1	10.3	10.3	--	--	--	1.6	10.6	--	--	**NS**	**NS**	**NS**
pH		--	*9.1*	*5.4*	--	7.4	8.5	--	*9.2*	*6.0*	6.5	7.2	7.2	--	*8.9*	--	6.5	*5.0*	--	--	**6.5-8.5**	**6.5-9.0**	**6.5-9^{CC}**
Conductivity (EC)	uS/cm	12	101	81	--	70	40	18	113	80	243	48	48	--	70	--	263	54	--	--	**NS**	**NS**	**NS**
Dissolved oxygen (DO)	mg/L	9.2	8.9	6.8	--	8.5	9.9	11.7	11.9	11.2	7.0	14.7	14.7	--	8.0	--	*4.1*	9.3	--	--	**5.0^{AA}**	**5.5-9.5^{3}**	**NS**
Conventional Parameters																							
pH		--	--	7.3	7.4	7.5	--	--	--	7.8	7.5	--	--	7.6	7.6	7.6	7.2	--	7.7	7.7	**6.5-9**	**6.5-9.0**	**6.5-9^{CC}**
Conductivity (EC)	uS/cm	--	--	55	55	66	--	--	--	87	246	--	--	62.4	68	63	179	--	65.8	80	**NS**	**NS**	**NS**
Hardness ($CaCO_3$)	mg/L	--	--	26.0	29.0	32.0	--	--	--	43.0	120.0	--	--	28.0	24.0	27.0	88.0	--	33.0	41.0	**NS**	**NS**	**NS**
Alkalinity ($CaCO_3$)	mg/L	--	--	26.5	25.4	32.4	--	--	--	44.0	129.0	--	--	31.2	26.7	30.7	85.5	--	31.4	38.9	**NS**	**NS**	**20^{CC}**
Total Dissolved Solids	mg/L	--	--	30.0	31.0	33.0	--	--	--	46.0	132.0	--	--	31.0	31.0	30.0	94.0	--	38.0	40.0	**NS**	**NS**	**NS**
Total Suspended Solids	mg/L	3.0	--	6.0	7.0	9.0	--	19.0	--	22.0	6.0	21.0	20.0	50.0	34.0	26.0	273.0	3.0	9.0	8.0	**NS**	**NS**	**NS**
Turbidity	NTU	3.5	6.9	9.6	8.1	15.3	20.7	7.2	10.8	15.5	26.8	5.0	5.0	--	26.2	14.2	70.2	3.8	--	7.2	**NS**	**NS**	**NS**
Major Ions																							
Carbonate (CO_3)	mg/L	--	--	< 0.5	< 0.5	< 0.5	--	--	--	< 0.5	< 0.5	--	--	< 0.5	< 0.5	< 0.5	< 0.5	--	< 0.5	< 0.5	**NS**	**NS**	**NS**
Bicarbonate (HCO_3 ($CaCO_3$))	mg/L	--	--	32.3	31.0	39.5	--	--	--	53.6	158.0	--	--	38.0	32.5	37.4	104.0	--	38.3	47.5	**NS**	**NS**	**NS**
Sodium (Na)	mg/L	--	--	1.0	0.8	0.9	--	--	--	1.5	5.0	--	--	1.2	1.2	1.0	3.1	--	1.0	1.0	**NS**	**NS**	**NS**
Potassium (K)	mg/L	--	--	< 0.3	< 0.3	< 0.3	--	--	--	< 0.3	1.5	--	--	0.5	< 0.3	0.4	1.4	--	0.4	< 0.3	**NS**	**NS**	**NS**
Calcium (Ca)	mg/L	--	--	7.6	8.7	9.5	--	--	--	12.8	35.2	--	--	8.1	6.9	8.0	26.2	--	9.1	11.6	**NS**	**NS**	**NS**
Magnesium (Mg)	mg/L	--	--	1.6	1.8	1.9	--	--	--	2.7	7.5	--	--	1.8	1.5	1.6	5.6	--	2.6	2.9	**NS**	**NS**	**NS**
Chloride (Cl)	mg/L	--	--	1.0	1.1	< 0.5	--	--	--	0.7	1.5	--	--	0.7	0.9	< 0.5	2.0	--	1.2	0.6	**230****	**NS**	**860^{MC}/230^{CC}**
Sulphate (SO_4)	mg/L	--	--	2.2	2.3	< 0.5	--	--	--	< 0.5	< 0.5	--	--	< 0.5	3.2	< 0.5	< 0.5	--	4.8	< 0.5	**NS**	**NS**	**NS**
Nutrients																							
Nitrite (NO_2-N)	mg/L	--	--	< 0.003	< 0.003	< 0.003	--	--	--	< 0.003	< 0.003	--	--	0.003	< 0.003	< 0.003	< 0.003	--	0.004	< 0.003	**0.018**	**0.018**	**NS**
Nitrate (NO_3-N)	mg/L	--	--	0.011	0.007	0.005	--	--	--	0.006	0.003	--	--	0.02	0.032	< 0.003	0.011	--	0.006	< 0.003	**NS**	**2.9**	**NS**
Nitrate + nitrite (NO_3 + NO_2 -N)	mg/L	--	--	0.011	0.007	0.005	--	--	--	0.006	0.003	--	--	*0.023*	*0.032*	< 0.003	0.011	--	0.010	< 0.003	**0.018*****	**NS**	**NS**
Nitrogen - Ammonia (NH_4-N)	mg/L	0.05	--	0.08	0.04	0.02	--	0.24	--	0.08	1.08	0.03	0.02	0.02	0.24	< 0.01	1.30	0.02	0.02	< 0.01	**1.37 to 2.20**	**0.015**	**NS^{4}**
Nitrogen - Kjeldahl (TKN)	mg/L	0.74	--	0.75	1.17	0.52	--	1.29	--	1.06	2.33	0.86	1.10	1.99	2.39	1.48	26.60	0.75	1.03	1.14	**NS**	**NS**	**NS**
Total nitrogen (TKN+NO_3 + NO_2)	mg/L	--	--	0.76	*1.18*	0.53	--	*1.29*	--	*1.07*	*2.33*	0.86	*1.10*	*2.01*	*2.42*	*1.48*	*26.61*	0.75	*1.04*	*1.14*	**1.0^{C}**	**NS**	**NS**
Phosphorus, total	mg/L	0.047	--	*0.066*	*0.058*	*0.077*	--	*0.121*	--	*0.122*	*0.095*	*0.083*	*0.080*	*0.201*	*0.086*	*0.065*	*1.670*	0.036	0.048	0.033	**0.05^{C}**	**NS**	**NS**
Total Metals																							
Aluminum (Al)	ug/L	39	--	80	58	51	--	*142*	--	83	14	32	28	*150*	60	55	73	17	18	11	**5^^{1}/100^^{2}**	**100^{a}**	**750^{MC}/87^{CC}**
Antimony (Sb)	ug/L	< 0.2	--	< 0.2	< 0.2	< 0.2	--	< 0.2	--	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	**NS**	**NS**	**NS**
Arsenic (As)	ug/L	< 0.2	--	0.9	0.7	0.8	--	4.7	--	0.8	0.4	< 0.2	< 0.2	0.4	0.4	0.4	< 0.2	< 0.2	0.4	0.7	**5.0^**	**5**	**340^{MC}/150^{CC}**
Barium (Ba)	ug/L	16.8	--	32.5	30.5	27.4	--	30.8	--	34	73.4	8.5	12.5	31.2	34.1	26.1	54.4	10.3	21.1	19.7	**NS**	**NS**	**NS**
Beryllium (Be)	ug/L	< 0.2	--	< 0.2	< 0.2	< 0.2	--	< 0.2	--	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	**NS**	**NS**	**NS**
Boron (B)	ug/L	< 10	--	10	< 10	< 10	--	10	--	10	50	20	10	20	30	10	30	10	10	10	**NS**	**NS**	**NS**
Cadmium (Cd)	ug/L	< 0.01	--	< 0.01	< 0.01	0.01	--	< 0.01	--	0.03	< 0.01	0.22	0.18	0.32	< 0.01	0.01	< 0.01	0.14	0.25	< 0.01	**Hardness^{H}^**	**0.017^{b}**	**20^{MC,H}/0.25^{CC,H}**
Chromium (Cr)	ug/L	1	--	2	7	< 1	--	1	--	< 1	< 1	1	1	1	1	< 1	< 1	1	1	< 1	**8.9^**	**8.9**	**570^{MC,H}/74^{CC,H}**
Cobalt (Co)	ug/L	< 0.3	--	0.5	0.4	0.4	--	< 0.3	--	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	**NS**	**NS**	**NS**
Copper (Cu)	ug/L	0.2	--	0.2	0.6	< 0.2	--	0.3	--	0.2	< 0.2	< 0.2	< 0.2	1	0.5	0.3	< 0.2	< 0.2	0.6	< 0.2	**Hardness^{H}**	**2^{b}**	**13^{MC,H}/9^{CC,H}**
Iron (Fe)	ug/L	--	--	*850*	*740*	*1510*	--	--	--	*1640*	*2220*	--	--	30	20	110	*3290*	--	70	130	**300**	**300**	**1000CC**
Lead (Pb)	ug/L	< 0.3	--	< 0.3	< 0.3	< 0.3	--	< 0.3	--	< 0.3	< 0.3	< 0.3	< 0.3	1.1	< 0.3	< 0.3	< 0.3	< 0.3	0.7	< 0.3	**Hardness^{H}^**	**2^{b}**	**65^{MC,H}/2.5^{CC,H}**
Lithium (Li)	ug/L	< 4	--	< 4	< 4	< 4	--	< 4	--	6	5	< 4	< 4	< 4	< 4	< 4	6	< 4	< 4	< 4	**NS**	**NS**	**NS**
Manganese (Mn)	ug/L	--	--	43	55	25	--	--	--	54	534	--	--	7	< 4	< 4	10	--	< 4	< 4	**NS**	**NS**	**NS**
Mercury (Hg)	ug/L	< 0.0006	--	--	--	< 0.0006	--	< 0.0006	--	< 0.0006	< 0.0006	< 0.0006	--	0.001	--	0.0028	< 0.0006	0.001	< 0.0006	0.001	**0.013^{A}/0.005^{C}**	**0.026^^**	**1.4^{MC,H}/0.77^{CC,H}**
Molybdenum (Mo)	ug/L	< 0.2	--	< 0.2	< 0.2	< 0.2	--	< 0.2	--	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	**73^**	**73**	**NS**
Nickel (Ni)	ug/L	< 0.5	--	0.9	0.9	0.7	--	0.6	--	0.8	0.7	0.9	1.3	1.4	0.8	0.7	0.5	1.2	1.2	0.5	**Hardness^{H}^**	**65^{b}**	**470^{MC,H}/52^{CC,H}**
Selenium (Se)	ug/L	< 0.2	--	0.3	0.3	< 0.2	--	< 0.2	--	< 0.2	< 0.2	< 0.2	< 0.2	0.3	0.2	< 0.2	< 0.2	< 0.2	0.2	< 0.2	**1.0^**	**1**	**5^{CC}**
Silicon (Si)	ug/L	1380	--	2230	2150	2910	--	1860	--	2400	3420	530	460	780	810	1020	2020	700	930	1870	**NS**	**NS**	**NS**
Silver (Ag)	ug/L	< 0.1	--	< 0.1	< 0.1	< 0.1	--	< 0.1	--	< 0.1	< 0.1	*0.2*	*0.2*	*2.1*	*3.4*	< 0.1	< 0.1	*0.3*	*2.1*	< 0.1	**0.1^**	**0.1**	**3.2^{MC,H}**
Strontium (Sr)	ug/L	20	--	32	31	36	--	31	--	51	143	24	26	42	41	44	112	29	42	54	**NS**	**NS**	**NS**
Sulphur (S)	ug/L	300	--	< 200	200	200	--	400	--	300	400	< 200	300	300	300	300	400	200	300	300	**NS**	**NS**	**NS**
Thallium (Tl)	ug/L	< 0.2	--	< 0.2	< 0.2	< 0.2	--	< 0.2	--	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	0.4	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	**0.8^**	**0.8**	**NS**
Tin (Sn)	ug/L	< 1	--	< 1	< 1	< 1	--	< 1	--	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	**NS**	**NS**	**NS**
Titanium (Ti)	ug/L	1	--	2	2	2	--	3	--	3	< 1	1	1	5	2	2	2	1	2	< 1	**NS**	**NS**	**NS**
Uranium (U)	ug/L	< 0.4	--	< 0.4	< 0.4	< 0.4	--	< 0.4	--	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	**NS**	**NS**	**NS**
Vanadium (V)	ug/L	< 1	--	< 1	< 1	< 1	--	< 1	--	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	**NS**	**NS**	**NS**
Zinc (Zn)	ug/L	5.3	--	*32.0*	26.9	11.9	--	6.5	--	5.6	12.7	5.0	6.0	12.2	*32.0*	15.4	10.6	4.3	10.0	9.0	**30^**	**30**	**120^{M,H}/120^{CC,H}**
Zirconium (Zr)	ug/L	0.3	--	< 0.2	< 0.2	< 0.2	--	0.4	--	0.5	< 0.2	2	1.6	0.2	< 0.2	< 0.2	< 0.2	1.5	0.2	< 0.2	**NS**	**NS**	**NS**
Polycyclic Aromatic Hydrocarbons																							
Naphthalene	ug/L	--	--	--	--	< 0.1	--	--	--	< 0.1	< 0.1	--	--	< 0.1	--	< 0.1	< 0.1	--	< 0.11	< 0.1	**1.1^**	**1.1**	**NS**
Acenaphthylene	ug/L	--	--	--	--	< 0.1	--	--	--	< 0.1	< 0.1	--	--	< 0.1	--	< 0.1	< 0.1	--	< 0.11	< 0.1	**NS**	**NS**	**NS**
Acenaphthene	ug/L	--	--	--	--	< 0.1	--	--	--	< 0.1	< 0.1	--	--	< 0.1	--	< 0.1	< 0.1	--	< 0.11	< 0.1	**5.8^**	**5.8**	**NS**
Fluorene	ug/L	--	--	--	--	< 0.05	--	--	--	< 0.05	< 0.05	--	--	< 0.05	--	< 0.05	< 0.05	--	< 0.054	< 0.05	**3^**	**3**	**NS**
Phenanthrene	ug/L	--	--	--	--	< 0.05	--	--	--	< 0.05	< 0.05	--	--	< 0.05	--	< 0.05	< 0.05	--	< 0.054	< 0.05	**0.4^**	**0.4**	**NS**
Anthracene	ug/L	--	--	--	--	< 0.01	--	--	--	*0.02*	< 0.01	--	--	< 0.01	--	< 0.01	< 0.01	--	< 0.011	< 0.01	**0.012^**	**0.012**	**NS**
Acridine	ug/L	--	--	--	--	< 0.2	--	--	--	< 0.2	< 0.2	--	--	< 0.2	--	< 0.2	< 0.2	--	< 0.22	< 0.2	**4.4^**	**NS**	**NS**
Fluoranthene	ug/L	--	--	--	--	< 0.04	--	--	--	*0.07*	< 0.04	--	--	< 0.04	--	< 0.04	< 0.04	--	< 0.043	< 0.04	**0.04^**	**0.04**	**NS**
Pyrene	ug/L	--	--	--	--	< 0.02	--	--	--	*0.06*	< 0.02	--	--	< 0.02	--	< 0.02	< 0.02	--	< 0.022	< 0.02	**0.025^**	**0.025**	**NS**
Benz[a]anthracene	ug/L	--	--	--	--	< 0.01	--	--	--	*0.03*	< 0.01	--	--	< 0.05	--	< 0.01	< 0.01	--	< 0.05	< 0.01	**0.018^**	**0.018**	**NS**
Chrysene	ug/L	--	--	--	--	< 0.05	--	--	--	0.07	< 0.05	--	--	< 0.05	--	< 0.05	< 0.05	--	< 0.05	< 0.05	**NS**	**NS**	**NS**
Benzo[b]fluoranthene	ug/L	--	--	--	--	< 0.1	--	--	--	< 0.1	< 0.1	--	--	< 0.1	--	< 0.1	< 0.1	--	< 0.1	< 0.1	**NS**	**NS**	**NS**
Benzo[k]fluoranthene	ug/L	--	--	--	--	< 0.1	--	--	--	< 0.1	< 0.05	--	--	< 0.05	--	< 0.1	< 0.05	--	< 0.05	< 0.1	**NS**	**NS**	**NS**
Benzo[a]pyrene	ug/L	--	--	--	--	< 0.01	--	--	--	*0.04*	< 0.01	--	--	< 0.05	--	< 0.01	< 0.01	--	< 0.05	< 0.01	**0.015^**	**0.015**	**NS**
Indeno[1,2,3-cd]pyrene	ug/L	--	--	--	--	< 0.1	--	--	--	< 0.1	< 0.1	--	--	< 0.1	--	< 0.1	< 0.1	--	< 0.1	< 0.1	**NS**	**NS**	**NS**
Dibenz[a,h]anthracene	ug/L	--	--	--	--	< 0.05	--	--	--	< 0.05	< 0.05	--	--	< 0.05	--	< 0.05	< 0.05	--	< 0.05	< 0.05	**NS**	**NS**	**NS**
Quinoline	ug/L	--	--	--	--	< 0.2	--	--	--	< 0.2	< 0.2	--	--	< 0.2	--	< 0.2	< 0.2	--	< 0.22	< 0.2	**NS**	**NS**	**NS**
Benzo[g,h,i]perylene	ug/L	--	--	--	--	< 0.05	--	--	--	< 0.05	< 0.05	--	--	< 0.05	--	< 0.05	< 0.05	--	< 0.054	< 0.05	**NS**	**NS**	**NS**
CCME B(a)P Equivalent	ug/L	--	--	--	--	< 0.0078	--	--	--	< 0.0078	< 0.0078	--	--	< 0.008	--	< 0.0078	< 0.0078	--	< 0.008	< 0.0078	**NS**	**NS**	**NS**

Notes:
--- - not analyzed
NS - not specified
^ - Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME, 2006
* - Alberta Environment Surface Water Quality Guidelines for use in Alberta (AENV, 1999
CC - continuous concentration guideline, National Recommended Water Quality Criteria (USEPA, 2006
MC - maximum concentration guideline, National Recommended Water Quality Criteria (USEPA, 2006)
*** - National Recommended Water Quality Criteria (USEPA, 2006)
^^ - indicates value for Inorganic Mercury
1 - value if pH <6.5, Ca <4.0, DOC <2
2 - value if pH ≥6.5, Ca ≥4.0, DOC ≥2
3 - refer to CCME summary table for DO guideline breakdown
4 - refer to USEPA summary table for Ammonia criteria calculations
A - Acute aquatic life guideline
AA - 1 day minimum, acute guideline
a - value if pH>6.5, Ca>4.0, DOC>2
b - dependent on hardness value
C - Chronic Aquatic Life guideline
H - dependent on hardness value
*** - value denotes NO_2-N guideline concentration
Italics - indicates that values exceed specified guideline

Table 7A-3 Water Quality in the Leismer Lease

Sample Site		WCL1		WCL2					WCL3		WCL4					WCL5			
Date	**Unit**	10-May-06	20-Aug-06	06-May-06	06-May-06	08-Aug-05	28-Sep-05	08-Feb-06	10-May-06	20-Aug-06	06-May-06	05-Aug-05	20-Aug-06	29-Sep-05	09-Feb-06	06-May-06	06-Aug-05	28-Sep-05	08-Feb-06
Field Parameters																			
Temperature	°C	10.8	14.1	6.5	--	14.5	5.0	0.1	8.4	15.2	7.6	15.9	15.0	5.5	0.1	7.5	15.4	5.5	0.8
pH		8.0	***6.2***	***9.7***	--	***9.3***	6.7	6.6	7.6	***6.4***	8.4	***9.2***	6.8	7.6	6.7	7.9	7.3	7.1	6.5
Conductivity (EC)	uS/cm	110	111	50	--	139	110	352	70	122	60	117	110	160	443	110	169	180	348
Dissolved oxygen (DO)	mg/L	6.7	9.7	10.0	--	9.8	11.1	11.3	9.4	6.4	11.7	11.5	10.0	12.6	12.8	11.7	8.9	12.6	10.7
Conventional Parameters																			
pH		--	7.8	--	--	7.6	7.9	7.5	--	7.7	--	--	7.9	8.1	7.7	--	8.1	8.2	7.8
Conductivity (EC)	uS/cm	--	89	--	--	85	118	407	--	98	--	--	89	164	438	--	170	179	356
Hardness ($CaCO_3$)	mg/L	--	41.0	--	--	47.0	57.0	190.0	--	45.0	--	--	42.0	87.0	220.0	--	88.0	98.0	180.0
Alkalinity ($CaCO_3$)	mg/L	--	53.3	--	--	42.3	61.4	221.0	--	49.7	--	--	44.4	86.1	232.0	--	92.6	99.2	195.0
Total Dissolved Solids	mg/L	--	52.0	--	--	48.0	63.0	217.0	--	51.0	--	--	47.0	92.0	235.0	--	95.0	98.0	192.0
Total Suspended Solids	mg/L	4.0	23.0	9.0	12.0	1.0	4.0	5.0	5.0	13.0	20.0	--	12.0	12.0	6.0	9.0	1.0	7.0	6.0
Turbidity	NTU	3.3	11.0	7.0	--	11.1	12.1	127.5	5.2	13.5	9.7	12.8	7.5	15.0	21.2	2.8	1.6	3.6	47.5
Major Ions																			
Carbonate (CO_3)	mg/L	--	< 0.5	--	--	< 0.5	< 0.5	< 0.5	--	< 0.5	--	--	< 0.5	< 0.5	< 0.5	--	< 0.5	< 0.5	< 0.5
Bicarbonate (HCO_3 ($CaCO_3$))	mg/L	--	65.1	--	--	51.6	74.9	270.0	--	60.6	--	--	54.1	105.0	283.0	--	113.0	121.0	238.0
Sodium (Na)	mg/L	--	1.4	--	--	1.6	2.6	9.7	--	0.9	--	--	1.4	2.6	6.5	--	2.2	2.8	4.4
Potassium (K)	mg/L	--	< 0.3	--	--	< 0.3	< 0.3	1.4	--	< 0.3	--	--	< 0.3	0.6	1.6	--	< 0.3	0.4	1.1
Calcium (Ca)	mg/L	--	11.9	--	--	13.1	16.1	56.0	--	13.7	--	--	12.2	25.2	62.5	--	24.1	27.4	51.3
Magnesium (Mg)	mg/L	--	2.8	--	--	3.5	4.0	12.8	--	2.6	--	--	2.9	5.9	14.4	--	6.8	7.2	12.9
Chloride (Cl)	mg/L	--	1.3	--	--	1.5	1.0	1.5	--	1.1	--	--	1.4	1.0	1.3	--	1.2	0.6	1.2
Sulphate (SO_4)	mg/L	--	1.4	--	--	< 5.0	< 0.5	0.5	--	2.2	--	--	1.9	2.0	7.7	--	4.5	< 0.5	< 0.5
Nutrients																			
Nitrite (NO_2-N)	mg/L	--	< 0.003	--	--	0.012	< 0.003	< 0.003	--	< 0.003	--	--	< 0.003	0.004	< 0.003	--	0.003	< 0.003	< 0.003
Nitrate (NO_3-N)	mg/L	--	0.033	--	--	0.084	0.015	0.133	--	0.011	--	--	0.022	0.061	0.058	--	0.010	0.004	0.017
Nitrate + nitrite (NO_3 + NO_2 -N)	mg/L	--	***0.033***	--	--	***0.096***	0.015	***0.133***	--	0.011	--	--	***0.022***	***0.065***	***0.058***	--	0.013	0.004	0.017
Nitrogen - Ammonia (NH_4-N)	mg/L	0.04	0.03	0.05	0.04	0.05	0.02	0.83	0.08	0.11	0.03	--	0.04	0.05	0.59	0.05	0.03	0.02	0.89
Nitrogen - Kjeldahl (TKN)	mg/L	0.83	0.90	0.84	0.88	1.02	0.78	1.71	0.85	1.59	0.91	--	0.94	0.76	1.20	0.67	0.41	0.54	1.48
Total nitrogen (TKN+NO_3 + NO_2)	mg/L	0.83	0.93	0.84	0.88	***1.12***	0.80	***1.84***	0.85	***1.60***	0.91	--	0.96	0.83	***1.26***	--	0.42	0.54	***1.50***
Phosphorus, total	mg/L	***0.062***	***0.120***	***0.078***	***0.079***	***0.091***	***0.103***	***0.272***	***0.052***	***0.076***	***0.129***	--	***0.098***	***0.130***	***0.079***	0.037	0.032	***0.058***	***0.133***
Total Metals																			
Aluminum (Al)	ug/L	32	***254***	***203***	***191***	***103***	55	28	24	44	92	--	***234***	***135***	23	100	23	24	46
Antimony (Sb)	ug/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	--	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Arsenic (As)	ug/L	< 0.2	1.1	0.6	0.6	1.6	1.1	1.6	6.2	0.8	0.4	--	1	1.1	0.8	< 0.2	0.2	0.3	< 0.2
Barium (Ba)	ug/L	19.2	50.8	22.7	21.7	32.3	32.5	98.5	37.8	53.5	35.9	--	52.6	51.9	105	21.3	24.2	24.4	62.7
Beryllium (Be)	ug/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	--	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Boron (B)	ug/L	20	20	20	20	10	20	60	20	20	20	--	20	20	50	20	20	10	20
Cadmium (Cd)	ug/L	0.14	< 0.01	0.24	0.18	***0.2***	0.02	< 0.01	0.52	< 0.01	0.16	--	< 0.01	***0.03***	< 0.01	< 0.01	***0.15***	0.02	< 0.01
Chromium (Cr)	ug/L	1	4	2	2	1	< 1	< 1	2	6	1	--	3	< 1	< 1	1	1	< 1	< 1
Cobalt (Co)	ug/L	< 0.3	0.4	0.4	0.3	0.7	0.4	< 0.3	< 0.3	< 0.3	0.3	--	0.3	0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
Copper (Cu)	ug/L	0.8	0.5	< 0.2	< 0.2	0.5	0.4	< 0.2	< 0.2	0.3	< 0.2	--	0.5	0.4	< 0.2	0.6	0.3	< 0.2	< 0.2
Iron (Fe)	ug/L	--	***1050***	--	--	***2290***	***2290***	***380***	--	***640***	--	--	***960***	***2860***	40	--	270	***540***	200
Lead (Pb)	ug/L	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	--	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
Lithium (Li)	ug/L	< 4	< 4	< 4	< 4	< 4	< 4	12	< 4	< 4	< 4	--	< 4	7	14	< 4	< 4	7	7
Manganese (Mn)	ug/L	--	14	--	--	49	78	696	--	13	--	--	9	54	606	--	10	51	2470
Mercury (Hg)	ug/L	< 0.0006	--	< 0.0006	< 0.0006	< 0.0006	< 0.0006	< 0.0006	--	--	< 0.0006	--	< 0.0006	< 0.0006	< 0.0006	< 0.0006	< 0.0006	< 0.0006	< 0.0006
Molybdenum (Mo)	ug/L	< 0.2	< 0.2	0.3	0.3	0.3	0.3	< 0.2	< 0.2	< 0.2	< 0.2	--	< 0.2	0.4	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Nickel (Ni)	ug/L	2.4	1.2	1.2	1.1	2.6	1.3	1.6	5.5	0.6	1.4	--	1.2	1.2	1.5	0.8	2.9	1	1.2
Selenium (Se)	ug/L	< 0.2	0.3	< 0.2	< 0.2	0.2	< 0.2	0.2	< 0.2	0.3	< 0.2	--	0.2	< 0.2	< 0.2	< 0.2	0.2	< 0.2	< 0.2
Silicon (Si)	ug/L	810	2870	2120	2230	2630	3810	7530	1620	3180	1730	--	2760	3670	6530	2640	4070	4570	7560
Silver (Ag)	ug/L	***0.2***	< 0.1	***0.7***	***0.5***	***1.7***	< 0.1	< 0.1	0.1	< 0.1	***0.5***	--	< 0.1	< 0.1	< 0.1	< 0.1	***3.1***	< 0.1	< 0.1
Strontium (Sr)	ug/L	31	57	30	30	59	75	211	45	56	37	--	56	91	212	59	104	107	184
Sulphur (S)	ug/L	600	500	700	600	500	400	900	500	400	700	--	500	1000	2500	300	300	200	300
Thallium (Tl)	ug/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	--	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Tin (Sn)	ug/L	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	--	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Titanium (Ti)	ug/L	2	5	5	5	4	2	3	3	2	4	--	5	3	1	3	4	2	2
Uranium (U)	ug/L	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	--	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
Vanadium (V)	ug/L	< 1	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	--	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Zinc (Zn)	ug/L	7.5	27.4	14.9	10.2	9.6	5.5	5.7	6.8	21.5	14.3	--	26.6	5.2	9.1	3.9	2.7	4.3	9.4
Zirconium (Zr)	ug/L	0.5	0.4	2	1	0.4	0.5	1.1	2.7	< 0.2	1	--	0.3	0.4	< 0.2	0.2	< 0.2	< 0.2	< 0.2
Polycyclic Aromatic Hydrocarbons																			
Naphthalene	ug/L	< 0.1	--	--	--	< 0.13	< 0.1	< 0.1	< 0.1	--	--	< 0.1	--	< 0.1	< 0.1	--	< 0.1	< 0.1	< 0.1
Acenaphthylene	ug/L	< 0.1	--	--	--	< 0.13	< 0.1	< 0.1	< 0.1	--	--	< 0.1	--	< 0.1	< 0.1	--	< 0.1	< 0.1	< 0.1
Acenaphthene	ug/L	< 0.1	--	--	--	< 0.13	< 0.1	< 0.1	< 0.1	--	--	< 0.1	--	< 0.1	< 0.1	--	< 0.1	< 0.1	< 0.1
Fluorene	ug/L	< 0.05	--	--	--	< 0.063	< 0.05	0.05	< 0.05	--	--	< 0.05	--	< 0.05	< 0.05	--	< 0.05	< 0.05	< 0.05
Phenanthrene	ug/L	< 0.05	--	--	--	< 0.063	< 0.05	0.31	< 0.05	--	--	< 0.05	--	< 0.05	< 0.05	--	< 0.05	< 0.05	0.05
Anthracene	ug/L	< 0.01	--	--	--	< 0.013	< 0.01	***0.04***	< 0.01	--	--	< 0.01	--	< 0.01	< 0.01	--	< 0.01	< 0.01	0.01
Acridine	ug/L	< 0.2	--	--	--	< 0.25	< 0.2	< 0.2	< 0.2	--	--	< 0.2	--	< 0.2	< 0.2	--	< 0.2	< 0.2	< 0.2
Fluoranthene	ug/L	< 0.04	--	--	--	< 0.05	< 0.04	***0.36***	< 0.04	--	--	< 0.04	--	< 0.04	< 0.04	--	< 0.04	< 0.04	0.04
Pyrene	ug/L	< 0.02	--	--	--	< 0.025	< 0.02	***0.26***	< 0.02	--	--	< 0.02	--	< 0.02	< 0.02	--	< 0.02	< 0.02	***0.04***
Benz[a]anthracene	ug/L	< 0.01	--	--	--	< 0.06	< 0.01	***0.1***	< 0.01	--	--	< 0.05	--	< 0.01	< 0.01	--	< 0.05	< 0.01	***0.02***
Chrysene	ug/L	< 0.05	--	--	--	< 0.06	< 0.05	0.1	< 0.05	--	--	< 0.05	--	< 0.05	< 0.05	--	< 0.05	< 0.05	< 0.05
Benzo[b]fluoranthene	ug/L	< 0.1	--	--	--	< 0.1	< 0.1	0.13	< 0.1	--	--	< 0.0001	--	< 0.1	< 0.1	--	< 0.1	< 0.1	< 0.1
Benzo[k]fluoranthene	ug/L	< 0.05	--	--	--	< 0.06	< 0.1	< 0.05	< 0.05	--	--	< 0.05	--	< 0.1	< 0.05	--	< 0.05	< 0.1	< 0.05
Benzo[a]pyrene	ug/L	< 0.01	--	--	--	< 0.06	< 0.01	***0.06***	< 0.01	--	--	< 0.05	--	< 0.01	< 0.01	--	< 0.05	< 0.01	0.01
Indeno[1,2,3-cd]pyrene	ug/L	< 0.1	--	--	--	< 0.1	< 0.1	< 0.1	< 0.1	--	--	< 0.1	--	< 0.1	< 0.1	--	< 0.1	< 0.1	< 0.1
Dibenz[a,h]anthracene	ug/L	< 0.05	--	--	--	< 0.06	< 0.05	< 0.05	< 0.05	--	--	< 0.05	--	< 0.05	< 0.05	--	< 0.05	< 0.05	< 0.05
Quinoline	ug/L	< 0.2	--	--	--	< 0.25	< 0.2	< 0.2	< 0.2	--	--	< 0.2	--	< 0.2	< 0.2	--	< 0.2	< 0.2	< 0.2
Benzo[g,h,i]perylene	ug/L	< 0.05	--	--	--	< 0.063	< 0.05	< 0.05	< 0.05	--	--	< 0.05	--	< 0.05	< 0.05	--	< 0.05	< 0.05	< 0.05
CCME B(a)P Equivalent	ug/L	< 0.008	--	--	--	< 0.010	< 0.008	0.083	< 0.008	--	--	< 0.010	--	< 0.008	< 0.008	--	< 0.008	< 0.008	< 0.008

Notes:

--- - not analyzed
NS - not specified
^ - Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME, 2006
* - Alberta Environment Surface Water Quality Guidelines for use in Alberta (AENV, 1999)
CC - continuous concentration guideline, National Recommended Water Quality Criteria (USEPA, 2006
MC - maximum concentration guideline, National Recommended Water Quality Criteria (USEPA, 2006)
*** - National Recommended Water Quality Criteria (USEPA, 2006)
^^ - indicates value for Inorganic Mercury
1 - value if pH <6.5, Ca <4.0, DOC <2
2 - value if pH $\geq$6.5, Ca $\geq$4.0, DOC $\geq$2
3 - refer to CCME summary table for DO guideline breakdown
4 - refer to USEPA summary table for Ammonia criteria calculations
A - Acute aquatic life guideline
A A - 1 day minimum, acute guideline
a - value if pH>6.5, Ca>4.0, DOC>2
b - dependent on hardness value
C - Chronic Aquatic Life guideline
H - dependent on hardness value
*** - value denotes NO_2-N guideline concentration
Italics - indicates that values exceed specified guideline

Table 7A-3 Water Quality in the Leismer Lease

Sample Site		WCL6		WCL6			WCL7	WCL8				WCL9					WCL10				W L11			
Date	**Unit**	06-May-06	06-Aug-05	20-Aug-06	28-Sep-05	08-Feb-06	29-Sep-05	06-May-06	05-Aug-05	20-Aug-06	28-Sep-05	07-May-06	04-Aug-05	20-Aug-06	28-Sep-05	10-Feb-06	07-May-06	07-May-06	04-Aug-05	28-Sep-05	03-May-06	03-Aug-05	27-Sep-05	07-Feb-06
Field Parameters																								
Temperature	°C	6.6	14.1	15.0	3.7	0.7	6.1	8.5	14.1	15.7	4.8	10.3	16.7	16.1	4.9	0.0	11.2	--	16.1	5.2	5.8	16.3	7.5	0.0
pH		8.0	*9.2*	7.2	7.9	6.5	*9.6*	*6.2*	*9.3*	7.3	7.1	7.6	6.9	7.4	7.6	6.6	6.6	--	7.0	*9.6*	*6.0*	*9.4*	7.1	6.6
Conductivity (EC)	uS/cm	131	224	281	230	742	230	96	144	184	140	75	71	118	160	443	90	--	77	240	137	137	200	422
Dissolved oxygen (DO)	mg/L	14.0	8.7	8.3	10.4	*0.8*	15.3	10.0	8.9	8.8	12.4	12.1	8.7	9.9	11.1	*2.5*	11.4	--	9.0	7.0	10.6	9.8	16.6	5.8
Conventional Parameters																								
pH		--	--	8.1	8.1	7.6	--	--	--	8.0	8.1	--	7.7	7.9	8.1	7.8	--	--	7.8	8.1	--	7.8	8.1	7.8
Conductivity (EC)	uS/cm	--	--	224	224	724	--	--	--	148	157	--	76	94	179	454	--	--	82	185	--	95	202	460
Hardness ($CaCO_3$)	mg/L	--	--	94.0	120.0	300.0	--	--	--	61.0	86.0	--	43.0	42.0	79.0	230.0	--	--	46.0	82.0	--	50.0	87.0	220.0
Alkalinity ($CaCO_3$)	mg/L	--	--	121.0	125.0	392.0	--	--	--	77.5	85.5	--	36.9	46.4	92.5	241.0	--	--	40.4	97.9	--	46.1	106.0	239.0
Total Dissolved Solids	mg/L	--	--	118.0	128.0	421.0	--	--	--	74.0	85.0	--	46.0	49.0	93.0	249.0	--	--	50.0	98.0	--	56.0	107.0	254.0
Total Suspended Solids	mg/L	4.0	--	2.0	2.0	20.0	--	7.0	--	3.0	3.0	24.0	16.0	31.0	12.0	5.0	30.0	30.0	18.0	24.0	27.0	32.0	14.0	3.0
Turbidity	NTU	1.9	2.5	2.1	2.5	56.6	16.8	4.1	3.1	2.2	4.3	14.5	10.5	11.8	14.5	26.2	13.5	--	16.8	17.1	13.0	22.9	--	16.0
Major Ions																								
Carbonate (CO_3)	mg/L	--	--	< 0.5	< 0.5	< 0.5	--	--	--	< 0.5	< 0.5	--	< 0.5	< 0.5	< 0.5	< 0.5	--	--	< 0.5	< 0.5	--	< 0.5	< 0.5	< 0.5
Bicarbonate (HCO_3 ($CaCO_3$))	mg/L	--	--	148.0	153.0	478.0	--	--	--	94.6	104.0	--	45.0	56.7	113.0	295.0	--	--	49.3	119.0	--	56.3	129.0	292.0
Sodium (Na)	mg/L	--	--	8.1	9.1	49.6	--	--	--	1.3	2.1	--	1.1	1.5	2.6	8.6	--	--	1.3	3.3	--	1.7	5.0	14.2
Potassium (K)	mg/L	--	--	< 0.3	< 0.3	2.6	--	--	--	< 0.3	< 0.3	--	< 0.3	< 0.3	0.5	1.9	--	--	< 0.3	0.5	--	0.5	0.7	2.1
Calcium (Ca)	mg/L	--	--	25.3	32.1	79.9	--	--	--	16.9	23.5	--	12.2	12.0	22.8	65.4	--	--	12.9	23.5	--	13.9	24.6	61.5
Magnesium (Mg)	mg/L	--	--	7.4	9.0	23.6	--	--	--	4.4	6.5	--	3.0	2.9	5.4	16.0	--	--	3.3	5.6	--	3.7	6.2	15.7
Chloride (Cl)	mg/L	--	--	1.1	1.0	1.5	--	--	--	0.9	0.7	--	1.6	1.4	1.0	1.2	--	--	1.5	0.9	--	1.5	1.2	1.4
Sulphate (SO_4)	mg/L	--	--	2.5	1.1	24.7	--	--	--	3.0	< 0.5	--	5.0	2.4	2.7	9.5	--	--	6.0	3.1	--	5.7	4.3	13.7
Nutrients																								
Nitrite (NO_2-N)	mg/L	--	--	< 0.003	< 0.003	< 0.003	--	--	--	< 0.003	< 0.003	--	0.003	< 0.003	< 0.003	< 0.003	--	--	0.006	< 0.003	--	0.005	< 0.003	< 0.003
Nitrate (NO_3-N)	mg/L	--	--	0.004	0.004	< 0.003	--	--	--	0.011	< 0.003	--	0.017	0.035	0.059	0.139	--	--	0.034	0.059	--	0.088	0.048	0.325
Nitrate + nitrite (NO_3 + NO_2 -N)	mg/L	--	--	0.004	0.004	< 0.003	--	--	--	0.011	< 0.003	--	*0.020*	*0.035*	*0.059*	*0.139*	--	--	*0.040*	*0.059*	--	*0.093*	*0.048*	*0.325*
Nitrogen - Ammonia (NH_4-N)	mg/L	0.03	--	0.05	0.03	*1.88*	--	0.02	--	0.07	< 0.01	0.03	0.03	0.04	< 0.01	0.55	0.03	0.03	0.04	< 0.01	0.05	< 0.01	< 0.01	0.35
Nitrogen - Kjeldahl (TKN)	mg/L	0.84	--	1.02	0.77	2.63	--	0.79	--	0.65	0.61	0.96	0.80	0.83	0.64	1.10	1.01	0.82	0.80	0.86	0.77	0.56	0.79	0.94
Total nitrogen (TKN+NO_3 + NO_2)	mg/L	0.84	--	*1.02*	0.77	*2.63*	--	0.79	--	0.66	0.61	0.96	0.82	0.87	0.70	*1.24*	*1.01*	0.82	0.84	0.92	0.77	0.65	0.84	*1.27*
Phosphorus, total	mg/L	0.047	--	*0.068*	*0.062*	*0.442*	--	0.048	--	0.040	0.037	*0.128*	*0.128*	*0.100*	*0.116*	*0.082*	*0.125*	*0.115*	*0.111*	*0.114*	*0.113*	*0.152*	*0.116*	*0.105*
Total Metals																								
Aluminum (Al)	ug/L	27	--	19	19	37	--	*127*	--	47	24	*297*	*222*	*277*	*128*	63	*309*	*316*	*340*	*140*	*410*	*564*	*148*	34
Antimony (Sb)	ug/L	< 0.2	--	< 0.2	< 0.2	< 0.2	--	< 0.2	--	< 0.2	< 0.2	< 0.2	0.4	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	0.7	< 0.2	< 0.2	< 0.2
Arsenic (As)	ug/L	4.5	--	0.6	0.4	1.4	--	0.3	--	1	0.8	0.8	1.4	1.1	1.1	0.9	2.6	6.4	1.4	1.2	0.5	2.2	1.3	0.8
Barium (Ba)	ug/L	13.7	--	23.5	19	64.9	--	25.3	--	36.4	26.1	37.4	42.6	50.7	50.7	98.8	36.7	38.2	41.4	51.8	35.8	44.9	46.6	83.4
Beryllium (Be)	ug/L	< 0.2	--	< 0.2	< 0.2	< 0.2	--	< 0.2	--	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Boron (B)	ug/L	40	--	50	40	140	--	20	--	10	< 10	20	10	20	20	60	20	20	10	30	30	20	40	70
Cadmium (Cd)	ug/L	< 0.01	--	< 0.01	< 0.01	< 0.01	--	0.14	--	< 0.01	< 0.01	0.2	*0.27*	< 0.01	*0.03*	< 0.01	< 0.01	0.19	*0.27*	*0.03*	0.26	*0.05*	*0.03*	< 0.01
Chromium (Cr)	ug/L	1	--	4	< 1	< 1	--	1	--	4	< 1	2	1	6	< 1	< 1	1	2	2	< 1	2	2	< 1	< 1
Cobalt (Co)	ug/L	< 0.3	--	< 0.3	< 0.3	< 0.3	--	0.3	--	< 0.3	< 0.3	0.4	0.5	0.3	< 0.3	< 0.3	0.3	0.5	0.6	0.3	0.6	0.7	0.3	< 0.3
Copper (Cu)	ug/L	0.3	--	1	< 0.2	< 0.2	--	< 0.2	--	0.3	< 0.2	< 0.2	0.7	1.2	0.3	< 0.2	0.7	0.3	0.7	0.3	0.7	1	0.4	< 0.2
Iron (Fe)	ug/L	--	--	*460*	*400*	120	--	--	--	*570*	*780*	--	*1090*	*950*	*2320*	40	--	--	*830*	*2280*	--	*490*	*1870*	50
Lead (Pb)	ug/L	< 0.3	--	< 0.3	< 0.3	< 0.3	--	< 0.3	--	< 0.3	< 0.3	< 0.3	0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	0.4	< 0.3	< 0.3	0.6	< 0.3	< 0.3
Lithium (Li)	ug/L	< 4	--	8	11	44	--	5	--	< 4	< 4	< 4	< 4	< 4	5	14	< 4	5	< 4	7	6	< 4	10	16
Manganese (Mn)	ug/L	--	--	19	23	2040	--	--	--	32	103	--	5	7	35	506	--	--	7	39	--	< 4	19	310
Mercury (Hg)	ug/L	< 0.0006	< 0.0006	--	< 0.0006	< 0.0006	--	< 0.0006	< 0.0006	--	< 0.0006	< 0.0006	--	--	< 0.0006	< 0.0006	< 0.0006	< 0.0006	0.001	< 0.0006	--	--	< 0.0006	< 0.0006
Molybdenum (Mo)	ug/L	< 0.2	--	< 0.2	< 0.2	< 0.2	--	< 0.2	--	< 0.2	0.2	0.2	0.3	< 0.2	0.4	< 0.2	0.3	0.3	0.3	0.6	1	0.4	0.7	0.4
Nickel (Ni)	ug/L	0.7	--	1.2	1.1	1.7	--	1.8	--	1.1	1	2.2	2.4	1.6	1.2	1.6	1	2.5	2.6	1.4	9.3	2.9	1.5	1.7
Selenium (Se)	ug/L	< 0.2	--	0.2	< 0.2	< 0.2	--	< 0.2	--	0.2	< 0.2	< 0.2	0.2	0.2	< 0.2	< 0.2	< 0.2	< 0.2	0.3	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Silicon (Si)	ug/L	2010	--	3530	4500	9360	--	2210	--	3140	3520	2050	2420	2850	3870	6610	2160	2020	2860	3980	2940	3140	4600	6450
Silver (Ag)	ug/L	< 0.1	--	< 0.1	< 0.1	< 0.1	--	*0.4*	--	< 0.1	< 0.1	*0.5*	*3.2*	< 0.1	< 0.1	< 0.1	< 0.1	*0.6*	*4*	< 0.1	*0.5*	*2.2*	< 0.1	< 0.1
Strontium (Sr)	ug/L	63	--	130	122	371	--	44	--	88	83	39	48	57	98	218	46	43	50	106	80	61	125	247
Sulphur (S)	ug/L	1400	--	700	800	7200	--	400	--	400	300	700	500	500	1200	2900	900	800	600	1400	2000	800	1900	4000
Thallium (Tl)	ug/L	< 0.2	--	< 0.2	< 0.2	< 0.2	--	< 0.2	--	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Tin (Sn)	ug/L	< 1	--	< 1	< 1	< 1	--	< 1	--	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Titanium (Ti)	ug/L	1	--	2	2	4	--	4	--	2	1	8	7	6	3	2	6	8	9	4	12	13	4	2
Uranium (U)	ug/L	< 0.4	--	< 0.4	< 0.4	< 0.4	--	< 0.4	--	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
Vanadium (V)	ug/L	< 1	--	< 1	< 1	< 1	--	< 1	--	< 1	< 1	< 1	< 1	1	< 1	< 1	< 1	< 1	1	< 1	10	2	< 1	< 1
Zinc (Zn)	ug/L	5	--	16.9	3.4	14.1	--	11.6	--	16.7	6.2	12.6	17.7	21.8	6.4	13.3	4.8	13.8	13.9	24.8	19	5.9	11.3	7.8
Zirconium (Zr)	ug/L	0.2	--	< 0.2	< 0.2	< 0.2	--	< 1	--	< 0.2	< 0.2	< 1	0.7	0.2	0.4	< 0.2	0.5	< 1	0.9	0.5	4	0.7	0.6	< 0.2
Polycyclic Aromatic Hydrocarbons																								
Naphthalene	ug/L	--	< 0.1	--	< 0.1	< 0.1	--	--	< 0.1	--	< 0.1	--	< 0.1	--	< 0.1	< 0.1	--	--	--	< 0.1	--	--	< 0.1	< 0.1
Acenaphthylene	ug/L	--	< 0.1	--	< 0.1	< 0.1	--	--	< 0.1	--	< 0.1	--	< 0.1	--	< 0.1	< 0.1	--	--	--	< 0.1	--	--	< 0.1	< 0.1
Acenaphthene	ug/L	--	< 0.1	--	< 0.1	< 0.1	--	--	< 0.1	--	< 0.1	--	< 0.1	--	< 0.1	< 0.1	--	--	--	< 0.1	--	--	< 0.1	< 0.1
Fluorene	ug/L	--	< 0.05	--	< 0.05	< 0.05	--	--	< 0.05	--	< 0.05	--	< 0.05	--	< 0.05	< 0.05	--	--	--	< 0.05	--	--	< 0.05	< 0.05
Phenanthrene	ug/L	--	< 0.05	--	< 0.05	< 0.05	--	--	< 0.05	--	< 0.05	--	< 0.05	--	< 0.05	< 0.05	--	--	--	< 0.05	--	--	< 0.05	< 0.05
Anthracene	ug/L	--	< 0.01	--	< 0.01	< 0.01	--	--	< 0.01	--	< 0.01	--	< 0.01	--	< 0.01	< 0.01	--	--	--	< 0.01	--	--	< 0.01	< 0.01
Acridine	ug/L	--	< 0.2	--	< 0.2	< 0.2	--	--	< 0.2	--	< 0.2	--	< 0.2	--	< 0.2	< 0.2	--	--	--	< 0.2	--	--	< 0.2	< 0.2
Fluoranthene	ug/L	--	< 0.04	--	< 0.04	< 0.04	--	--	< 0.04	--	< 0.04	--	< 0.04	--	< 0.04	< 0.04	--	--	--	< 0.04	--	--	< 0.04	< 0.04
Pyrene	ug/L	--	< 0.02	--	< 0.02	< 0.02	--	--	< 0.02	--	< 0.02	--	< 0.02	--	< 0.02	< 0.02	--	--	--	< 0.02	--	--	< 0.02	0.02
Benz[a]anthracene	ug/L	--	< 0.05	--	< 0.01	< 0.01	--	--	< 0.05	--	< 0.01	--	< 0.05	--	< 0.01	< 0.01	--	--	--	< 0.01	--	--	< 0.01	*0.02*
Chrysene	ug/L	--	< 0.05	--	< 0.05	< 0.05	--	--	< 0.05	--	< 0.05	--	< 0.05	--	< 0.05	< 0.05	--	--	--	< 0.05	--	--	< 0.05	< 0.05
Benzo[b]fluoranthene	ug/L	--	< 0.1	--	< 0.1	< 0.1	--	--	< 0.1	--	< 0.1	--	< 0.1	--	< 0.1	< 0.1	--	--	--	< 0.1	--	--	< 0.1	< 0.1
Benzo[k]fluoranthene	ug/L	--	< 0.05	--	< 0.1	< 0.05	--	--	< 0.05	--	< 0.1	--	< 0.05	--	< 0.1	< 0.05	--	--	--	< 0.1	--	--	< 0.1	< 0.05
Benzo[a]pyrene	ug/L	--	< 0.05	--	< 0.01	< 0.01	--	--	< 0.05	--	< 0.01	--	< 0.05	--	< 0.01	< 0.01	--	--	--	< 0.01	--	--	< 0.01	< 0.01
Indeno[1,2,3-cd]pyrene	ug/L	--	< 0.1	--	< 0.1	< 0.1	--	--	< 0.1	--	< 0.1	--	< 0.1	--	< 0.1	< 0.1	--	--	--	< 0.1	--	--	< 0.1	< 0.1
Dibenz[a,h]anthracene	ug/L	--	< 0.05	--	< 0.05	< 0.05	--	--	< 0.05	--	< 0.05	--	< 0.05	--	< 0.05	< 0.05	--	--	--	< 0.05	--	--	< 0.05	< 0.05
Quinoline	ug/L	--	< 0.2	--	< 0.2	< 0.2	--	--	< 0.2	--	< 0.2	--	< 0.2	--	< 0.2	< 0.2	--	--	--	< 0.2	--	--	< 0.2	< 0.2
Benzo[g,h,i]perylene	ug/L	--	< 0.05	--	< 0.05	< 0.05	--	--	< 0.05	--	< 0.05	--	< 0.05	--	< 0.05	< 0.05	--	--	--	< 0.05	--	--	< 0.05	< 0.05
CCME B(a)P Equivalent	ug/L	--	< 0.00001	--	< 0.008	< 0.008	--	--	< 0.008	--	< 0.008	--	< 0.008	--	< 0.008	< 0.008	--	--	--	< 0.008	--	--	< 0.008	< 0.008

Notes:

--- - not analyzed
NS - not specified
^ - Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME, 2006)
* - Alberta Environment Surface Water Quality Guidelines for use in Alberta (AENV, 1999)
CC - continuous concentration guideline, National Recommended Water Quality Criteria (USEPA, 2006)
MC - maximum concentration guideline, National Recommended Water Quality Criteria (USEPA, 2006)
*** - National Recommended Water Quality Criteria (USEPA, 2006)
^^ - indicates value for Inorganic Mercury
1 - value if pH <6.5, Ca <4.0, DOC <2
2 - value if pH ≥6.5, Ca ≥4.0, DOC ≥2
3 - refer to CCME summary table for DO guideline breakdown
4 - refer to USEPA summary table for Ammonia criteria calculations
A - Acute aquatic life guideline
A A - 1 day minimum, acute guideline
a - value if pH>6.5, Ca>4.0, DOC>2
b - dependent on hardness value
C - Chronic Aquatic Life guideline
H - dependent on hardness value
*** - value denotes NO_2-N guideline concentration
Italics - indicates that values exceed specified guideline

Table 7A-3 Water Quality in the Leismer Lease

Sample Site		WCL12				WCL13			WCL14				LL2					LL3	
Date	**Unit**	07-May-06	04-Aug-05	28-Sep-05	11-Feb-06	03-May-06	20-Aug-06	07-Feb-06	07-May-06	08-Aug-05	08-Aug-05	30-Sep-05	04-Aug-05	04-Oct-05	04-Oct-05	10-Feb-06	07-May-06	19-Aug-06	10-May-06
Field Parameters																			
Temperature	°C	7.8	15.5	5.2	0.0	6.7	17.6	0.8	7.8	15.9	--	6.7	17.5	7.0	6.9	--	10.9	--	11.1
pH		***6.3***	6.7	***9.6***	6.8	6.9	7.6	6.7	***6.2***	***9.3***	--	7.7	6.8	***6.0***	***6.4***	--	7.2	8.2	***5.2***
Conductivity (EC)	uS/cm	93	94	310	326	91	123	314	--	159	--	170	156	160	160	--	179	140	89
Dissolved oxygen (DO)	mg/L	10.9	7.3	12.3	6.5	12.9	9.8	6.6	11.0	10.2	--	12.3	7.9	12.3	11.5	--	14.0	7.0	12.7
Conventional Parameters																			
pH		--	7.7	8.1	7.9	--	8.0	7.8	--	7.8	7.8	8.1	8.0	8.2	8.2	7.8	--	7.7	--
Conductivity (EC)	uS/cm	--	97	217	417	--	99	369	--	112	112	193	144	160	159	210	--	116	--
Hardness ($CaCO_3$)	mg/L	--	52.0	110.0	190.0	--	48.0	180.0	--	59.0	58.0	100.0	76.0	82.0	78.0	110.0	--	47.0	--
Alkalinity ($CaCO_3$)	mg/L	--	48.6	115.0	218.0	--	50.0	197.0	--	57.0	57.1	104.0	76.0	85.0	86.4	110.0	--	52.7	--
Total Dissolved Solids	mg/L	--	58.0	123.0	231.0	--	53.0	196.0	--	66.0	65.0	108.0	84.0	83.0	82.0	112.0	--	55.0	--
Total Suspended Solids	mg/L	26.0	40.0	5.0	3.0	21.0	4.0	3.0	36.0	21.0	21.0	10.0	1.0	7.0	7.0	3.0	1.0	23.0	7.0
Turbidity	NTU	7.9	13.6	10.1	17.2	5.8	2.8	18.9	15.7	21.3	--	--	3.6	2.5	2.9	1.4	3.2	12.7	--
Major Ions																			
Carbonate (CO_3)	mg/L	--	< 0.5	< 0.5	< 0.5	--	< 0.5	< 0.5	--	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	--	< 0.5	--
Bicarbonate (HCO_3 ($CaCO_3$))	mg/L	--	59.3	141.0	266.0	--	61.0	240.0	--	69.5	69.7	127.0	92.7	104.0	105.0	134.0	--	64.3	--
Sodium (Na)	mg/L	--	1.9	7.3	15.0	--	2.0	10.4	--	1.9	1.9	2.6	1.6	1.6	1.4	2.2	--	1.0	--
Potassium (K)	mg/L	--	0.7	1.1	2.4	--	< 0.3	2.2	--	0.6	0.5	1.1	0.5	0.5	0.4	0.9	--	< 0.3	--
Calcium (Ca)	mg/L	--	14.3	29.3	54.1	--	12.8	47.6	--	16.4	16.1	28.3	19.7	22.6	21.6	30.7	--	14.5	--
Magnesium (Mg)	mg/L	--	4.1	7.9	14.4	--	3.9	14.3	--	4.4	4.3	8.2	6.4	6.3	5.9	9.0	--	2.7	--
Chloride (Cl)	mg/L	--	1.4	1.2	1.5	--	1.4	1.6	--	1.5	1.1	1.0	1.4	0.9	0.8	1.6	--	0.8	--
Sulphate (SO_4)	mg/L	--	4.7	3.6	10.1	--	2.3	-0.5	--	4.6	4.6	1.2	8.1	< 0.5	< 0.5	0.6	--	4.0	--
Nutrients																			
Nitrite (NO_2-N)	mg/L	--	0.007	0.004	< 0.003	--	< 0.003	< 0.003	--	0.003	0.003	0.003	0.005	< 0.003	< 0.003	< 0.003	--	< 0.003	--
Nitrate (NO_3-N)	mg/L	--	0.036	0.117	0.441	--	0.034	0.317	--	0.048	0.052	0.051	0.027	< 0.003	< 0.003	0.015	--	0.005	--
Nitrate + nitrite (NO_3 + NO_2 -N)	mg/L	--	***0.043***	***0.121***	***0.441***	--	***0.034***	***0.317***	--	***0.051***	***0.055***	***0.054***	***0.032***	< 0.003	< 0.003	0.015	--	0.005	--
Nitrogen - Ammonia (NH_4-N)	mg/L	0.04	0.04	0.04	0.18	0.05	0.03	0.27	0.05	0.05	0.04	0.07	0.04	< 0.01	0.01	0.35	0.05	0.10	0.06
Nitrogen - Kjeldahl (TKN)	mg/L	0.96	0.96	0.65	0.66	0.84	0.77	0.86	1.04	0.95	0.92	0.88	0.64	0.94	0.92	1.47	1.05	1.58	0.71
Total nitrogen (TKN+NO_3 + NO_2)	mg/L	0.96	***1.00***	0.77	***1.10***	0.84	0.80	***1.18***	***1.04***	***1.00***	0.98	0.93	0.67	0.94	0.92	***1.49***	***1.05***	***1.59***	0.71
Phosphorus, total	mg/L	***0.158***	***0.258***	***0.135***	***0.184***	***0.067***	***0.065***	***0.067***	***0.170***	***0.184***	***0.187***	***0.219***	0.021	0.019	0.019	0.022	0.035	***0.165***	***0.063***
Total Metals																			
Aluminum (Al)	ug/L	***248***	***957***	58	17	***289***	88	47	***466***	***184***	***233***	***186***	16	9	9	7	11	96	16
Antimony (Sb)	ug/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Arsenic (As)	ug/L	0.8	2	1.8	1.4	< 0.2	0.8	0.2	1.2	3	3	3.4	0.2	0.4	0.4	< 0.2	< 0.2	1.6	< 0.2
Barium (Ba)	ug/L	36.6	51.8	49.7	68.9	28.8	33.1	61.2	42.9	49.9	50	34.5	20.5	21.4	21.3	24.3	24.8	68.3	35.5
Beryllium (Be)	ug/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Boron (B)	ug/L	20	20	40	70	20	20	50	20	20	20	20	10	10	10	20	20	70	20
Cadmium (Cd)	ug/L	< 0.01	***0.29***	0.02	< 0.01	0.01	< 0.01	< 0.01	< 0.01	***0.21***	***0.16***	***0.04***	***0.25***	0.01	< 0.01	< 0.01	0.2	***0.03***	0.11
Chromium (Cr)	ug/L	1	1	< 1	< 1	1	4	< 1	2	1	1	< 1	1	< 1	< 1	< 1	1	2	1
Cobalt (Co)	ug/L	0.3	0.8	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	0.4	0.8	0.8	0.7	< 0.3	< 0.3	< 0.3	< 0.3	0.4	< 0.3	< 0.3
Copper (Cu)	ug/L	0.7	1.4	0.3	0.3	1	0.5	< 0.2	0.8	0.7	1.3	0.4	3	0.6	0.7	< 0.2	< 0.2	1.2	< 0.2
Iron (Fe)	ug/L	--	***1200***	***2850***	***540***	--	***640***	120	--	***2160***	***2140***	***2740***	120	50	40	170	--	250	--
Lead (Pb)	ug/L	0.3	0.4	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	0.5	< 0.3	< 0.3	< 0.3	***5.8***	0.4	0.6	< 0.3	< 0.3	0.4	< 0.3
Lithium (Li)	ug/L	< 4	< 4	10	16	< 4	< 4	12	< 4	< 4	< 4	9	< 4	< 4	< 4	< 4	5	< 4	< 4
Manganese (Mn)	ug/L	--	56	114	252	--	16	188	--	63	57	565	< 4	< 4	< 4	67	--	8	--
Mercury (Hg)	ug/L	--	0.0019	< 0.0006	< 0.0006	< 0.0006	--	< 0.0006	< 0.0006	< 0.0006	< 0.0006	< 0.0006	--	< 0.0006	--	< 0.0006	< 0.0006	--	< 0.0006
Molybdenum (Mo)	ug/L	0.4	0.5	0.9	0.8	0.2	< 0.2	< 0.2	0.3	0.4	0.5	0.9	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	0.2	< 0.2
Nickel (Ni)	ug/L	1.1	3.1	1.5	1.3	1.1	1.1	1.3	1.3	2.9	2.8	2	2.5	0.9	0.9	< 0.5	3.4	1.2	1.8
Selenium (Se)	ug/L	< 0.2	0.4	< 0.2	< 0.2	< 0.2	0.2	< 0.2	< 0.2	0.2	0.2	< 0.2	0.2	< 0.2	< 0.2	< 0.2	< 0.2	0.3	< 0.2
Silicon (Si)	ug/L	2700	3500	4860	6830	2160	2430	4520	3010	2720	2740	4450	2310	2660	2640	3610	2760	3270	1710
Silver (Ag)	ug/L	< 0.1	***3.9***	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	***1.5***	***1.8***	< 0.1	***2.9***	< 0.1	< 0.1	< 0.1	***0.2***	***3.8***	***0.3***
Strontium (Sr)	ug/L	63	69	154	254	47	54	184	59	75	77	122	55	64	64	74	67	58	40
Sulphur (S)	ug/L	1200	1100	1600	3100	800	400	1300	1000	700	700	700	400	400	400	400	400	400	300
Thallium (Tl)	ug/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Tin (Sn)	ug/L	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Titanium (Ti)	ug/L	5	20	3	2	7	3	2	10	7	8	5	2	< 1	< 1	< 1	3	4	2
Uranium (U)	ug/L	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
Vanadium (V)	ug/L	< 1	1	< 1	< 1	< 1	< 1	< 1	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Zinc (Zn)	ug/L	6.2	17.4	20.6	9	5	27.8	12.1	5.7	10.7	10.5	3.3	11	8.5	8.3	12.4	3.1	***31.8***	4.6
Zirconium (Zr)	ug/L	0.5	1.3	0.5	< 0.2	1	< 0.2	< 0.2	0.6	0.3	0.4	0.6	0.7	< 0.2	< 0.2	< 0.2	1.2	0.8	0.6
Polycyclic Aromatic Hydrocarbons																			
Naphthalene	ug/L	--	--	< 0.1	< 0.1	--	--	< 0.1	--	< 0.1	< 0.1	< 0.1	< 0.11	< 0.1	< 0.1	< 0.1	--	--	--
Acenaphthylene	ug/L	--	--	< 0.1	< 0.1	--	--	< 0.1	--	< 0.1	< 0.1	< 0.1	< 0.11	< 0.1	< 0.1	< 0.1	--	--	--
Acenaphthene	ug/L	--	--	< 0.1	< 0.1	--	--	< 0.1	--	< 0.1	< 0.1	< 0.1	< 0.11	< 0.1	< 0.1	< 0.1	--	--	--
Fluorene	ug/L	--	--	< 0.05	< 0.05	--	--	< 0.05	--	< 0.05	< 0.05	< 0.05	< 0.056	< 0.05	< 0.05	< 0.05	--	--	--
Phenanthrene	ug/L	--	--	< 0.05	< 0.05	--	--	< 0.05	--	< 0.05	< 0.05	< 0.05	< 0.056	< 0.05	< 0.05	< 0.05	--	--	--
Anthracene	ug/L	--	--	< 0.01	< 0.01	--	--	< 0.01	--	< 0.01	< 0.01	< 0.01	< 0.011	< 0.01	< 0.01	< 0.01	--	--	--
Acridine	ug/L	--	--	< 0.2	< 0.2	--	--	< 0.2	--	< 0.2	< 0.2	< 0.2	< 0.22	< 0.2	< 0.2	< 0.2	--	--	--
Fluoranthene	ug/L	--	--	< 0.04	< 0.04	--	--	< 0.04	--	< 0.04	< 0.04	< 0.04	< 0.044	< 0.04	< 0.04	< 0.04	--	--	--
Pyrene	ug/L	--	--	< 0.02	< 0.02	--	--	< 0.02	--	< 0.02	< 0.02	< 0.02	< 0.022	< 0.02	< 0.02	< 0.02	--	--	--
Benz[a]anthracene	ug/L	--	--	< 0.01	< 0.01	--	--	< 0.01	--	< 0.05	< 0.05	< 0.01	< 0.06	< 0.01	< 0.01	< 0.01	--	--	--
Chrysene	ug/L	--	--	< 0.05	< 0.05	--	--	< 0.05	--	< 0.05	< 0.05	< 0.05	< 0.06	< 0.05	< 0.05	< 0.05	--	--	--
Benzo[b]fluoranthene	ug/L	--	--	< 0.1	< 0.1	--	--	< 0.1	--	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	--	--	--
Benzo[k]fluoranthene	ug/L	--	--	< 0.1	< 0.05	--	--	< 0.05	--	< 0.05	< 0.05	< 0.1	< 0.06	< 0.1	< 0.1	< 0.05	--	--	--
Benzo[a]pyrene	ug/L	--	--	< 0.01	< 0.01	--	--	< 0.01	--	< 0.05	< 0.05	< 0.01	< 0.06	< 0.01	< 0.01	< 0.01	--	--	--
Indeno[1,2,3-cd]pyrene	ug/L	--	--	< 0.1	< 0.1	--	--	< 0.1	--	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	--	--	--
Dibenz[a,h]anthracene	ug/L	--	--	< 0.05	< 0.05	--	--	< 0.05	--	< 0.05	< 0.05	< 0.05	< 0.06	< 0.05	< 0.05	< 0.05	--	--	--
Quinoline	ug/L	--	--	< 0.2	< 0.2	--	--	< 0.2	--	< 0.2	< 0.2	< 0.2	< 0.22	< 0.2	< 0.2	< 0.2	--	--	--
Benzo[g,h,i]perylene	ug/L	--	--	< 0.05	< 0.05	--	--	< 0.05	--	< 0.05	< 0.05	< 0.05	< 0.056	< 0.05	< 0.05	< 0.05	--	--	--
CCME B(a)P Equivalent	ug/L	--	--	< 0.008	< 0.008	--	--	< 0.008	--	< 0.008	< 0.008	< 0.008	< 0.009	< 0.008	< 0.008	< 0.008	--	--	--

Notes:

--- - not analyzed
NS - not specified
^ - Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME, 2006)
* - Alberta Environment Surface Water Quality Guidelines for use in Alberta (AENV, 1999)
CC - continuous concentration guideline, National Recommended Water Quality Criteria (USEPA, 2006)
MC - maximum concentration guideline, National Recommended Water Quality Criteria (USEPA, 2006)
*** - National Recommended Water Quality Criteria (USEPA, 2006)
^^ - indicates value for Inorganic Mercury
1 - value if pH <6.5, Ca <4.0, DOC <2
2 - value if pH ≥6.5, Ca ≥4.0, DOC ≥2
3 - refer to CCME summary table for DO guideline breakdown
4 - refer to USEPA summary table for Ammonia criteria calculations
A - Acute aquatic life guideline
AA - 1 day minimum, acute guideline
a - value if pH>6.5, Ca>4.0, DOC>2
b - dependent on hardness value
C - Chronic Aquatic Life guideline
H - dependent on hardness value
*** - value denotes NO_2-N guideline concentration
Italics - indicates that values exceed specified guideline

Table 7A-3 Water Quality in the Leismer Lease

Sample Site		LL4			LL4		LL5				AENV Freshwater Aquatic Life*	CCME Water Quality Guidelines - Freshwater^	EPA Freshwater Water Quality***
Date	Unit	08-Aug-05	19-Aug-06	04-Oct-05	10-Feb-06	07-May-06	04-Aug-05	04-Oct-05	10-Feb-06	10-May-06			
Field Parameters													
Temperature	°C	17.1	--	--	0.9	10.8	16.5	--	2.5	11.8	NS	NS	NS
pH		6.8	*8.9*	--	6.7	*5.6*	7.7	--	6.9	6.8	6.5-8.5	6.5-9.0	6.5-9^{CC}
Conductivity (EC)	uS/cm	73	80	--	298	71	280	--	395	223	NS	NS	NS
Dissolved oxygen (DO)	mg/L	8.7	7.0	--	6.0	12.5	8.2	--	5.0	11.1	5.0^{AA}	5.5-9.5^{3}	NS
Conventional Parameters													
pH		--	7.8	7.9	7.5	--	8.2	8.3	7.8	--	6.5-9	6.5-9.0	6.5-9^{CC}
Conductivity (EC)	uS/cm	--	82	104	400	--	251	279	399	--	NS	NS	NS
Hardness ($CaCO_3$)	mg/L	--	35.0	48.0	200.0	--	130.0	150.0	210.0	--	NS	NS	NS
Alkalinity ($CaCO_3$)	mg/L	--	37.4	51.7	214.0	--	136.0	156.0	214.0	--	NS	NS	20^{CC}
Total Dissolved Solids	mg/L	--	41.0	53.0	224.0	--	140.0	152.0	214.0	--	NS	NS	NS
Total Suspended Solids	mg/L	--	15.0	5.0	5.0	5.0	1.0	3.0	7.0	3.0	NS	NS	NS
Turbidity	NTU	10.6	10.9	9.7	28.1	8.6	3.4	1.4	9.7	--	NS	NS	NS
Major Ions													
Carbonate (CO_3)	mg/L	--	< 0.5	< 0.5	< 0.5	--	< 0.5	< 0.5	< 0.5	--	NS	NS	NS
Bicarbonate (HCO_3 ($CaCO_3$))	mg/L	--	45.6	63.1	261.0	--	166.0	190.0	261.0	--	NS	NS	NS
Sodium (Na)	mg/L	--	1.6	2.1	8.7	--	2.0	2.3	3.2	--	NS	NS	NS
Potassium (K)	mg/L	--	< 0.3	< 0.3	1.5	--	1.1	1.3	2.0	--	NS	NS	NS
Calcium (Ca)	mg/L	--	10.0	13.7	58.7	--	34.5	41.4	59.6	--	NS	NS	NS
Magnesium (Mg)	mg/L	--	2.4	3.4	13.7	--	10.0	11.0	15.0	--	NS	NS	NS
Chloride (Cl)	mg/L	--	1.4	0.7	2.8	--	1.3	0.5	1.9	--	230^{CC}	NS	860^{MC}/230^{CC}
Sulphate (SO_4)	mg/L	--	2.5	< 0.5	1.5	--	8.8	1.3	0.8	--	NS	NS	NS
Nutrients													
Nitrite (NO_2-N)	mg/L	--	< 0.003	< 0.003	< 0.003	--	0.007	< 0.003	< 0.003	--	0.018	0.018	NS
Nitrate (NO_3-N)	mg/L	--	0.005	< 0.003	0.027	--	0.035	< 0.003	< 0.003	--	NS	2.9	NS
Nitrate + nitrite (NO_3 + NO_2 -N)	mg/L	--	0.005	< 0.003	*0.027*	--	*0.042*	< 0.003	< 0.003	--	0.018***	NS	NS
Nitrogen - Ammonia (NH_4-N)	mg/L	--	0.03	0.03	0.49	0.03	0.04	0.03	0.35	0.03	1.37 to 2.20	0.015	NS^{4}
Nitrogen - Kjeldahl (TKN)	mg/L	--	1.32	0.81	2.10	0.75	0.48	0.74	1.36	0.82	NS	NS	NS
Total nitrogen (TKN+NO_3 + NO_2)	mg/L	--	*1.33*	0.81	*2.13*	0.75	0.52	0.74	*1.36*	0.82	1.0^{C}	NS	NS
Phosphorus, total	mg/L	--	*0.102*	*0.097*	*0.175*	*0.080*	0.016	0.021	*0.078*	0.028	0.05^{C}	NS	NS
Total Metals													
Aluminum (Al)	ug/L	--	54	48	38	51	9	10	9	22	5^^{1}/100^^{2}	100^{a}	750^{MC}/87^{CC}
Antimony (Sb)	ug/L	--	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	NS	NS	NS
Arsenic (As)	ug/L	--	1	1.1	0.8	0.3	0.3	0.4	0.2	6.4	5.0^	5	340^{MC}/150^{CC}
Barium (Ba)	ug/L	--	36.2	29.3	86.4	21.1	41.2	40.4	69.1	36.4	NS	NS	NS
Beryllium (Be)	ug/L	--	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	NS	NS	NS
Boron (B)	ug/L	--	40	10	40	20	10	10	10	20	NS	NS	NS
Cadmium (Cd)	ug/L	--	< 0.01	*0.04*	< 0.01	0.15	*0.31*	0.03	< 0.01	0.13	Hardness^{H}^	0.017^{b}	20^{MC,H}/0.25^{CC,H}
Chromium (Cr)	ug/L	--	1	< 1	< 1	1	1	< 1	< 1	1	8.9^	8.9	570^{MC,H}/74^{CC,H}
Cobalt (Co)	ug/L	--	< 0.3	< 0.3	0.6	< 0.3	0.4	< 0.3	< 0.3	0.5	NS	NS	NS
Copper (Cu)	ug/L	--	0.9	0.2	2	< 0.2	1	0.3	< 0.2	< 0.2	Hardness^{H}	2^{b}	13^{MC,H}/9^{CC,H}
Iron (Fe)	ug/L	--	*1080*	*2520*	*6400*	--	120	30	*970*	--	300	300	1000CC
Lead (Pb)	ug/L	--	0.8	< 0.3	< 0.3	< 0.3	1	0.5	< 0.3	< 0.3	Hardness^{H}^	2^{b}	65^{MC,H}/2.5^{CC,H}
Lithium (Li)	ug/L	--	< 4	6	15	4	< 4	5	5	< 4	NS	NS	NS
Manganese (Mn)	ug/L	--	30	34	1420	--	25	< 4	1060	--	NS	NS	NS
Mercury (Hg)	ug/L	< 0.0006	--	0.0044	< 0.0006	< 0.0006	< 0.0006	--	< 0.0006	< 0.0006	0.013^{A}/0.005^{C}	0.026^^	1.4^{MC,H}/0.77^{CC,H}
Molybdenum (Mo)	ug/L	--	< 0.2	0.4	< 0.2	0.2	0.3	0.4	< 0.2	0.3	73^	73	NS
Nickel (Ni)	ug/L	--	1.8	1.1	2.1	1.7	4.1	1.7	1.5	4.4	Hardness^{H}^	65^{b}	470^{MC,H}/52^{CC,H}
Selenium (Se)	ug/L	--	0.2	< 0.2	< 0.2	< 0.2	0.2	< 0.2	< 0.2	< 0.2	1.0^	1	5^{CC}
Silicon (Si)	ug/L	--	1790	2800	11000	1360	3280	2230	4230	2420	NS	NS	NS
Silver (Ag)	ug/L	--	*3.1*	< 0.1	< 0.1	*0.4*	*2.6*	< 0.1	< 0.1	0.1	0.1^	0.1	3.2^{MC,H}
Strontium (Sr)	ug/L	--	53	66	213	37	74	87	108	62	NS	NS	NS
Sulphur (S)	ug/L	--	500	400	1100	500	900	700	700	1300	NS	NS	NS
Thallium (Tl)	ug/L	--	0.6	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	0.8^	0.8	NS
Tin (Sn)	ug/L	--	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	NS	NS	NS
Titanium (Ti)	ug/L	--	2	2	2	3	4	1	< 1	3	NS	NS	NS
Uranium (U)	ug/L	--	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	NS	NS	NS
Vanadium (V)	ug/L	--	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	NS	NS	NS
Zinc (Zn)	ug/L	--	*35.4*	4.1	9.7	4.9	11.5	6.1	7.3	4.1	30^	30	120^{M,H}/120^{CC,H}
Zirconium (Zr)	ug/L	--	0.8	0.4	0.5	1.3	2.7	< 0.2	< 0.2	0.8	NS	NS	NS
Polycyclic Aromatic Hydrocarbons													
Naphthalene	ug/L	--	--	< 0.1	< 0.1	--	< 0.12	< 0.1	< 0.1	--	1.1^	1.1	NS
Acenaphthylene	ug/L	--	--	< 0.1	< 0.1	--	< 0.12	< 0.1	< 0.1	--	NS	NS	NS
Acenaphthene	ug/L	--	--	< 0.1	< 0.1	--	< 0.12	< 0.1	< 0.1	--	5.8^	5.8	NS
Fluorene	ug/L	--	--	< 0.05	< 0.05	--	< 0.061	< 0.05	< 0.05	--	3^	3	NS
Phenanthrene	ug/L	--	--	< 0.05	< 0.05	--	< 0.061	< 0.05	< 0.05	--	0.4^	0.4	NS
Anthracene	ug/L	--	--	< 0.01	< 0.01	--	< 0.012	< 0.01	< 0.01	--	0.012^	0.012	NS
Acridine	ug/L	--	--	< 0.2	< 0.2	--	< 0.24	< 0.2	< 0.2	--	4.4^	NS	NS
Fluoranthene	ug/L	--	--	< 0.04	< 0.04	--	< 0.049	< 0.04	< 0.04	--	0.04^	0.04	NS
Pyrene	ug/L	--	--	< 0.02	< 0.02	--	< 0.024	< 0.02	< 0.02	--	0.025^	0.025	NS
Benz[a]anthracene	ug/L	--	--	< 0.01	< 0.01	--	< 0.06	< 0.01	< 0.01	--	0.018^	0.018	NS
Chrysene	ug/L	--	--	< 0.05	< 0.05	--	< 0.06	< 0.05	< 0.05	--	NS	NS	NS
Benzo[b]fluoranthene	ug/L	--	--	< 0.1	< 0.1	--	< 0.1	< 0.1	< 0.1	--	NS	NS	NS
Benzo[k]fluoranthene	ug/L	--	--	< 0.1	< 0.05	--	< 0.06	< 0.1	< 0.05	--	NS	NS	NS
Benzo[a]pyrene	ug/L	--	--	< 0.01	< 0.01	--	< 0.06	< 0.01	< 0.01	--	0.015^	0.015	NS
Indeno[1,2,3-cd]pyrene	ug/L	--	--	< 0.1	< 0.1	--	< 0.1	< 0.1	< 0.1	--	NS	NS	NS
Dibenz[a,h]anthracene	ug/L	--	--	< 0.05	< 0.05	--	< 0.06	< 0.05	< 0.05	--	NS	NS	NS
Quinoline	ug/L	--	--	< 0.2	< 0.2	--	< 0.24	< 0.2	< 0.2	--	NS	NS	NS
Benzo[g,h,i]perylene	ug/L	--	--	< 0.05	< 0.05	--	< 0.061	< 0.05	< 0.05	--	NS	NS	NS
CCME B(a)P Equivalent	ug/L	--	--	< 0.008	< 0.008	--	< 0.010	< 0.008	< 0.008	--	NS	NS	NS

Notes:

--- - not analyzed
NS - not specified
^ - Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME, 2006)
* - Alberta Environment Surface Water Quality Guidelines for use in Alberta (AENV, 1999)
CC - continuous concentration guideline, National Recommended Water Quality Criteria (USEPA, 2006
MC - maximum concentration guideline, National Recommended Water Quality Criteria (USEPA, 2006)
*** - National Recommended Water Quality Criteria (USEPA, 2006)
^^ - indicates value for Inorganic Mercury
1 - value if pH <6.5, Ca <4.0, DOC <2
2 - value if pH $\geq$6.5, Ca $\geq$4.0, DOC $\geq$2
3 - refer to CCME summary table for DO guideline breakdown
4 - refer to USEPA summary table for Ammonia criteria calculations
A - Acute aquatic life guideline
A A - 1 day minimum, acute guideline
a - value if pH>6.5, Ca>4.0, DOC>2
b - dependent on hardness value
C - Chronic Aquatic Life guideline
H - dependent on hardness value
*** - value denotes NO_2-N guideline concentration
Italics - indicates that values exceed specified guideline

Appendix 7B Historical Water Quality in Waterbodies in the RSA

Table 7B-1 Water Quality Waterbodies in the Hangingtone and Horse River Basins

Parameter	Unit	Spring, Waterbodies (2001-2002)						Summer, Waterbodies (1987 and 2001)						Fall, Waterbodies (1998, 2000)						Winter, Waterbodies (2001, 2006)						AENV Freshwater Aquatic Life*	CCME Water Quality Guidelines - Freshwater^	EPA Freshwater Water Quality***
		Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N			
Field Parameters																												
Temperature	°C	6.6	8.1	7.3	7.0	7.7	2	16.9	18.2	17.9	17.4	18.0	3	5.1	13.7	13.1	8.1	13.4	6	0.7	0.8	0.8	0.7	0.8	2	NS	NS	NS
pH		4.1	7.2	5.6	4.9	6.4	3	4.5	7.5	5.9	4.5	6.5	5	5.3	7.8	7.6	5.8	7.8	6	4.7	7.0	5.9	4.9	6.9	4	6.5-8.5	6.5-9.0	$6.5\text{-}9^{CC}$
Conductivity (EC)	uS/cm	15	15	15	15	15	1	15	18	16	16	17	3	168	207	188	182	194	4	23	23	23	23	23	1	NS	NS	NS
Dissolved oxygen (DO)	mg/L	16.6	18.0	17.3	17.0	17.7	2	8.9	9.7	9.6	9.2	9.7	3	13.0	13.2	13.1	13.0	13.1	2	13.1	15.9	14.5	13.8	15.2	2	5.0AA	5.5-9.53	NS
Conventional Parameters																												
pH		6.8	7.1	6.9	6.9	7.0	2	4.3	7.3	6.8	6.7	7.1	9	6.3	7.9	7.3	6.6	7.6	8	6.2	6.6	6.4	6.4	6.5	4	6.5-9	6.5-9.0	$6.5\text{-}9^{CC}$
Conductivity (EC)	uS/cm	28	39	34	31	36	2	16	128	47	32	78	10	18	212	185	60	195	6	27	126	39	30	67	4	NS	NS	NS
Hardness ($CaCO_3$)	mg/L	6.0	17.0	11.5	8.8	14.3	2	5.9	66.4	18.8	10.2	30.0	10	7.0	112.0	73.0	20.2	93.3	6	10.0	66.0	13.5	10.8	28.5	4	NS	NS	NS
Alkalinity ($CaCO_3$)	mg/L	9.0	17.0	13.0	11.0	15.0	2	< 5.0	61.1	17.9	6.0	27.7	10	3.3	22.8	4.3	3.4	5.7	8	6.0	61.0	10.5	6.0	26.5	4	NS	NS	20^{CC}
Total Dissolved Solids	mg/L	11.0	18.5	14.8	12.9	16.6	2	< 10.0	81.3	23.0	13.0	32.0	9	< 10.0	112.0	97.0	26.5	106.0	6	< 10.0	64.0	15.8	11.4	29.5	4	NS	NS	NS
Total Suspended Solids	mg/L	< 3.0	12.0	4.0	2.6	6.8	4	< 3.0	9.0	3.0	2.6	4.5	4	< 3.0	6.0	2.8	1.5	4.0	6	< 3.0	2.0	1.8	1.5	2.0	4	NS	NS	NS
Turbidity	NTU	2.2	3.2	2.7	2.4	2.9	2	1.8	4.0	3.5	2.7	3.8	3	0.7	1.7	1.4	0.9	1.6	6	0.8	1.4	1.1	1.0	1.3	2	NS	NS	NS
Major Ions																												
Carbonate (CO_3)	mg/L	--	--	--	--	--	0	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	2	< 0.5	< 5.0	< 5.000	< 1.625	< 5.000	6	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	2	NS	NS	NS
Bicarbonate (HCO_3 ($CaCO_3$))	mg/L	11.0	21.0	16.0	13.5	18.5	2	< 5.0	74.5	21.6	7.4	33.8	10	4.0	135.0	54.9	6.7	103.5	8	7.3	75.0	13.2	7.3	33.0	4	NS	NS	NS
Sodium (Na)	mg/L	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	2	< 1.0	11.7	1.1	0.5	6.6	9	< 1.0	20.0	0.8	0.4	8.0	8	< 1.0	1.0	0.6	0.5	0.7	4	NS	NS	NS
Potassium (K)	mg/L	0.3	0.6	0.4	0.4	0.5	2	< 0.3	3.3	0.5	0.3	0.7	9	< 0.3	0.8	0.4	0.3	0.5	7	0.4	0.8	0.6	0.4	0.7	4	NS	NS	NS
Calcium (Ca)	mg/L	1.7	4.5	3.1	2.4	3.8	2	1.6	12.4	3.8	2.4	5.1	8	2.0	33.8	9.9	2.3	22.8	8	2.7	18.5	3.7	3.0	7.9	4	NS	NS	NS
Magnesium (Mg)	mg/L	0.5	1.4	1.0	0.7	1.2	2	0.5	5.5	2.0	0.9	2.8	10	0.5	9.5	3.3	0.7	5.6	8	0.9	4.8	1.1	0.9	2.1	4	NS	NS	NS
Chloride (Cl)	mg/L	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	2	< 1.0	6.8	0.9	0.6	1.3	9	< 1.0	6.0	0.4	0.2	1.6	8	< 1.0	1.9	1.0	0.9	1.2	4	230**	NS	$860^{MC}/230^{CC}$
Sulphate (SO_4)	mg/L	1.8	3.3	2.5	2.1	2.9	2	1.0	9.8	3.6	1.3	7.1	9	< 0.5	19.1	2.0	1.0	4.5	8	< 0.5	4.2	1.3	0.8	2.2	4	NS	NS	NS
Nutrients																												
Nitrite (NO_2-N)	mg/L	--	--	--	--	--	0	< 0.003	0.026	0.001	0.001	0.002	8	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	2	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	2	0.018	0.018	NS
Nitrate (NO_3 -N)	mg/L	--	--	--	--	--	0	< 0.004	0.151	0.002	0.002	0.020	7	< 0.003	0.011	0.006	0.004	0.009	2	0.005	0.032	0.019	0.012	0.025	2	NS	2.9	NS
Nitrate + nitrite (NO_3 + NO_2 -N)	mg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	1	< 0.10	0.18	0.01	0.003	0.030	9	< 0.100	0.011	0.031	0.001	0.050	8	0.01	0.20	0.03	0.02	0.12	3	0.018***	NS	NS
Nitrogen - Ammonia (NH_4-N)	mg/L	0.030	1.190	0.030	0.030	0.610	3	< 0.050	0.140	0.024	0.018	0.054	4	0.002	0.010	0.007	0.003	0.010	4	0.05	2.39	0.08	0.06	1.24	3	1.37 to 2.20	0.015	NS^{4}
Nitrogen - Kjeldahl (TKN)	mg/L	0.001	0.002	0.001	0.001	0.001	3	0.340	0.800	0.533	0.435	0.650	4	0.500	2.200	0.805	0.628	1.425	6	0.72	3.40	1.02	0.87	2.21	3	NS	NS	NS
Total nitrogen (TKN+NO_3 + NO_2)	mg/L	0.001	0.002	0.001	0.001	0.001	3	0.031	0.800	0.517	0.469	0.594	5	0.494	2.200	0.809	0.630	1.425	6	0.72	3.40	1.05	0.89	2.22	3	1.0C	NS	NS
Phosphorus, total	mg/L	0.019	0.043	0.022	0.021	0.033	3	0.013	0.028	0.015	0.014	0.019	4	0.002	0.080	0.038	0.010	0.058	8	0.013	0.030	0.023	0.018	0.027	3	0.05C	NS	NS
Total organic carbon	mg/L	9	12	11	10	11	2	12	16	14	13	15	2	--	--	--	--	--	0	13	25	19	16	22	2	NS	NS	NS
Dissolved organic carbon	mg/L	8	10	9	8	9	2	10	12	11	11	12	2	11	33	25	14	28	6	11	19	15	13	17	2	NS	NS	NS
Organics																												
Total Phenolics	mg/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	0.005C	NS	NS
Total recoverable hydrocarbons	mg/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	NS	NS	NS
Total Metals																												
Aluminum (Al)	ug/L	27	130	102	65	116	3	30	210	43	40	61	6	57	92	75	66	83	2	46	360	166	106	263	3	5^1/100^2	100a	$750^{MC}/87^{CC}$
Antimony (Sb)	ug/L	< 0.2	< 5.0	< 0.2	< 0.2	< 2.6	3	< 5.0	< 0.2	< 0.2	< 0.2	< 0.2	6	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	2	< 0.2	< 5.0	< 0.2	< 0.2	< 2.6	3	NS	NS	NS
Arsenic (As)	ug/L	< 0.2	< 1.0	< 0.2	< 0.2	< 0.6	3	< 1.0	0.5	0.3	0.2	0.5	7	0.6	0.7	0.7	0.6	0.7	2	< 0.2	< 1.0	< 0.2	< 0.2	< 0.6	3	5.0^	5	$340^{MC}/150^{CC}$
Barium (Ba)	ug/L	10.8	21.9	10.9	10.9	16.4	3	2.4	18.1	11.7	4.0	14.3	7	10.9	11.3	11.1	11.0	11.2	2	14.5	32.2	19.1	16.8	25.6	3	NS	NS	NS
Beryllium (Be)	ug/L	< 0.2	< 1.0	< 0.2	< 0.2	< 0.6	3	< 0.1	< 1.0	< 0.2	< 0.2	< 0.2	6	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	2	< 0.2	< 1.0	< 0.2	< 0.2	< 0.6	3	NS	NS	NS
Boron (B)	ug/L	< 10.0	5.0	5.0	5.0	5.0	3	< 10.0	19.4	7.5	5.0	13.8	6	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	2	< 10.0	20.0	8.0	6.5	14.0	3	NS	NS	NS
Cadmium (Cd)	ug/L	< 0.200	0.320	0.160	0.130	0.240	3	< 1.000	0.300	0.191	0.143	0.278	6	0.030	0.030	0.030	0.030	0.030	2	< 0.010	0.300	0.005	0.005	0.153	3	HardnessH^	0.017b	$20^{MC,H}/0.25^{CC,H}$
Chromium (Cr)	ug/L	< 0.8	1.0	1.0	0.7	1.0	3	< 1.0	1.0	0.5	0.3	0.5	7	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	2	< 1.0	2.3	0.8	0.6	1.5	3	8.9^	8.9	$570^{MC,H}/74^{CC,H}$
Cobalt (Co)	ug/L	< 0.3	< 0.2	< 0.3	< 0.3	< 0.3	3	< 1.0	0.1	0.1	0.1	0.2	7	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	2	< 0.3	0.4	0.2	0.2	0.3	3	NS	NS	NS
Copper (Cu)	ug/L	< 0.2	6.0	0.1	0.1	3.1	3	< 1.0	3.0	0.8	0.6	1.5	7	0.6	2.7	1.7	1.1	2.2	2	< 0.2	6.0	0.2	0.1	3.1	3	HardnessH	2b	$13^{MC,H}/9^{CC,H}$
Iron (Fe)	ug/L	273	273	273	273	273	1	40	650	117	47	178	6	60	400	230	145	315	2	110	540	249	180	395	3	300	300	1000CC
Lead (Pb)	ug/L	< 0.30	0.70	0.15	0.15	0.43	3	< 0.30	5.40	0.10	0.05	1.39	6	1.20	2.70	1.95	1.58	2.33	2	< 0.30	1.80	0.15	0.15	0.98	3	HardnessH^	2b	$65^{MC,H}/2.5^{CC,H}$
Lithium (Li)	ug/L	< 4.0	< 6.0	< 4.0	< 4.0	< 5.0	3	< 6.0	5.5	2.6	2.0	3.2	6	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	2	< 4.0	< 6.0	< 4.0	< 4.0	< 5.0	3	NS	NS	NS
Manganese (Mn)	ug/L	16.0	16.0	16.0	16.0	16.0	1	< 4.0	88.0	21.1	9.0	48.1	7	9.0	41.0	25.0	17.0	33.0	2	16.0	67.0	43.0	29.5	55.0	3	NS	NS	NS
Mercury (Hg)	ug/L	< 0.0006	< 0.2000	< 0.001	< 0.001	< 0.100	3	< 0.0009	0.2000	0.1000	0.0255	0.1000	7	< 0.0006	< 0.0006	< 0.0006	< 0.0006	< 0.0006	2	< 0.0006	< 0.2000	< 0.0006	< 0.0006	< 0.1003	3	0.013A/0.005C	0.026^^	$1.4^{MC,H}/0.77^{CC,H}$
Molybdenum (Mo)	ug/L	< 0.2	0.1	0.1	0.1	0.1	3	0.7	< 1.0	0.5	0.3	0.5	7	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	2	< 0.2	0.7	0.1	0.1	0.4	3	73^	73	NS
Nickel (Ni)	ug/L	< 0.5	1.0	0.6	0.4	0.8	3	< 1.0	2.1	0.3	0.3	0.4	7	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	2	< 0.5	3.6	0.3	0.3	1.9	3	HardnessH^	65b	$470^{MC,H}/52^{CC,H}$
Selenium (Se)	ug/L	< 0.2	< 0.8	< 0.2	< 0.2	< 0.5	3	< 0.8	0.3	0.3	0.2	0.3	4	< 0.2	0.4	0.3	0.2	0.3	2	< 0.8	0.4	0.4	0.3	0.4	3	1.0^	1	5^{CC}
Silicon (Si)	ug/L	50	220	135	93	178	2	180	250	215	198	233	2	150	250	200	175	225	2	100	245	173	136	209	2	NS	NS	NS
Silver (Ag)	ug/L	< 0.40	0.40	0.30	0.25	0.35	3	< 0.40	2.70	0.13	0.05	0.88	6	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	2	< 0.10	< 0.40	< 0.10	< 0.10	< 0.25	3	0.1^	0.1	$3.2^{MC,H}$
Strontium (Sr)	ug/L	6.1	9.0	8.0	7.1	8.5	3	7.2	21.6	10.1	8.5	18.4	6	9.0	10.0	9.5	9.3	9.8	2	10.0	19.9	12.0	11.0	16.0	3	NS	NS	NS
Sulphur (S)	ug/L	400	500	450	425	475	2	500	500	500	500	500	2	400	500	450	425	475	2	650	800	725	688	763	2	NS	NS	NS
Thallium (Tl)	ug/L	< 0.2	< 0.1	< 0.2	< 0.2	< 0.2	3	< 0.1	< 0.2	< 0.1	< 0.2	< 0.2	6	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	2	< 0.2	< 0.1	< 0.2	< 0.2	< 0.2	3	0.8^	0.8	NS
Tin (Sn)	ug/L	< 0.4	< 1.0	< 1.0	< 0.7	< 1.0	3	< 0.4	< 1.0	< 1.0	< 1.0	< 1.0	3	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	2	< 0.4	< 1.0	< 1.0	< 0.7	< 1.0	3	NS	NS	NS
Titanium (Ti)	ug/L	< 1.0	1.5	1.0	0.8	1.3	3	< 1.0	4.0	1.5	1.1	2.4	6	< 1.0	1.0	0.8	0.6	0.9	2	< 1.0	2.5	0.5	0.5	1.5	3	NS	NS	NS
Uranium (U)	ug/L	< 0.1	< 0.4	< 0.4	< 0.3	< 0.4	3	< 0.1	< 0.5	< 0.5	< 0.5	< 0.5	6	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	2	< 0.1	< 0.4	< 0.4	< 0.3	< 0.4	3	NS	NS	NS
Vanadium (V)	ug/L	< 1.0	0.5	0.5	0.5	0.5	3	< 2.0	0.4	0.4	0.2	0.5	7	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	2	< 1.0	1.2	0.5	0.5	0.9	3	NS	NS	NS
Zinc (Zn)	ug/L	6	29	12	9	20	3	2	45	5	4	24	7	6	21	13	10	17	2	23	31	28	26	30	3	30^	30	$120^{M,H}/120^{CC,H}$
Zirconium (Zr)	ug/L	2.4	9.2	5.8	4.1	7.5	2	< 0.2	< 1.0	< 1.0	< 1.0	< 1.0	5	0.2	0.3	0.3	0.2	0.3	2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	2	NS	NS	NS

Table 7B-1 Water Quality Waterbodies in the Hangingtone and Horse River Basins

Parameter	Unit	Spring, Waterbodies (2001-2002)						Summer, Waterbodies (1987 and 2001)						Fall, Waterbodies (1998, 2000)						Winter, Waterbodies (2001, 2006)						AENV Freshwater Aquatic Life*	CCME Water Quality Guidelines - Freshwater^	EPA Freshwater Water Quality***
		Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N			
Dissolved Metals																												
Aluminum	ug/L	--	--	--	--	--	0	< 5	57	17	9	24	5	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**$750^{MC}/87^{CC}$**
Antimony	ug/L	--	--	--	--	--	0	< 0.2	5.5	0.1	0.1	0.1	5	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Arsenic	ug/L	--	--	--	--	--	0	< 0.2	0.6	0.4	0.1	0.5	4	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**$340^{MC}/150^{CC}$**
Barium	ug/L	--	--	--	--	--	0	1.1	19.2	5.8	2.9	15.4	5	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Beryllium	ug/L	--	--	--	--	--	0	< 0.1	< 0.5	< 0.1	< 0.1	< 0.2	5	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Bismuth	ug/L	--	--	--	--	--	0	< 0.5	< 7.0	< 0.5	< 0.5	< 2.1	4	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	
Boron	ug/L	--	--	--	--	--	0	11.5	72.2	35.8	14.8	40.0	5	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Cadmium	ug/L	--	--	--	--	--	0	< 0.500	0.017	0.017	0.005	0.100	5	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**$20^{MC,H}/0.25^{CC,H}$**
Chromium	ug/L	--	--	--	--	--	0	< 0.5	< 1.0	< 0.5	< 0.5	< 0.8	5	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**$570^{MC,H}/74^{CC,H}$**
Cobalt	ug/L	--	--	--	--	--	0	< 0.1	< 0.7	< 0.1	< 0.1	< 0.3	5	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Copper	ug/L	--	--	--	--	--	0	< 1.0	2.6	0.5	0.5	1.0	5	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**$13^{MC,H}/9^{CC,H}$**
Iron	ug/L	--	--	--	--	--	0	4	1010	140	85	495	5	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**1000CC**
Lead	ug/L	--	--	--	--	--	0	< 0.1	< 2.0	< 0.1	< 0.1	< 0.3	5	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**$65^{MC,H}/2.5^{CC,H}$**
Lithium	ug/L	--	--	--	--	--	0	< 7.0	12.6	3.5	3.0	4.9	5	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Manganese	ug/L	--	--	--	--	--	0	< 4.0	28.2	8.1	4.0	9.7	5	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Mercury	ug/L	--	--	--	--	--	0	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	3	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**$1.4^{MC,H}/0.77^{CC,H}$**
Molybdenum	ug/L	--	--	--	--	--	0	< 0.2	< 1.0	< 1.0	< 1.0	< 1.0	5	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Nickel	ug/L	--	--	--	--	--	0	< 0.5	1.7	0.3	0.3	0.6	4	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**$470^{MC,H}/52^{CC,H}$**
Silver	ug/L	--	--	--	--	--	0	< 1.00	0.20	0.05	0.05	0.20	5	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**$3.2^{MC,H}$**
Strontium	ug/L	--	--	--	--	--	0	10.7	98.9	21.6	20.7	30.0	5	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Sulphur	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Thallium	ug/L	--	--	--	--	--	0	< 1.0	< 4.0	< 1.0	< 1.0	< 1.0	5	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Tin	ug/L	--	--	--	--	--	0	< 0.5	< 3.0	< 0.5	< 0.5	< 1.0	5	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Titanium	ug/L	--	--	--	--	--	0	< 0.4	2.8	1.5	0.9	2.2	2	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Vanadium	ug/L	--	--	--	--	--	0	< 1.0	0.3	0.3	0.2	0.5	5	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Zinc	ug/L	--	--	--	--	--	0	1	2	2	1	2	5	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**$120^{M,H}/120^{CC,H}$**
Polycyclic Aromatic Hydrocarbons																												
Naphthalene	ug/L	--	--	--	--	--	0	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	2	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	2	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	2	**1.1^**	**1.1**	**NS**
Acenaphthylene	ug/L	--	--	--	--	--	0	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	2	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	2	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	2	**NS**	**NS**	**NS**
Acenaphthene	ug/L	--	--	--	--	--	0	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	2	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	2	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	2	**5.8^**	**5.8**	**NS**
Fluorene	ug/L	--	--	--	--	--	0	< 0.05	< 0.052	< 0.051	< 0.0505	< 0.0515	2	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	2	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	2	**3^**	**3**	**NS**
Phenanthrene	ug/L	--	--	--	--	--	0	< 0.05	< 0.052	< 0.051	< 0.0505	< 0.0515	2	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	2	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	2	**0.4^**	**0.4**	**NS**
Anthracene	ug/L	--	--	--	--	--	0	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	2	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	2	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	2	**0.012^**	**0.012**	**NS**
Acridine	ug/L	--	--	--	--	--	0	< 0.2	< 0.21	< 0.205	< 0.2025	< 0.2075	2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	2	**4.4^**	**NS**	**NS**
Fluoranthene	ug/L	--	--	--	--	--	0	< 0.04	< 0.042	< 0.041	< 0.0405	< 0.0415	2	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	2	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	2	**0.04^**	**0.04**	**NS**
Pyrene	ug/L	--	--	--	--	--	0	< 0.02	< 0.021	< 0.0205	< 0.0203	< 0.02075	2	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	2	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	2	**0.025^**	**0.025**	**NS**
Benz[a]anthracene	ug/L	--	--	--	--	--	0	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	2	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	2	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	2	**0.018^**	**0.018**	**NS**
Chrysene	ug/L	--	--	--	--	--	0	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	2	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	2	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	2	**NS**	**NS**	**NS**
Benzo[b]fluoranthene	ug/L	--	--	--	--	--	0	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	2	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	2	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	2	**NS**	**NS**	**NS**
Benzo[k]fluoranthene	ug/L	--	--	--	--	--	0	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	2	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	2	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	2	**NS**	**NS**	**NS**
Benzo[a]pyrene	ug/L	--	--	--	--	--	0	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	2	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	2	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	2	**0.015^**	**0.015**	**NS**
Indeno[1,2,3-cd]pyrene	ug/L	--	--	--	--	--	0	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	2	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	2	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	2	**NS**	**NS**	**NS**
Dibenz[a,h]anthracene	ug/L	--	--	--	--	--	0	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	2	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	2	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	2	**NS**	**NS**	**NS**
Quinoline	ug/L	--	--	--	--	--	0	< 0.2	< 0.21	< 0.205	< 0.2025	< 0.2075	2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	2	**NS**	**NS**	**NS**
Benzo[g,h,i]perylene	ug/L	--	--	--	--	--	0	< 0.05	< 0.052	< 0.051	< 0.0505	< 0.0515	2	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	2	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	2	**NS**	**NS**	**NS**
CCME BP Equivalent	ug/L	--	--	--	--	--	0	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	2	< 0.0078	< 0.0078	< 0.0078	< 0.0078	< 0.0078	2	< 0.0078	< 0.0078	< 0.0078	< 0.0078	< 0.0078	2	**NS**	**NS**	**NS**

Notes:

--- - not analyzed
NS - not specified
^ - Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME, 2006)
* - Alberta Environment Surface Water Quality Guidelines for use in Alberta (AENV, 1999)
CC - continuous concentration guideline, National Recommended Water Quality Criteria (USEPA, 2006
MC - maximum concentration guideline, National Recommended Water Quality Criteria (USEPA, 2006
*** - National Recommended Water Quality Criteria (USEPA, 2006)
^^ - indicates value for Inorganic Mercury
1 - value if pH <6.5, Ca <4.0, DOC <2
2 - value if pH ≥6.5, Ca ≥4.0, DOC ≥2
3 - refer to CCME summary table for DO guideline breakdowr
4 - refer to USEPA summary table for Ammonia criteria calculations
A - Acute aquatic life guideline
AA - 1 day minimum, acute guideline
a - value if pH>6.5, Ca>4.0, DOC>2
b - dependent on hardness value
C - Chronic Aquatic Life guideline
H - dependent on hardness value
*** - value denotes NO_2-N guideline concentration
Italics - indicates that values exceed specified guideline

Appendix 7B Historical Water Quality in Waterbodies in the RSA

Table 7B-2 Water Quality in Waterbodies the House River Basin

Parameter	Unit	Spring 2006	Summer 2006	Fall, waterbodies (1998)						AENV Freshwater Aquatic Life*	CCME Water Quality Guidelines - Freshwater^	EPA Freshwater Water Quality***
				Min	Max	Median	25th percentile	75th percentile	N			
Field Parameters												
Temperature	°C	11.1	--	--	--	--	--	--	0	NS	NS	NS
pH		5.2	8.2	--	--	--	--	--	0	6.5-8.5	6.5-9.0	$6.5\text{-}9^{CC}$
Conductivity (EC)	uS/cm	89	140	--	--	--	--	--	0	NS	NS	NS
Dissolved oxygen (DO)	mg/L	12.7	7.0	--	--	--	--	--	0	5.0AA	5.5-9.53	NS
Conventional Parameters												
pH		--	7.7	6.9	8.8	7.3	7.1	7.9	15	6.5-9	6.5-9.0	$6.5\text{-}9^{CC}$
Conductivity (EC)	uS/cm	--	116	--	--	--	--	--	0	NS	NS	NS
Hardness ($CaCO_3$)	mg/L	--	47.0	--	--	--	--	--	0	NS	NS	NS
Alkalinity ($CaCO_3$)	mg/L	--	52.7	10.3	97.7	29.0	15.2	48.2	15	NS	NS	20^{CC}
Total Dissolved Solids	mg/L	--	55.0	--	--	--	--	--	0	NS	NS	NS
Total Suspended Solids	mg/L	7	23.0	--	--	--	--	--	0	NS	NS	NS
Turbidity	NTU	--	12.7	0.7	24.0	1.6	1.3	4.9	15	NS	NS	NS
Major Ions												
Carbonate (CO_3)	mg/L	--	< 0.5	5.8	9.8	7.8	6.8	8.8	2	NS	NS	NS
Bicarbonate (HCO_3 ($CaCO_3$))	mg/L	--	64.3	12.5	106.6	35.3	18.6	58.7	15	NS	NS	NS
Sodium (Na)	mg/L	--	1.0	0.7	15.4	3.7	1.0	4.4	15	NS	NS	NS
Potassium (K)	mg/L	--	< 0.3	0.2	1.2	0.9	0.5	1.0	15	NS	NS	NS
Calcium (Ca)	mg/L	--	14.5	2.9	30.3	9.9	5.6	16.3	15	NS	NS	NS
Magnesium (Mg)	mg/L	--	2.7	1.2	7.1	2.5	1.4	3.7	15	NS	NS	NS
Chloride (Cl)	mg/L	--	0.8	0.01	10.7	0.4	0.2	2.1	14	230**	NS	$860^{MC}/230^{CC}$
Sulphate (SO_4)	mg/L	--	4.0	0.3	3.5	1.3	0.5	3.2	15	NS	NS	NS
Nutrients												
Nitrite (NO_2-N)	mg/L	--	< 0.003	--	--	--	--	--	0	0.018	0.018	NS
Nitrate (NO_3 -N)	mg/L	--	0.005	--	--	--	--	--	0	NS	2.9	NS
Nitrate + nitrite (NO_3 + NO_2 -N)	mg/L	--	0.01	0.0002	0.61	0.002	0.001	0.004	14	0.018***	NS	NS
Nitrogen - Ammonia (NH_4-N)	mg/L	0.06	0.10	0.001	0.800	0.008	0.002	0.103	14	1.37 to 2.20	0.015	NS[4]
Nitrogen - Kjeldahl (TKN)	mg/L	0.71	1.58	--	--	--	--	--	0	NS	NS	NS
Total nitrogen (TKN+NO_3 + NO_2)	mg/L	0.71	1.58	--	--	--	--	--	0	1.0C	NS	NS
Phosphorus, total	mg/L	0.063	0.165	0.019	0.156	0.046	0.025	0.077	15	0.05C	NS	NS
Total organic carbon	mg/L	--	--	--	--	--	--	--	0	NS	NS	NS
Dissolved organic carbon	mg/L	--	--	10	30	13	11	16	15	NS	NS	NS
Organics												
Total Phenolics	mg/L	--	--	--	--	--	--	--	0	0.005C	NS	NS
Total recoverable hydrocarbons	mg/L	--	--	--	--	--	--	--	0	NS	NS	NS
Total Metals												
Aluminum (Al)	ug/L	16	96	--	--	--	--	--	0	5^1/100^2	100a	$750^{MC}/87^{CC}$
Antimony (Sb)	ug/L	< 0.2	< 0.2	--	--	--	--	--	0	NS	NS	NS
Arsenic (As)	ug/L	< 0.2	1.6	--	--	--	--	--	0	5.0^	5	$340^{MC}/150^{CC}$
Barium (Ba)	ug/L	35.5	68.3	--	--	--	--	--	0	NS	NS	NS
Beryllium (Be)	ug/L	< 0.2	< 0.2	--	--	--	--	--	0	NS	NS	NS
Boron (B)	ug/L	20	70	--	--	--	--	--	0	NS	NS	NS
Cadmium (Cd)	ug/L	0.110	0.030	--	--	--	--	--	0	HardnessH^	0.017b	$20^{MC,H}/0.25^{CC,H}$
Chromium (Cr)	ug/L	1.0	2.0	--	--	--	--	--	0	8.9^	8.9	$570^{MC,H}/74^{CC,H}$
Cobalt (Co)	ug/L	< 0.3	< 0.3	--	--	--	--	--	0	NS	NS	NS
Copper (Cu)	ug/L	< 0.2	1.2	--	--	--	--	--	0	HardnessH	2b	$13^{MC,H}/9^{CC,H}$
Iron (Fe)	ug/L	--	250	--	--	--	--	--	0	300	300	1000CC
Lead (Pb)	ug/L	< 0.3	0.40	--	--	--	--	--	0	HardnessH^	2b	$65^{MC,H}/2.5^{CC,H}$
Lithium (Li)	ug/L	< 4	< 4.0	--	--	--	--	--	0	NS	NS	NS
Manganese (Mn)	ug/L	--	8.0	--	--	--	--	--	0	NS	NS	NS
Mercury (Hg)	ug/L	< 0.0006	--	--	--	--	--	--	0	0.013A/0.005C	0.026^^	$1.4^{MC,H}/0.77^{CC,H}$
Molybdenum (Mo)	ug/L	< 0.2	0.2	--	--	--	--	--	0	73^	73	NS
Nickel (Ni)	ug/L	1.8	1.2	--	--	--	--	--	0	HardnessH^	65b	$470^{MC,H}/52^{CC,H}$
Selenium (Se)	ug/L	< 0.2	0.3	--	--	--	--	--	0	1.0^	1	5^{CC}
Silicon (Si)	ug/L	1710	3270	--	--	--	--	--	0	NS	NS	NS
Silver (Ag)	ug/L	0.300	3.80	--	--	--	--	--	0	0.1^	0.1	$3.2^{MC,H}$
Strontium (Sr)	ug/L	40	58	--	--	--	--	--	0	NS	NS	NS
Sulphur (S)	ug/L	300	400	--	--	--	--	--	0	NS	NS	NS
Thallium (Tl)	ug/L	< 0.2	< 0.2	--	--	--	--	--	0	0.8^	0.8	NS
Tin (Sn)	ug/L	< 1.0	< 1.0	--	--	--	--	--	0	NS	NS	NS
Titanium (Ti)	ug/L	2.0	4.0	--	--	--	--	--	0	NS	NS	NS
Uranium (U)	ug/L	< 0.4	< 0.4	--	--	--	--	--	0	NS	NS	NS
Vanadium (V)	ug/L	< 1.0	< 1.0	--	--	--	--	--	0	NS	NS	NS
Zinc (Zn)	ug/L	4.6	32	--	--	--	--	--	0	30^	30	$120^{M,H}/120^{CC,H}$
Zirconium (Zr)	ug/L	0.6	0.8	--	--	--	--	--	0	NS	NS	NS

Table 7B-2 Water Quality in Waterbodies the House River Basin

Parameter	Unit	Spring 2006	Summer 2006	Fall, waterbodies (1998)						AENV Freshwater Aquatic Life*	CCME Water Quality Guidelines - Freshwater^	EPA Freshwater Water Quality***
				Min	Max	Median	25th percentile	75th percentile	N			
Dissolved Metals												
Aluminum	ug/L	--	--	--	--	--	--	--	0	NS	NS	$750^{MC}/87^{CC}$
Antimony	ug/L	--	--	--	--	--	--	--	0	NS	NS	NS
Arsenic	ug/L	--	--	--	--	--	--	--	0	NS	NS	$340^{MC}/150^{CC}$
Barium	ug/L	--	--	--	--	--	--	--	0	NS	NS	NS
Beryllium	ug/L	--	--	--	--	--	--	--	0	NS	NS	NS
Bismuth	ug/L	--	--	--	--	--	--	--	0	NS	NS	
Boron	ug/L	--	--	--	--	--	--	--	0	NS	NS	NS
Cadmium	ug/L	--	--	--	--	--	--	--	0	NS	NS	$20^{MC,H}/0.25^{CC,H}$
Chromium	ug/L	--	--	--	--	--	--	--	0	NS	NS	$570^{MC,H}/74^{CC,H}$
Cobalt	ug/L	--	--	--	--	--	--	--	0	NS	NS	NS
Copper	ug/L	--	--	--	--	--	--	--	0	NS	NS	$13^{MC,H}/9^{CC,H}$
Iron	ug/L	--	--	--	--	--	--	--	0	NS	NS	1000CC
Lead	ug/L	--	--	--	--	--	--	--	0	NS	NS	$65^{MC,H}/2.5^{CC,H}$
Lithium	ug/L	--	--	--	--	--	--	--	0	NS	NS	NS
Manganese	ug/L	--	--	--	--	--	--	--	0	NS	NS	NS
Mercury	ug/L	--	--	--	--	--	--	--	0	NS	NS	$1.4^{MC,H}/0.77^{CC,H}$
Molybdenum	ug/L	--	--	--	--	--	--	--	0	NS	NS	NS
Nickel	ug/L	--	--	--	--	--	--	--	0	NS	NS	$470^{MC,H}/52^{CC,H}$
Silver	ug/L	--	--	--	--	--	--	--	0	NS	NS	$3.2^{MC,H}$
Strontium	ug/L	--	--	--	--	--	--	--	0	NS	NS	NS
Sulphur	ug/L	--	--	--	--	--	--	--	0	NS	NS	NS
Thallium	ug/L	--	--	--	--	--	--	--	0	NS	NS	NS
Tin	ug/L	--	--	--	--	--	--	--	0	NS	NS	NS
Titanium	ug/L	--	--	--	--	--	--	--	0	NS	NS	NS
Vanadium	ug/L	--	--	--	--	--	--	--	0	NS	NS	NS
Zinc	ug/L	--	--	--	--	--	--	--	0	NS	NS	$120^{M,H}/120^{CC,H}$
Polycyclic Aromatic Hydrocarbons												
Naphthalene	ug/L	--	--	--	--	--	--	--	0	1.1^	1.1	NS
Acenaphthylene	ug/L	--	--	--	--	--	--	--	0	NS	NS	NS
Acenaphthene	ug/L	--	--	--	--	--	--	--	0	5.8^	5.8	NS
Fluorene	ug/L	--	--	--	--	--	--	--	0	3^	3	NS
Phenanthrene	ug/L	--	--	--	--	--	--	--	0	0.4^	0.4	NS
Anthracene	ug/L	--	--	--	--	--	--	--	0	0.012^	0.012	NS
Acridine	ug/L	--	--	--	--	--	--	--	0	4.4^	NS	NS
Fluoranthene	ug/L	--	--	--	--	--	--	--	0	0.04^	0.04	NS
Pyrene	ug/L	--	--	--	--	--	--	--	0	0.025^	0.025	NS
Benz[a]anthracene	ug/L	--	--	--	--	--	--	--	0	0.018^	0.018	NS
Chrysene	ug/L	--	--	--	--	--	--	--	0	NS	NS	NS
Benzo[b]fluoranthene	ug/L	--	--	--	--	--	--	--	0	NS	NS	NS
Benzo[k]fluoranthene	ug/L	--	--	--	--	--	--	--	0	NS	NS	NS
Benzo[a]pyrene	ug/L	--	--	--	--	--	--	--	0	0.015^	0.015	NS
Indeno[1,2,3-cd]pyrene	ug/L	--	--	--	--	--	--	--	0	NS	NS	NS
Dibenz[a,h]anthracene	ug/L	--	--	--	--	--	--	--	0	NS	NS	NS
Quinoline	ug/L	--	--	--	--	--	--	--	0	NS	NS	NS
Benzo[g,h,i]perylene	ug/L	--	--	--	--	--	--	--	0	NS	NS	NS
CCME B(a)P Equivalent	ug/L	--	--	--	--	--	--	--	0	NS	NS	NS

Notes:

--- - not analyzed
NS - not specified
^ - Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME, 2006)
* - Alberta Environment Surface Water Quality Guidelines for use in Alberta (AENV, 1999)
CC - continuous concentration guideline, National Recommended Water Quality Criteria (USEPA, 2006
MC - maximum concentration guideline, National Recommended Water Quality Criteria (USEPA, 2006)
*** - National Recommended Water Quality Criteria (USEPA, 2006)
^^ - indicates value for Inorganic Mercury
1 - value if pH <6.5, Ca <4.0, DOC <2
2 - value if pH ≥6.5, Ca ≥4.0, DOC ≥2
3 - refer to CCME summary table for DO guideline breakdown
4 - refer to USEPA summary table for Ammonia criteria calculations
A - Acute aquatic life guideline
A A - 1 day minimum, acute guideline
a - value if pH>6.5, Ca>4.0, DOC>2
b - dependent on hardness value
C - Chronic Aquatic Life guideline
H - dependent on hardness value
*** - value denotes NO_2-N guideline concentration
Italics - indicates that values exceed specified guideline

Appendix 7B Historical Water Quality in Waterbodies in the RSA

Table 7B-3 Water Quality in Waterbodies in the Upper Christina River Basin

Parameter	Unit	Spring, Waterbodies (2006)						Summer, Waterbodies (1983, 2005 and 2006)						Fall, Waterbodies (1998, 2001, 2005)						Winter, Waterbodies (2006)						AENV Freshwater Aquatic Life*	CCME Water Quality Guidelines - Freshwater^	EPA Freshwater Water Quality***
		Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N			
Field Parameters																												
Temperature	°C	10.3	11.8	10.8	10.6	10.9	5	11.5	19.5	17.3	16.0	18.0	14	7.0	7.0	7.0	7.0	7.0	1	0.9	2.5	1.6	1.3	2.1	3	**NS**	**NS**	**NS**
pH		***5.0***	7.2	6.8	***5.6***	7.2	5	6.8	***8.9***	7.8	7.7	7.9	15	***6.0***	***6.0***	***6.0***	***6.0***	***6.0***	1	6.5	6.9	6.7	6.6	6.8	3	**6.5-8.5**	**6.5-9.0**	**6.5-9[CC]**
Conductivity (EC)	uS/cm	48	223	71	54	179	5	19	280	77	71	137	6	160	160	160	160	160	1	263	395	298	281	347	3	**NS**	**NS**	**NS**
Dissolved oxygen (DO)	mg/L	9.3	14.7	12.5	11.1	14.0	5	***0.8***	9.5	7.4	6.0	8.0	17	12.3	12.3	12.3	12.3	12.3	1	***4.1***	6.0	5.0	***4.6***	5.5	3	**5.0AA**	**5.5-9.5[3]**	**NS**
Conventional Parameters																												
pH		--	--	--	--	--	0	7.6	***9.4***	7.7	7.6	8.0	9	***4.4***	8.3	7.5	***6.1***	7.7	18	7.2	7.8	7.7	7.5	7.8	4	**6.5-9**	**6.5-9.0**	**6.5-9[CC]**
Conductivity (EC)	uS/cm	--	--	--	--	--	0	62	251	107	67	140	8	63	279	104	80	160	5	179	400	305	202	399	4	**NS**	**NS**	**NS**
Hardness ($CaCO_3$)	mg/L	--	--	--	--	--	0	24.0	130.0	47.5	31.8	70.0	8	27.0	150.0	48.0	41.0	80.0	5	88.0	210.0	155.0	104.5	202.5	4	**NS**	**NS**	**NS**
Alkalinity ($CaCO_3$)	mg/L	--	--	--	--	--	0	26.7	136.0	51.2	31.4	72.3	8	0.0	156.0	30.9	4.8	41.5	18	85.5	214.0	162.0	103.9	214.0	4	**NS**	**NS**	**20[CC]**
Total Dissolved Solids	mg/L	--	--	--	--	--	0	31.0	140.0	55.0	36.3	78.0	8	28.5	152.0	43.3	37.5	60.4	8	94.0	224.0	163.0	107.5	216.5	4	**NS**	**NS**	**NS**
Total Suspended Solids	mg/L	1.0	20.5	3.0	3.0	5.0	5	1.0	50.0	12.0	3.0	29.3	6	3.0	26.0	7.0	5.0	8.0	5	3.0	273.0	6.0	4.5	73.5	4	**NS**	**NS**	**NS**
Turbidity	NTU	3.2	8.6	4.4	3.6	5.9	4	3.4	26.2	10.7	5.4	22.4	5	0.6	58.0	2.6	1.3	7.3	18	1.4	70.2	18.9	7.6	38.7	4	**NS**	**NS**	**NS**
Major Ions																												
Carbonate (CO_3)	mg/L	--	--	--	--	--	0	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	6	< 0.5	0.9	0.3	0.3	0.3	6	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	4	**NS**	**NS**	**NS**
Bicarbonate (HCO_3 ($CaCO_3$))	mg/L	--	--	--	--	--	0	32.5	166.0	62.3	38.2	88.4	8	2.5	190.0	38.0	6.8	49.8	17	104.0	261.0	197.5	126.5	261.0	4	**NS**	**NS**	**NS**
Sodium (Na)	mg/L	--	--	--	--	--	0	1.0	2.0	1.6	1.2	2.0	8	0.3	2.3	1.2	0.7	1.7	18	2.2	8.7	3.2	2.9	4.6	4	**NS**	**NS**	**NS**
Potassium (K)	mg/L	--	--	--	--	--	0	< 0.3	1.1	0.5	0.3	0.7	8	< 0.3	1.5	0.5	0.3	0.6	18	0.9	2.0	1.5	1.3	1.6	4	**NS**	**NS**	**NS**
Calcium (Ca)	mg/L	--	--	--	--	--	0	6.9	34.5	13.0	8.9	19.2	8	0.9	41.4	9.6	1.9	11.5	18	26.2	59.6	44.7	29.6	58.9	4	**NS**	**NS**	**NS**
Magnesium (Mg)	mg/L	--	--	--	--	--	0	1.5	10.0	3.8	2.3	5.4	8	0.3	11.0	2.3	0.8	3.3	18	5.6	15.0	11.4	8.2	14.0	4	**NS**	**NS**	**NS**
Chloride (Cl)	mg/L	--	--	--	--	--	0	< 1.0	1.4	1.1	0.7	1.3	8	< 0.5	0.9	0.3	0.2	0.5	16	1.6	2.8	2.0	1.8	2.2	4	**230****	**NS**	**860[MC]/230[CC]**
Sulphate (SO_4)	mg/L	--	--	--	--	--	0	< 5.0	8.8	2.9	2.5	5.6	8	< 0.5	1.8	0.5	0.3	1.3	18	< 0.5	1.5	0.7	0.5	1.0	4	**NS**	**NS**	**NS**
Nutrients																												
Nitrite (NO_2-N)	mg/L	--	--	--	--	--	0	< 0.050	0.007	0.004	0.002	0.006	8	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	5	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	4	**0.018**	**0.018**	**NS**
Nitrate (NO_3 -N)	mg/L	--	--	--	--	--	0	< 0.050	0.035	0.025	0.013	0.030	7	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	5	< 0.003	0.027	0.013	0.009	0.018	4	**NS**	**2.9**	**NS**
Nitrate + nitrite (NO_3 + NO_2 -N)	mg/L	--	--	--	--	--	0	< 0.05	***0.04***	***0.03***	***0.02***	***0.03***	8	< 0.003	***0.279***	0.002	0.002	0.002	17	0.00	***0.03***	0.01	0.01	0.02	4	**0.018*****	**NS**	**NS**
Nitrogen - Ammonia (NH_4-N)	mg/L	0.02	0.05	0.03	0.03	0.03	5	0.02	0.24	0.04	0.02	0.04	8	< 0.010	0.259	0.015	0.005	0.030	16	0.35	1.30	0.42	0.35	0.69	4	**1.37 to 2.20**	**0.015**	**NS[4]**
Nitrogen - Kjeldahl (TKN)	mg/L	0.75	1.05	0.82	0.75	0.98	5	0.48	2.39	1.18	0.63	1.61	8	0.03	1.48	0.78	0.09	0.98	8	1.36	26.60	1.79	1.44	8.23	4	**NS**	**NS**	**NS**
Total nitrogen (TKN+NO_3 + NO_2)	mg/L	0.75	***1.05***	0.82	0.75	0.98	5	0.52	***2.42***	***1.18***	0.64	***1.57***	8	0.03	***1.47***	0.77	0.09	0.98	8	***1.35***	***26.61***	***1.80***	***1.45***	***8.25***	4	**1.0C**	**NS**	**NS**
Phosphorus, total	mg/L	0.028	***0.082***	0.036	0.035	***0.080***	5	0.016	***0.201***	***0.067***	0.023	***0.095***	8	0.016	***0.164***	0.034	0.026	***0.063***	18	0.022	***1.670***	***0.127***	***0.064***	***0.549***	4	**0.05C**	**NS**	**NS**
Total organic carbon	mg/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Dissolved organic carbon	mg/L	--	--	--	--	--	0	0.1	0.1	0.1	0.1	0.1	1	10	24	15	13	16	13	--	--	--	--	--	0	**NS**	**NS**	**NS**
Organics																												
Total Phenolics	mg/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**0.005C**	**NS**	**NS**
Total recoverable hydrocarbons	mg/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Total Metals																												
Aluminum (Al)	ug/L	11	51	22	17	30	5	9	***150***	36	17	59	6	9	55	11	10	48	5	7	73	24	9	47	4	**5^1/100^2**	**100[a]**	**750[MC]/87[CC]**
Antimony (Sb)	ug/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	5	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	6	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	5	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	4	**NS**	**NS**	**NS**
Arsenic (As)	ug/L	< 0.2	***6.4***	0.1	0.1	0.3	5	0.2	1.0	0.4	0.3	0.4	6	0.4	1.1	0.4	0.4	0.7	5	< 0.2	0.8	0.2	0.1	0.4	4	**5.0^**	**5**	**340[MC]/150[CC]**
Barium (Ba)	ug/L	10.3	36.4	21.1	10.5	24.8	5	20.5	41.2	32.7	23.6	35.7	6	19.7	40.4	26.1	21.4	29.3	5	24.3	86.4	61.8	46.9	73.4	4	**NS**	**NS**	**NS**
Beryllium (Be)	ug/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	5	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	6	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	5	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	4	**NS**	**NS**	**NS**
Boron (B)	ug/L	10.0	20.0	20.0	15.0	20.0	5	10.0	40.0	15.0	10.0	27.5	6	10.0	10.0	10.0	10.0	10.0	5	10.0	40.0	25.0	17.5	32.5	4	**NS**	**NS**	**NS**
Cadmium (Cd)	ug/L	0.13	0.20	0.15	0.14	0.20	5	< 0.01	***0.32***	***0.25***	***0.07***	***0.30***	6	< 0.010	0.040	0.010	0.008	***0.030***	5	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	4	**HardnessH^**	**0.017[b]**	**20[MC,H]/0.25[CC,H]**
Chromium (Cr)	ug/L	1.0	1.0	1.0	1.0	1.0	5	1.0	1.0	1.0	1.0	1.0	6	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	5	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	4	**8.9^**	**8.9**	**570[MC,H]/74[CC,H]**
Cobalt (Co)	ug/L	< 0.3	0.5	0.2	0.2	0.4	5	< 0.3	0.4	0.2	0.2	0.2	6	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	5	< 0.3	0.6	0.2	0.2	0.3	4	**NS**	**NS**	**NS**
Copper (Cu)	ug/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	5	0.5	3.0	1.0	0.7	1.0	6	< 0.2	0.7	0.3	0.2	0.3	5	< 0.2	2.0	0.1	0.1	0.6	4	**HardnessH**	**2[b]**	**13[MC,H]/9[CC,H]**
Iron (Fe)	ug/L	--	--	--	--	--	0	20	***1080***	95	40	120	6	30	***2520***	110	45	130	5	170	***6400***	***2130***	***770***	***4068***	4	**300**	**300**	**1000CC**
Lead (Pb)	ug/L	< 0.30	< 0.30	< 0.30	< 0.30	< 0.30	5	< 0.30	***5.80***	0.90	0.73	1.08	6	< 0.30	0.50	0.15	0.15	0.50	5	< 0.30	< 0.30	< 0.30	< 0.30	< 0.30	4	**HardnessH^**	**2[b]**	**65[MC,H]/2.5[CC,H]**
Lithium (Li)	ug/L	< 4.0	5.0	2.0	2.0	4.0	5	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	6	< 4.0	6.0	2.0	2.0	5.0	5	< 4.0	15.0	5.5	4.3	8.3	4	**NS**	**NS**	**NS**
Manganese (Mn)	ug/L	--	--	--	--	--	0	< 4.0	30.0	4.5	2.0	20.5	6	< 4.0	34.0	2.0	2.0	2.0	5	10.0	1420.0	563.5	52.8	1150.0	4	**NS**	**NS**	**NS**
Mercury (Hg)	ug/L	< 0.0006	0.0010	0.0003	0.0003	0.0003	5	< 0.0006	0.0010	0.0003	0.0003	0.0005	4	< 0.0006	0.0044	0.0019	0.0008	0.0032	4	< 0.0006	< 0.0006	< 0.0006	< 0.0006	< 0.0006	4	**0.013A/0.005C**	**0.026^^**	**1.4[MC,H]/0.77[CC,H]**
Molybdenum (Mo)	ug/L	< 0.2	0.3	0.1	0.1	0.2	5	< 0.2	0.3	0.1	0.1	0.1	6	< 0.2	0.4	0.1	0.1	0.4	5	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	4	**73^**	**73**	**NS**
Nickel (Ni)	ug/L	1.1	4.4	1.7	1.2	3.4	5	0.8	4.1	1.6	1.3	2.3	6	0.5	1.7	0.9	0.7	1.1	5	< 0.5	2.1	1.0	0.4	1.7	4	**HardnessH^**	**65[b]**	**470[MC,H]/52[CC,H]**
Selenium (Se)	ug/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	5	0.2	0.3	0.2	0.2	0.2	6	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	5	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	4	**1.0^**	**1**	**5[CC]**
Silicon (Si)	ug/L	495	2760	1360	700	2420	5	780	3280	1360	840	2180	6	1020	2800	2230	1870	2650	5	2020	11000	3920	3213	5923	4	**NS**	**NS**	**NS**
Silver (Ag)	ug/L	0.10	***0.40***	***0.20***	***0.20***	***0.30***	5	***2.10***	***3.40***	***2.75***	***2.23***	***3.05***	6	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	5	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	4	**0.1^**	**0.1**	**3.2[MC,H]**
Strontium (Sr)	ug/L	25.0	67.0	37.0	29.0	62.0	5	41.0	74.0	47.5	42.0	54.5	6	44	87	64	54	66	5	74.0	213.0	110.0	99.5	137.3	4	**NS**	**NS**	**NS**
Sulphur (S)	ug/L	50	1300	400	200	500	5	300	900	350	300	475	6	300	700	400	300	400	5	400	1100	550	400	800	4	**NS**	**NS**	**NS**
Thallium (Tl)	ug/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	5	< 0.2	0.6	0.1	0.1	0.3	6	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	5	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	4	**0.8^**	**0.8**	**NS**
Tin (Sn)	ug/L	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	5	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	6	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	5	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	4	**NS**	**NS**	**NS**
Titanium (Ti)	ug/L	1.0	3.0	3.0	1.0	3.0	5	2.0	5.0	2.0	2.0	3.5	6	< 1.0	2.0	1.0	0.5	2.0	5	< 1.0	2.0	1.3	0.5	2.0	4	**NS**	**NS**	**NS**
Uranium (U)	ug/L	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	5	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	6	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	5	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	4	**NS**	**NS**	**NS**
Vanadium (V)	ug/L	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	5	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	6	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	5	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	4	**NS**	**NS**	**NS**
Zinc (Zn)	ug/L	3	6	4	4	5	5	10	***35***	12	11	27	6	4	15	8	6	9	5	7	12	10	9	11	4	**30^**	**30**	**120[M,H]/120[CC,H]**
Zirconium (Zr)	ug/L	0.8	1.8	1.3	1.2	1.5	5	< 0.2	2.7	0.5	0.2	0.8	6	< 0.2	0.4	0.1	0.1	0.1	5	< 0.2	0.5	0.1	0.1	0.2	4	**NS**	**NS**	**NS**

Table 7B-3 Water Quality in Waterbodies in the Upper Christina River Basin

Parameter	Unit	Spring, Waterbodies (2006)						Summer, Waterbodies (1983, 2005 and 2006)						Fall, Waterbodies (1998, 2001, 2005)						Winter, Waterbodies (2006)						AENV Freshwater Aquatic Life*	CCME Water Quality Guidelines - Freshwater^	EPA Freshwater Water Quality***
		Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N			
Dissolved Metals																												
Aluminum	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**$750^{MC}/87^{CC}$**
Antimony	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Arsenic	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**$340^{MC}/150^{CC}$**
Barium	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Beryllium	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Bismuth	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	
Boron	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Cadmium	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**$20^{MC,H}/0.25^{CC,H}$**
Chromium	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**$570^{MC,H}/74^{CC,H}$**
Cobalt	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Copper	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**$13^{MC,H}/9^{CC,H}$**
Iron	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**1000CC**
Lead	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**$65^{MC,H}/2.5^{CC,H}$**
Lithium	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Manganese	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Mercury	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**$1.4^{MC,H}/0.77^{CC,H}$**
Molybdenum	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Nickel	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**$470^{MC,H}/52^{CC,H}$**
Silver	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**$3.2^{MC,H}$**
Strontium	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Sulphur	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Thallium	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Tin	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Titanium	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Vanadium	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Zinc	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**$120^{M,H}/120^{CC,H}$**
Polycyclic Aromatic Hydrocarbons																												
Naphthalene	ug/L	--	--	--	--	--	0	< 0.120	< 0.100	< 0.110	< 0.113	< 0.108	4	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	5	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	4	**1.1^**	**1.1**	**NS**
Acenaphthylene	ug/L	--	--	--	--	--	0	< 0.100	< 0.120	< 0.110	< 0.108	< 0.113	4	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	5	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	4	**NS**	**NS**	**NS**
Acenaphthene	ug/L	--	--	--	--	--	0	< 0.100	< 0.120	< 0.110	< 0.108	< 0.113	4	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	5	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	4	**5.8^**	**5.8**	**NS**
Fluorene	ug/L	--	--	--	--	--	0	< 0.05	< 0.06	< 0.06	< 0.05	< 0.06	4	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	5	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	4	**3^**	**3**	**NS**
Phenanthrene	ug/L	--	--	--	--	--	0	< 0.05	< 0.06	< 0.06	< 0.05	< 0.06	4	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	5	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	4	**0.4^**	**0.4**	**NS**
Anthracene	ug/L	--	--	--	--	--	0	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	4	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	4	**0.012^**	**0.012**	**NS**
Acridine	ug/L	--	--	--	--	--	0	< 0.20	< 0.24	< 0.22	< 0.22	< 0.23	4	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	5	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	4	**4.4^**	**NS**	**NS**
Fluoranthene	ug/L	--	--	--	--	--	0	< 0.04	< 0.05	< 0.04	< 0.04	< 0.05	4	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	5	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	4	**0.04^**	**0.04**	**NS**
Pyrene	ug/L	--	--	--	--	--	0	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	4	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	5	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	4	**0.025^**	**0.025**	**NS**
Benz[a]anthracene	ug/L	--	--	--	--	--	0	< 0.05	< 0.06	< 0.06	< 0.05	< 0.06	4	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	4	**0.018^**	**0.018**	**NS**
Chrysene	ug/L	--	--	--	--	--	0	< 0.05	< 0.06	< 0.06	< 0.05	< 0.06	4	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	5	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	4	**NS**	**NS**	**NS**
Benzo[b]fluoranthene	ug/L	--	--	--	--	--	0	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	4	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	5	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	4	**NS**	**NS**	**NS**
Benzo[k]fluoranthene	ug/L	--	--	--	--	--	0	< 0.05	< 0.06	< 0.06	< 0.05	< 0.06	4	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	5	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	4	**NS**	**NS**	**NS**
Benzo[a]pyrene	ug/L	--	--	--	--	--	0	< 0.05	< 0.06	< 0.06	< 0.05	< 0.06	4	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	4	**0.015^**	**0.015**	**NS**
Indeno[1,2,3-cd]pyrene	ug/L	--	--	--	--	--	0	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	4	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	5	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	4	**NS**	**NS**	**NS**
Dibenz[a,h]anthracene	ug/L	--	--	--	--	--	0	< 0.05	< 0.06	< 0.06	< 0.05	< 0.06	4	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	5	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	4	**NS**	**NS**	**NS**
Quinoline	ug/L	--	--	--	--	--	0	< 0.20	< 0.24	< 0.22	< 0.22	< 0.23	4	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	5	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	4	**NS**	**NS**	**NS**
Benzo[g,h,i]perylene	ug/L	--	--	--	--	--	0	< 0.05	< 0.05	< 0.06	< 0.05	< 0.06	4	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	5	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	4	**NS**	**NS**	**NS**
CCME B(a)P Equivalent	ug/L	--	--	--	--	--	0	< 0.008	< 0.010	< 0.009	< 0.008	< 0.009	4	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	5	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	4	**NS**	**NS**	**NS**

Notes:

--- - not analyzed
NS - not specified
^ - Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME, 2006)
* - Alberta Environment Surface Water Quality Guidelines for use in Alberta (AENV, 1999)
CC - continuous concentration guideline, National Recommended Water Quality Criteria (USEPA, 2006
MC - maximum concentration guideline, National Recommended Water Quality Criteria (USEPA, 2006
*** - National Recommended Water Quality Criteria (USEPA, 2006)
^^ - indicates value for Inorganic Mercury
1 - value if pH <6.5, Ca <4.0, DOC <2
2 - value if pH ≥6.5, Ca ≥4.0, DOC ≥2
3 - refer to CCME summary table for DO guideline breakdowr
4 - refer to USEPA summary table for Ammonia criteria calculations
A - Acute aquatic life guideline
A A - 1 day minimum, acute guideline
a - value if pH>6.5, Ca>4.0, DOC>2
b - dependent on hardness value
C - Chronic Aquatic Life guideline
H - dependent on hardness value
*** - value denotes NO_2-N guideline concentration
Italics - indicates that values exceed specified guideline

Appendix 7B Historical Water Quality in Waterbodies in the RSA

Table 7B-4. Water Quality in Waterbodies the Mid-Christina River Basin

Parameter	Unit	Spring, Waterbodies (1976, 1980, 1988, and 2004)						Summer, Waterbodies (1983 and 2004)						Fall, Waterbodies (1998)						Winter, Waterbodies (1966, 1971, and 1986)						AENV Freshwater Aquatic Life*	CCME Water Quality Guidelines - Freshwater^	EPA Freshwater Water Quality***
		Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N			
Field Parameters																												
Temperature	°C	11.8	13.6	12.1	12.0	12.9	3	6.0	20.0	13.1	7.3	17.6	55	--	--	--	--	--	0	2.1	3.8	3.2	2.5	3.5	28	**NS**	**NS**	**NS**
pH		7.3	8.3	7.5	7.5	7.7	4	6.8	***9.5***	8.0	7.2	8.1	10	--	--	--	--	--	0	***6.0***	6.7	6.5	***6.3***	6.6	28	**6.5-8.5**	**6.5-9.0**	**$6.5-9^{CC}$**
Conductivity (EC)	uS/cm	57	198	67	62	101	4	43	137	59	50	84	4	--	--	--	--	--	0	184	210	192	188	196	28	**NS**	**NS**	**NS**
Dissolved oxygen (DO)	mg/L	6.3	6.4	6.3	6.3	6.4	3	***4.4***	14.4	8.3	7.2	9.0	49	--	--	--	--	--	0	***1.4***	9.3	8.1	5.8	9.1	26	**5.0AA**	**5.5-9.53**	**NS**
Conventional Parameters																												
pH		7.6	7.9	7.8	7.7	7.8	6	7.6	8.9	8.1	7.8	8.3	7	7.3	***9.5***	8.2	7.9	8.7	19	7.4	7.8	7.7	7.6	7.8	3	**6.5-9**	**6.5-9.0**	**$6.5-9^{CC}$**
Conductivity (EC)	uS/cm	58	146	69	68	139	5	55	224	163	77	201	7	--	--	--	--	--	0	202	239	222	214	229	4	**NS**	**NS**	**NS**
Hardness ($CaCO_3$)	mg/L	30.0	99.0	49.5	34.0	68.0	6	27.0	105.0	67.0	40.5	92.0	7	67.0	67.0	67.0	67.0	67.0	1	101.0	130.0	114.0	105.0	117.0	5	**NS**	**NS**	**NS**
Alkalinity ($CaCO_3$)	mg/L	27.0	101.0	51.0	32.3	79.5	6	25.0	118.0	84.0	36.0	103.5	7	21.4	123.5	76.8	54.2	92.9	19	103.0	124.1	116.3	113.1	120.0	5	**NS**	**NS**	**20^{CC}**
Total Dissolved Solids	mg/L	60.0	108.0	78.0	71.5	92.8	6	40.0	130.0	87.0	65.0	118.0	7	87.0	87.0	87.0	87.0	87.0	1	118.7	206.0	130.5	123.7	172.0	5	**NS**	**NS**	**NS**
Total Suspended Solids	mg/L	< 3.0	4.0	4.0	2.8	4.0	3	< 3.0	3.0	2.3	1.5	3.0	4	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Turbidity	NTU	--	--	--	--	--	0	--	--	--	--	--	0	0.9	23.0	3.7	1.8	8.8	18	--	--	--	--	--	0	**NS**	**NS**	**NS**
Major Ions																												
Carbonate (CO_3)	mg/L	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	3	< 5.0	11.0	2.5	2.5	2.5	6	5.9	19.6	8.4	7.4	11.1	7	--	--	--	--	--	0	**NS**	**NS**	**NS**
Bicarbonate (HCO_3 ($CaCO_3$))	mg/L	32.0	123.0	63.0	39.5	97.1	6	30.0	140.0	80.0	44.0	125.5	7	26.1	136.2	80.0	60.1	103.6	19	137.9	151.3	141.8	139.8	146.5	3	**NS**	**NS**	**NS**
Sodium (Na)	mg/L	2.0	5.0	2.0	2.0	3.5	6	1.0	7.0	4.0	2.0	6.5	7	1.2	10.2	3.6	2.1	6.5	19	7.0	8.0	7.0	7.0	7.5	3	**NS**	**NS**	**NS**
Potassium (K)	mg/L	0.6	1.0	1.0	0.8	1.0	6	0.2	1.0	0.9	0.5	1.0	7	0.1	1.6	0.9	0.7	1.0	19	0.9	1.0	1.0	1.0	1.0	3	**NS**	**NS**	**NS**
Calcium (Ca)	mg/L	8.0	25.3	12.5	9.0	17.5	6	7.0	29.0	17.0	10.0	24.5	7	6.9	51.4	20.5	15.6	25.8	19	29.0	32.0	31.0	30.0	31.5	3	**NS**	**NS**	**NS**
Magnesium (Mg)	mg/L	2.0	8.8	4.5	3.3	5.8	6	2.0	8.0	6.0	4.0	7.5	7	2.3	10.1	6.0	5.0	7.6	19	8.0	9.0	9.0	8.5	9.0	3	**NS**	**NS**	**NS**
Chloride (Cl)	mg/L	< 1.0	2.0	2.0	0.9	2.0	6	< 1.0	2.0	1.0	0.5	2.0	7	0.1	3.1	0.4	0.2	0.6	19	< 1.0	2.0	0.5	0.5	0.5	5	**230****	**NS**	**$860^{MC}/230^{CC}$**
Sulphate (SO_4)	mg/L	< 5.0	2.0	2.0	1.3	2.4	6	< 5.0	3.0	2.5	1.0	2.5	7	0.2	2.5	0.5	0.3	0.9	18	< 5.0	24.0	2.5	2.5	21.0	5	**NS**	**NS**	**NS**
Nutrients																												
Nitrite (NO_2-N)	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	1	< 0.0500	< 0.0500	< 0.0500	< 0.0500	< 0.0500	3	--	--	--	--	--	0	0.002	0.002	0.002	0.002	0.002	3	**0.018**	**0.018**	**NS**
Nitrate (NO_3 -N)	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	1	--	--	--	--	--	0	--	--	--	--	--	0	0.26	0.26	0.26	0.26	0.26	1	**NS**	**2.9000**	**NS**
Nitrate + nitrite (NO_3 + NO_2 -N)	mg/L	< 0.10	***0.05***	***0.05***	***0.05***	***0.05***	4	< 0.1000	< 0.0500	< 0.1000	< 0.1000	< 0.0500	7	0.0001	0.0103	0.0006	0.0004	0.0010	19	***0.084***	***0.170***	***0.100***	***0.092***	***0.135***	3	**0.018*****	**NS**	**NS**
Nitrogen - Ammonia (NH_4-N)	mg/L	< 0.050	0.103	0.025	0.025	0.045	4	< 0.0500	0.0300	0.0250	0.0215	0.0250	7	0.0000	0.3000	0.0083	0.0034	0.0228	19	0.009	0.015	0.014	0.012	0.015	3	**1.37 to 2.20**	**0.0150**	**NS^{4}**
Nitrogen - Kjeldahl (TKN)	mg/L	0.69	1.30	0.90	0.85	1.00	4	0.4200	1.9400	0.8000	0.5200	1.2500	7	0.0019	0.0019	0.0019	0.0019	0.0019	1	0.430	0.480	0.460	0.445	0.470	3	**NS**	**NS**	**NS**
Total nitrogen (TKN+NO_3 + NO_2)	mg/L	0.74	***1.40***	1.00	0.94	***1.10***	4	0.37	***1.89***	0.90	0.55	***1.35***	7	0.0022	0.0022	0.0022	0.0022	0.0022	1	0.530	0.630	0.564	0.547	0.597	3	**1.0C**	**NS**	**NS**
Phosphorus, total	mg/L	0.017	0.041	0.027	0.020	0.035	4	0.012	***0.092***	0.020	0.015	0.035	7	0.014	***0.412***	***0.077***	0.032	***0.146***	19	0.016	0.034	0.016	0.016	0.025	3	**0.05C**	**NS**	**NS**
Total organic carbon	mg/L	11	27	18	15	23	3	15	35	19	17	25	4	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Dissolved organic carbon	mg/L	10	23	16	11	17	5	15	34	19	17	24	4	7	26	19	15	21	18	--	--	--	--	--	0	**NS**	**NS**	**NS**
Organics																												
Total Phenolics	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	3	0.004	***0.018***	***0.014***	***0.010***	***0.016***	4	--	--	--	--	--	0	--	--	--	--	--	0	**0.005C**	**NS**	**NS**
Total recoverable hydrocarbons	mg/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	3	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	4	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Total Metals																												
Aluminum (Al)	ug/L	20	30	30	25	30	3	< 20	20	10	10	13	4	--	--	--	--	--	0	--	--	--	--	--	0	**5^1/100^2**	**100a**	**$750^{MC}/87^{CC}$**
Antimony (Sb)	ug/L	0.9	1.1	1.0	1.0	1.1	3	0.6	0.7	0.7	0.7	0.7	4	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Arsenic (As)	ug/L	< 0.4	0.5	0.2	0.2	0.3	4	< 0.4	0.6	0.5	0.4	0.5	4	--	--	--	--	--	0	--	--	--	--	--	0	**5.0^**	**5**	**$340^{MC}/150^{CC}$**
Barium (Ba)	ug/L	2.0	19.0	4.5	2.0	10.0	4	4.0	21.0	7.0	4.0	12.8	4	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Beryllium (Be)	ug/L	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	3	< 1.0	0.5	0.5	0.5	0.5	4	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Boron (B)	ug/L	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	3	< 20.0	20.0	10.0	10.0	12.5	4	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Cadmium (Cd)	ug/L	< 1.0	< 0.2	< 0.2	< 0.4	< 0.2	4	< 0.2	***0.1***	***0.1***	***0.1***	***0.1***	4	--	--	--	--	--	0	--	--	--	--	--	0	**HardnessH^**	**0.017b**	**$20^{MC,H}/0.25^{CC,H}$**
Chromium (Cr)	ug/L	< 0.8	2.0	1.6	1.0	1.9	4	< 0.8	0.8	0.4	0.4	0.5	4	--	--	--	--	--	0	--	--	--	--	--	0	**8.9^**	**8.9**	**$570^{MC,H}/74^{CC,H}$**
Cobalt (Co)	ug/L	< 1.0	< 0.2	< 0.2	< 0.4	< 0.2	4	< 0.2	0.1	0.1	0.1	0.1	4	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Copper (Cu)	ug/L	< 1.0	2.0	1.3	0.5	2.0	4	< 1.0	2.0	0.5	0.5	0.9	4	--	--	--	--	--	0	--	--	--	--	--	0	**HardnessH**	**2b**	**$13^{MC,H}/9^{CC,H}$**
Iron (Fe)	ug/L	70	***1510***	100	85	***805***	3	40	***320***	60	40	140	4	--	--	--	--	--	0	--	--	--	--	--	0	**300**	**300**	**1000CC**
Lead (Pb)	ug/L	0.10	0.30	0.20	0.15	0.25	3	0.05	0.20	0.15	0.09	0.20	4	--	--	--	--	--	0	--	--	--	--	--	0	**HardnessH^**	**2b**	**$65^{MC,H}/2.5^{CC,H}$**
Lithium (Li)	ug/L	< 6.0	< 6.0	< 6.0	< 6.0	< 6.0	3	< 6.0	3.0	3.0	3.0	3.0	4	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Manganese (Mn)	ug/L	6.0	48.0	27.5	9.8	45.0	4	10.0	49.0	25.5	14.5	38.5	4	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Mercury (Hg)	ug/L	< 0.1000	0.0011	0.0009	0.0005	***0.0133***	4	< 0.0006	0.0003	0.0003	0.0003	0.0003	4	--	--	--	--	--	0	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	3	**0.013A/0.005C**	**0.026^^**	**$1.4^{MC,H}/0.77^{CC,H}$**
Molybdenum (Mo)	ug/L	< 0.1	< 1.0	< 0.1	< 0.1	< 0.3	4	< 0.1	0.3	0.1	0.1	0.1	4	--	--	--	--	--	0	--	--	--	--	--	0	**73^**	**73**	**NS**
Nickel (Ni)	ug/L	< 0.2	2.4	1.2	0.3	2.1	4	0.2	1.4	0.5	0.2	0.9	4	--	--	--	--	--	0	--	--	--	--	--	0	**HardnessH^**	**65b**	**$470^{MC,H}/52^{CC,H}$**
Selenium (Se)	ug/L	< 0.4	0.5	0.2	0.2	0.3	4	< 0.4	0.2	0.2	0.2	0.2	4	--	--	--	--	--	0	--	--	--	--	--	0	**1.0^**	**1**	**5^{CC}**
Silicon (Si)	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Silver (Ag)	ug/L	< 0.005	0.005	0.003	0.003	0.004	3	< 0.001	0.008	0.003	0.002	0.005	4	--	--	--	--	--	0	--	--	--	--	--	0	**0.1^**	**0.1**	**$3.2^{MC,H}$**
Strontium (Sr)	ug/L	10	20	10	10	15	3	20	60	25	20	38	4	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Sulphur (S)	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Thallium (Tl)	ug/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	3	< 0.1	0.1	0.1	0.1	0.1	4	--	--	--	--	--	0	--	--	--	--	--	0	**0.8^**	**0.8**	**NS**
Tin (Sn)	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Titanium (Ti)	ug/L	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	3	< 5.0	2.5	2.5	2.5	2.5	4	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Uranium (U)	ug/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	3	< 0.1	0.1	0.1	0.1	0.1	4	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Vanadium (V)	ug/L	0.2	0.6	0.6	0.4	0.6	3	< 0.2	0.1	0.1	0.1	0.1	4	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Zinc (Zn)	ug/L	8	23	16	12	20	3	< 4	10	6	4	8	4	--	--	--	--	--	0	--	--	--	--	--	0	**30^**	**30**	**$120^{M,H}/120^{CC,H}$**
Zirconium (Zr)	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**

Table 7B-4. Water Quality in Waterbodies the Mid-Christina River Basin

Parameter	Unit	Spring, Waterbodies (1976, 1980, 1988, and 2004)						Summer, Waterbodies (1983 and 2004)						Fall, Waterbodies (1998)						Winter, Waterbodies (1966, 1971, and 1986)						AENV Freshwater Aquatic Life*	CCME Water Quality Guidelines - Freshwater^	EPA Freshwater Water Quality***
		Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N			
Dissolved Metals																												
Aluminum	ug/L	< 10	10	10	8	10	3	< 10	5	5	5	5	4	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**$750^{MC}/87^{CC}$**
Antimony	ug/L	1.0	1.1	1.1	1.1	1.1	3	0.5	0.7	0.6	0.6	0.6	4	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Arsenic	ug/L	< 0.4	0.5	0.5	0.4	0.5	3	< 0.4	0.6	0.5	0.4	0.5	4	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**$340^{MC}/150^{CC}$**
Barium	ug/L	2.0	6.0	2.0	2.0	4.0	3	2.0	21.0	5.5	2.8	11.3	4	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Beryllium	ug/L	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	3	< 1.0	0.5	0.5	0.5	0.5	4	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Bismuth	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	
Boron	ug/L	10.0	10.0	10.0	10.0	10.0	3	10.0	20.0	10.0	10.0	12.5	4	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Cadmium	ug/L	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	3	< 0.10	0.05	0.05	0.05	0.05	4	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**$20^{MC,H}/0.25^{CC,H}$**
Chromium	ug/L	0.6	0.7	0.6	0.6	0.7	3	< 0.4	0.7	0.2	0.2	0.3	4	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**$570^{MC,H}/74^{CC,H}$**
Cobalt	ug/L	0.1	0.3	0.2	0.2	0.3	3	< 0.1	0.1	0.1	0.1	0.1	4	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Copper	ug/L	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	3	< 0.6	0.3	0.3	0.3	0.3	4	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**$13^{MC,H}/9^{CC,H}$**
Iron	ug/L	50	1140	60	55	600	3	20	140	45	28	80	4	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**1000CC**
Lead	ug/L	< 0.1	0.1	0.1	0.1	0.1	3	0.1	0.4	0.3	0.1	0.4	4	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**$65^{MC,H}/2.5^{CC,H}$**
Lithium	ug/L	1.0	2.0	2.0	1.5	2.0	3	3.0	5.0	3.0	3.0	3.5	4	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Manganese	ug/L	2.0	3.0	3.0	2.5	3.0	3	< 1.0	18.0	3.5	0.9	9.0	4	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Mercury	ug/L	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	3	< 0.10	0.05	0.05	0.05	0.05	4	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**$1.4^{MC,H}/0.77^{CC,H}$**
Molybdenum	ug/L	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	3	< 0.10	0.50	0.13	0.05	0.28	4	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Nickel	ug/L	< 0.10	0.20	0.10	0.08	0.15	3	< 0.10	1.20	0.35	0.09	0.75	4	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**$470^{MC,H}/52^{CC,H}$**
Silver	ug/L	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	3	< 0.20	0.10	0.10	0.10	0.10	4	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**$3.2^{MC,H}$**
Strontium	ug/L	20	20	20	20	20	3	20	60	20	20	30	4	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Sulphur	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Thallium	ug/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	3	< 0.05	0.05	0.03	0.03	0.03	4	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Tin	ug/L	< 0.30	1.10	0.30	0.23	0.70	3	< 0.30	0.40	0.28	0.15	0.40	4	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Titanium	ug/L	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	3	< 0.10	0.05	0.05	0.05	0.05	4	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Vanadium	ug/L	0.20	0.30	0.20	0.20	0.25	3	< 0.1	0.30	0.05	0.05	0.11	4	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Zinc	ug/L	4	12	5	5	9	3	3	4	4	3	4	4	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**$120^{M,H}/120^{CC,H}$**
Polycyclic Aromatic Hydrocarbons																												
Naphthalene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**1.1^**	**1.1**	**NS**
Acenaphthylene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Acenaphthene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**5.8^**	**5.8**	**NS**
Fluorene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**3^**	**3**	**NS**
Phenanthrene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**0.4^**	**0.4**	**NS**
Anthracene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**0.012^**	**0.012**	**NS**
Acridine	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**4.4^**		**NS**
Fluoranthene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**0.04^**	**0.04**	**NS**
Pyrene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**0.025^**	**0.025**	**NS**
Benz[a]anthracene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**0.018^**	**0.018**	**NS**
Chrysene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Benzo[b]fluoranthene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Benzo[k]fluoranthene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Benzo[a]pyrene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**0.015^**	**0.015**	**NS**
Indeno[1,2,3-cd]pyrene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Dibenz[a,h]anthracene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Quinoline	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Benzo[g,h,i]perylene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
CCME B(a)P Equivalent	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**

Notes:

--- - not analyzed
NS - not specified
^ - Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME, 2006)
* - Alberta Environment Surface Water Quality Guidelines for use in Alberta (AENV, 1999)
CC - continuous concentration guideline, National Recommended Water Quality Criteria (USEPA, 2006
MC - maximum concentration guideline, National Recommended Water Quality Criteria (USEPA, 2006)
*** - National Recommended Water Quality Criteria (USEPA, 2006)
^^ - indicates value for Inorganic Mercury
1 - value if pH <6.5, Ca <4.0, DOC <2
2 - value if pH ≥6.5, Ca ≥4.0, DOC ≥2
3 - refer to CCME summary table for DO guideline breakdown
4 - refer to USEPA summary table for Ammonia criteria calculations
A - Acute aquatic life guideline
A A - 1 day minimum, acute guideline
a - value if pH>6.5, Ca>4.0, DOC>2
b - dependent on hardness value
C - Chronic Aquatic Life guideline
H - dependent on hardness value
*** - value denotes NO_2-N guideline concentration
Italics - indicates that values exceed specified guideline

Appendix 7B Historical Water Quality in Waterbodies in the RSA

Table 7B-5 Water Quality in Waterbodies in the Lower Christina River Basin

Parameter	Unit	Spring, Waterbodies (1977 - 1983, 1994, 1996 - 1998, 2000 - 2002, 2005)						Summer, Waterbodies (1970, 1972 - 1975, 1977 - 1983, 1989 - 2004)						Fall, Waterbodies (2000, 2001, 2004, 2005)						Winter, Waterbodies (1976 - 1981, 2001)						AENV Freshwater Aquatic Life*	CCME Water Quality Guidelines - Freshwater^	EPA Freshwater Water Quality***
		Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N			
Field Parameters																												
Temperature	°C	0.0	15.5	10.0	6.9	12.9	16	8.0	22.5	17.0	16.0	19.0	72	13.0	15.6	14.5	13.8	15.0	18	0.0	4.5	1.0	0.5	2.1	28	NS	NS	NS
pH		7.4	***9.0***	8.1	7.6	8.3	17	6.7	***10.0***	8.1	7.6	8.4	57	***6.0***	8.5	7.6	7.3	8.0	23	6.5	8.5	7.8	7.5	8.1	20	6.5-8.5	6.5-9.0	6.5-9^{CC}
Conductivity (EC)	uS/cm	15	466	110	105	122	11	8	304	118	102	128	54	22	223	118	75	190	18	96	196	132	111	152	16	NS	NS	NS
Dissolved oxygen (DO)	mg/L	***4.7***	14.3	10.5	8.6	11.4	12	***4.7***	11.7	8.9	8.1	10.0	59	6.7	9.7	8.1	7.6	8.8	14	6.4	15.4	9.3	6.7	11.6	10	5.0^{AA}	5.5-9.5^{3}	NS
Conventional Parameters																												
pH		***6.3***	8.4	7.5	7.2	7.7	37	***5.9***	8.9	7.7	7.3	7.9	98	***4.6***	***9.1***	7.6	7.1	8.0	54	***5.7***	8.0	7.3	7.1	7.6	40	6.5-9	6.5-9.0	6.5-9^{CC}
Conductivity (EC)	uS/cm	24	357	109	88	139	37	23	302	116	109	136	107	26	320	99	85	185	33	32	218	134	106	150	40	NS	NS	NS
Hardness ($CaCO_3$)	mg/L	10.0	140.0	53.6	35.8	70.0	26	10.0	222.0	60.0	49.8	68.5	59	11.0	141.0	44.0	37.0	85.8	34	15.0	91.0	61.4	45.0	67.0	12	NS	NS	NS
Alkalinity ($CaCO_3$)	mg/L	8.0	139.5	50.6	39.8	56.5	36	7.0	285.0	50.6	46.2	58.0	108	0.5	168.0	47.5	28.7	99.2	54	8.0	106.0	58.9	49.6	67.8	40	NS	NS	20^{CC}
Total Dissolved Solids	mg/L	11.0	178.0	80.0	64.0	122.0	21	10.0	190.0	75.0	67.0	110.0	53	15.0	310.0	120.0	100.0	152.5	36	14.0	54.0	32.0	15.3	51.8	6	NS	NS	NS
Total Suspended Solids	mg/L	< 3.0	22.0	3.0	1.5	7.0	11	< 3.0	18.0	5.0	1.5	7.0	23	< 3.0	22.0	4.0	1.5	8.0	33	< 3.0	10.0	1.5	1.5	5.8	3	NS	NS	NS
Turbidity	NTU	--	--	--	--	--	--	--	--	--	--	--	0	0.4	33.0	4.1	1.6	6.7	24	--	--	--	--	--	0	NS	NS	NS
Major Ions																												
Carbonate (CO_3)	mg/L	< 5.0	2.5	2.5	0.3	2.5	10	< 5.0	11.0	2.5	2.5	2.5	31	< 5.0	12.4	2.5	2.5	2.5	34	--	--	--	--	--	0	NS	NS	NS
Bicarbonate (HCO_3 ($CaCO_3$))	mg/L	10.0	221.0	58.6	42.8	80.0	22	9.0	186.0	69.0	54.0	82.0	53	0.9	204.0	61.9	40.3	121.8	54	10.0	130.0	53.5	21.0	57.5	6	NS	NS	NS
Sodium (Na)	mg/L	< 1.0	14.5	2.8	2.0	4.0	37	< 1.0	22.0	2.6	2.1	3.1	99	< 1.0	28.9	4.5	2.0	8.3	54	< 1.0	10.0	2.7	2.3	3.0	39	NS	NS	NS
Potassium (K)	mg/L	0.2	11.0	1.0	0.8	1.6	37	0.1	3.0	0.9	0.8	1.1	97	0.3	3.3	1.2	0.7	1.8	54	0.2	2.1	1.0	0.8	1.2	40	NS	NS	NS
Calcium (Ca)	mg/L	2.8	60.9	15.2	10.6	18.5	37	2.5	38.4	15.3	14.1	16.7	102	1.1	41.8	15.1	9.8	23.9	54	4.0	28.6	18.5	15.1	21.3	40	NS	NS	NS
Magnesium (Mg)	mg/L	0.8	17.3	4.0	3.1	5.1	37	0.8	52.0	4.1	3.9	5.0	98	0.3	13.6	4.5	2.6	7.7	54	1.2	8.7	5.0	4.0	5.6	39	NS	NS	NS
Chloride (Cl)	mg/L	< 1.0	2.0	0.9	0.6	2.0	33	< 1.0	6.0	0.7	0.5	1.0	84	< 1.0	6.6	0.8	0.5	2.0	52	0.5	2.2	1.0	0.9	1.1	40	230**	NS	860^{MC}/230^{CC}
Sulphate (SO_4)	mg/L	< 0.5	29.0	6.0	4.0	10.0	37	< 5.0	96.0	6.4	5.0	8.8	94	0.2	16.1	2.5	1.3	4.3	54	1.9	13.8	7.6	6.0	8.5	40	NS	NS	NS
Nutrients																												
Nitrite (NO_2-N)	mg/L	0.001	***0.025***	0.003	0.002	0.006	11	< 0.050	***0.050***	0.003	0.002	0.005	58	--	--	--	--	--	0	0.002	0.010	0.003	0.002	0.004	27	0.018	0.018	NS
Nitrate (NO_3 -N)	mg/L	0.002	0.220	0.014	0.008	0.129	10	0.002	0.050	0.003	0.002	0.010	40	--	--	--	--	--	0	0.002	0.570	0.039	0.011	0.240	26	NS	2.9	NS
Nitrate + nitrite (NO_3 + NO_2 -N)	mg/L	< 0.10	***0.21***	***0.04***	0.01	***0.05***	24	< 0.10	***0.20***	0.01	0.00	***0.05***	92	< 0.10	***0.20***	***0.05***	0.004	***0.050***	53	< 0.10	***0.58***	***0.04***	0.01	***0.21***	38	0.018***	NS	NS
Nitrogen - Ammonia (NH_4-N)	mg/L	< 0.05	0.06	0.03	0.03	0.03	7	< 0.05	0.08	0.03	0.03	0.03	23	< 0.05	0.75	0.025	0.02	0.04	48	0.18	0.18	0.18	0.18	0.18	1	1.37 to 2.20	0.015	NS^{4}
Nitrogen - Kjeldahl (TKN)	mg/L	0.09	1.80	0.82	0.70	1.08	22	0.28	2.90	1.00	0.80	1.20	57	0.05	3.20	1.20	1.10	1.65	35	0.42	2.08	0.86	0.70	1.09	35	NS	NS	NS
Total nitrogen (TKN+NO_3 + NO_2)	mg/L	0.11	***1.70***	0.88	0.68	***1.02***	22	0.29	***3.00***	***1.01***	0.83	***1.30***	57	0.05	***3.10***	***1.10***	1.00	***1.60***	35	0.49	***2.66***	***1.04***	0.73	***1.25***	35	1.0^{C}	NS	NS
Phosphorus, total	mg/L	0.017	***0.300***	0.029	0.025	0.042	29	0.016	***2.400***	0.035	0.027	0.050	118	0.010	***0.192***	0.050	0.030	***0.078***	54	0.013	***0.074***	0.024	0.019	0.032	35	0.05^{C}	NS	NS
Total organic carbon	mg/L	16	32	21	18	28	11	12	45	26	22	31	23	12	55	32	25	34	30	26	45	29	28	37	3	NS	NS	NS
Dissolved organic carbon	mg/L	13	32	18	15	26	11	11	35	22	19	26	23	5	49	22	18	30	54	19	35	21	20	28	3	NS	NS	NS
Organics																												
Total Phenolics	mg/L	< 0.001	***0.015***	***0.013***	0.003	***0.015***	9	0.002	***0.019***	***0.016***	***0.012***	***0.018***	6	< 0.001	***0.015***	***0.008***	0.002	***0.012***	15	--	--	--	--	--	0	0.005^{C}	NS	NS
Total recoverable hydrocarbons	mg/L	< 0.5	2.7	0.8	0.4	2.1	8	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	13	--	--	--	--	--	0	NS	NS	NS
Total Metals																												
Aluminum (Al)	ug/L	< 20	***150***	31	27	67	11	< 10	***200***	60	30	60	21	2	***230***	30	18	70	29	***240***	***240***	***240***	***240***	***240***	1	5^^{1}/100^^{2}	100^{a}	750^{MC}/87^{CC}
Antimony (Sb)	ug/L	< 5.00	2.50	1.26	0.02	2.50	10	< 5.00	0.03	2.50	1.88	2.50	20	< 5.00	0.09	0.03	0.02	0.05	29	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	1	NS	NS	NS
Arsenic (As)	ug/L	< 1.00	0.50	0.50	0.34	0.50	11	< 1.00	0.62	0.50	0.50	0.50	21	< 1.00	1.10	0.45	0.37	0.50	29	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	1	5.0^	5	340^{MC}/150^{CC}
Barium (Ba)	ug/L	8.3	37.9	15.4	9.9	17.4	10	3.0	45.1	15.2	10.3	26.1	19	< 0.1	67.7	17.9	13.0	22.4	29	34.0	34.0	34.0	34.0	34.0	1	NS	NS	NS
Beryllium (Be)	ug/L	< 1.000	0.500	0.257	0.006	0.500	10	< 1.000	0.016	0.500	0.500	0.500	19	< 1.000	0.220	0.020	0.009	0.090	29	< 1	< 1	< 1	< 1	< 1	1	NS	NS	NS
Boron (B)	ug/L	10.0	46.0	19.3	14.6	21.0	10	< 20.0	63.5	30.0	19.9	50.0	19	< 0.1	83.3	22.1	18.0	34.1	29	17.0	17.0	17.0	17.0	17.0	1	NS	NS	NS
Cadmium (Cd)	ug/L	< 0.20	***1.20***	0.02	0.01	***0.10***	11	< 0.200	***4.900***	***0.100***	***0.100***	***0.257***	23	< 0.200	***0.330***	***0.030***	0.010	***0.100***	29	***0.500***	***0.500***	***0.500***	***0.500***	***0.500***	1	Hardness^{H}^	0.017^{b}	20^{MC,H}/0.25^{CC,H}
Chromium (Cr)	ug/L	< 0.8	6.0	0.4	0.2	0.4	11	< 2.0	***15.5***	0.8	0.4	6.1	21	< 0.8	0.7	0.2	0.1	0.4	29	1.8	1.8	1.8	1.8	1.8	1	8.9^	8.9	570^{MC,H}/74^{CC,H}
Cobalt (Co)	ug/L	< 0.20	0.20	0.10	0.04	0.10	10	< 0.20	1.90	0.10	0.10	0.25	22	< 0.20	0.20	0.07	0.04	0.10	29	0.70	0.70	0.70	0.70	0.70	1	NS	NS	NS
Copper (Cu)	ug/L	< 1.0	5.0	0.5	0.2	0.8	11	< 1.0	10.0	0.5	0.5	1.0	23	< 0.1	3.0	0.2	0.1	0.5	29	2.0	2.0	2.0	2.0	2.0	1	Hardness^{H}	2^{b}	13^{MC,H}/9^{CC,H}
Iron (Fe)	ug/L	< 10	***2200***	151	86	***428***	14	< 10	***2000***	130	110	***441***	23	< 3	***964***	240	119	***370***	29	***1690***	***1690***	***1690***	***1690***	***1690***	1	300	300	1000CC
Lead (Pb)	ug/L	< 0.30	***9.60***	0.08	0.05	0.23	11	< 0.30	***15.20***	0.50	0.25	1.15	23	< 0.01	2.60	0.30	0.09	0.99	29	0.70	0.70	0.70	0.70	0.70	1	Hardness^{H}^	2^{b}	65^{MC,H}/2.5^{CC,H}
Lithium (Li)	ug/L	< 6.0	7.8	3.0	3.0	4.2	10	< 6.0	10.0	3.0	3.0	7.8	19	< 6.0	14.1	4.5	3.0	7.0	29	< 6.0	< 6.0	< 6.0	< 6.0	< 6.0	1	NS	NS	NS
Manganese (Mn)	ug/L	4.0	88.0	41.6	21.4	67.8	11	11.0	188.0	38.0	19.5	74.5	23	6.9	301.3	32.6	18.5	69.3	29	204.0	204.0	204.0	204.0	204.0	1	NS	NS	NS
Mercury (Hg)	ug/L	< 0.200	***0.050***	***0.025***	0.005	***0.100***	11	< 0.200	***0.100***	0.003	0.001	***0.025***	22	< 0.2000	***0.0435***	0.0050	0.0003	***0.0420***	29	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	1	0.013^{A}/0.005^{C}	0.026^^	1.4^{MC,H}/0.77^{CC,H}
Molybdenum (Mo)	ug/L	< 0.10	0.60	0.09	0.04	0.10	11	< 0.10	0.60	0.07	0.05	0.20	20	< 0.10	0.90	0.06	0.03	0.09	29	0.40	0.40	0.40	0.40	0.40	1	73^	73	NS
Nickel (Ni)	ug/L	< 0.5	7.0	0.3	0.2	0.9	11	< 0.5	30.0	0.4	0.2	0.7	23	< 0.1	7.4	0.2	0.0	0.5	29	2.4	2.4	2.4	2.4	2.4	1	Hardness^{H}^	65^{b}	470^{MC,H}/52^{CC,H}
Selenium (Se)	ug/L	< 0.8	0.4	0.3	0.1	0.4	10	< 0.8	***2.0***	0.4	0.4	0.9	19	< 0.8	0.5	0.3	0.2	0.3	29	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	1	1.0^	1	5^{CC}
Silicon (Si)	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	NS	NS	NS
Silver (Ag)	ug/L	< 0.400	0.005	0.005	0.003	***0.200***	11	< 0.400	0.012	0.005	0.003	0.010	20	< 0.400	***0.160***	0.005	0.003	0.020	29	< 0.40	< 0.40	< 0.40	< 0.40	< 0.40	1	0.1^	0.1	3.2^{MC,H}
Strontium (Sr)	ug/L	27.4	114.0	40.6	35.8	55.7	10	4.6	117.0	60.7	35.4	96.4	19	0.0	195.0	50.0	36.8	84.3	28	65.0	65.0	65.0	65.0	65.0	1	NS	NS	NS
Sulphur (S)	ug/L	519	2580	1070	891	1160	5	--	--	--	--	--	0	< 200	5570	337	100	945	11	--	--	--	--	--	0	NS	NS	NS
Thallium (Tl)	ug/L	< 0.10	0.05	0.0264	0.00	0.05	10	< 0.10	0.20	0.05	0.05	0.05	19	< 0.10	0.02	0.002	0.002	0.007	29	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	1	0.8^	0.8	NS
Tin (Sn)	ug/L	< 0.40	< 0.03	0.02	0.02	0.2	9	< 0.40	0.09	0.04	0.02	0.09	5	< 0.03	4.80	0.06	0.02	0.32	18	0.50	0.50	0.50	0.50	0.50	1	NS	NS	NS
Titanium (Ti)	ug/L	< 0.6	5.6	1.0	0.4	2.2	10	< 5.0	5.0	2.5	2.5	2.5	19	0.2	4.5	1.2	0.7	1.5	28	5.5	5.5	5.5	5.5	5.5	1	NS	NS	NS
Uranium (U)	ug/L	< 0.10	0.10	0.04	0.02	0.05	10	< 0.10	0.50	0.05	0.05	0.05	19	< 0.10	0.10	0.02	0.02	0.05	29	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	1	NS	NS	NS
Vanadium (V)	ug/L	< 0.20	0.50	0.16	0.10	0.31	10	< 1.00	5.10	0.34	0.14	2.28	20	0.04	0.64	0.23	0.17	0.33	29	0.80	0.80	0.80	0.80	0.80	1	NS	NS	NS
Zinc (Zn)	ug/L	< 4	30	5	2	13	11	< 4	***53***	5	4	9	23	1	***190***	11	7	30	29	25	25	25	25	25	1	30^	30	120^{M,H}/120^{CC,H}
Zirconium (Zr)	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	NS	NS	NS

Table 7B-5 Water Quality in Waterbodies in the Lower Christina River Basin

Parameter	Unit	Spring, Waterbodies (1977 - 1983, 1994, 1996 - 1998, 2000 - 2002, 2005)						Summer, Waterbodies (1970, 1972 - 1975, 1977 - 1983, 1989 - 2004)						Fall, Waterbodies (2000, 2001, 2004, 2005)						Winter, Waterbodies (1976 - 1981, 2001)						AENV Freshwater Aquatic Life*	CCME Water Quality Guidelines - Freshwater^	EPA Freshwater Water Quality***
		Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N			
Dissolved Metals																												
Aluminum	ug/L	2	42	8	3	18	5	2	14	7	3	11	4	1	48	4	2	18	10	--	--	--	--	--	0	NS	NS	$750^{MC}/87^{CC}$
Antimony	ug/L	0.005	0.020	0.018	0.016	0.020	5	0.010	0.020	0.018	0.015	0.019	4	0.008	0.024	0.014	0.011	0.022	10	--	--	--	--	--	0	NS	NS	NS
Arsenic	ug/L	0.19	0.35	0.31	0.27	0.34	5	0.22	0.60	0.40	0.35	0.42	5	0.20	0.56	0.37	0.28	0.44	10	--	--	--	--	--	0	NS	NS	$340^{MC}/150^{CC}$
Barium	ug/L	7.1	33.9	12.2	9.5	13.3	5	7.7	38.3	10.4	9.3	17.8	4	10.6	64.9	15.7	13.2	24.4	10	--	--	--	--	--	0	NS	NS	NS
Beryllium	ug/L	< 0.003	0.012	0.002	0.002	0.006	5	< 0.003	0.007	0.002	0.002	0.004	4	< 0.003	0.012	0.002	0.002	0.006	10	--	--	--	--	--	0	NS	NS	NS
Bismuth	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	NS	NS	
Boron	ug/L	13.7	43.6	18.3	15.9	23.2	5	16.4	190.0	31.9	19.8	62.4	5	15.6	78.9	21.6	19.0	35.0	10	--	--	--	--	--	0	NS	NS	NS
Cadmium	ug/L	0.002	0.009	0.006	0.004	0.007	5	< 0.002	0.091	0.003	0.002	0.025	4	0.002	0.042	0.005	0.002	0.013	10	--	--	--	--	--	0	NS	NS	$20^{MC,H}/0.25^{CC,H}$
Chromium	ug/L	0.075	0.306	0.122	0.091	0.205	5	0.126	0.150	0.143	0.136	0.147	4	< 0.030	0.683	0.278	0.109	0.399	10	--	--	--	--	--	0	NS	NS	$570^{MC,H}/74^{CC,H}$
Cobalt	ug/L	0.017	0.042	0.028	0.026	0.029	5	0.023	0.041	0.032	0.026	0.037	4	0.019	0.096	0.040	0.027	0.066	10	--	--	--	--	--	0	NS	NS	NS
Copper	ug/L	0.092	0.396	0.205	0.108	0.265	5	0.153	0.392	0.224	0.176	0.296	4	0.078	0.462	0.157	0.130	0.230	10	--	--	--	--	--	0	NS	NS	$13^{MC,H}/9^{CC,H}$
Iron	ug/L	4	413	19	17	131	5	13	280	18	15	85	4	8	608	80	21	151	10	--	--	--	--	--	0	NS	NS	1000CC
Lead	ug/L	0.011	0.049	0.024	0.022	0.034	5	0.029	0.044	0.033	0.031	0.037	4	0.005	0.148	0.024	0.007	0.053	10	--	--	--	--	--	0	NS	NS	$65^{MC,H}/2.5^{CC,H}$
Lithium	ug/L	1.65	7.81	4.12	3.85	5.99	5	2.57	9.22	5.57	3.82	7.47	4	2.51	13.50	5.69	4.53	9.09	10	--	--	--	--	--	0	NS	NS	NS
Manganese	ug/L	0.70	1.97	0.93	0.74	1.61	5	0.91	3.03	1.56	1.28	2.05	4	0.67	53.50	3.78	1.43	11.40	10	--	--	--	--	--	0	NS	NS	NS
Mercury	ug/L	< 0.01	< 0.01	0.01	0.01	0.01	5	< 0.01	< 0.01	0.01	0.01	0.01	4	< 0.01	0.02	0.01	0.01	0.01	10	--	--	--	--	--	0	NS	NS	$1.4^{MC,H}/0.77^{CC,H}$
Molybdenum	ug/L	0.008	0.087	0.077	0.025	0.087	5	0.001	0.111	0.052	0.022	0.084	4	< 0.001	0.100	0.045	0.035	0.070	10	--	--	--	--	--	0	NS	NS	NS
Nickel	ug/L	0.013	0.473	0.107	0.029	0.275	5	< 0.005	0.229	0.111	0.076	0.148	4	< 0.005	0.548	0.070	0.059	0.275	10	--	--	--	--	--	0	NS	NS	$470^{MC,H}/52^{CC,H}$
Silver	ug/L	< 0.0005	0.0011	0.0006	0.0003	0.0009	5	< 0.0005	< 0.0005	0.0003	0.0003	0.0003	4	< 0.0005	0.0016	0.0003	0.0003	0.0006	10	--	--	--	--	--	0	NS	NS	$3.2^{MC,H}$
Strontium	ug/L	34.7	102.0	41.4	38.8	58.2	5	35.1	115.0	53.7	44.7	73.4	4	29.4	189.0	53.2	44.6	84.6	10	--	--	--	--	--	0	NS	NS	NS
Sulphur	ug/L	517	2579	895	573	1030	5	--	--	--	--	--	0	< 200	4610	139	100	1000	10	--	--	--	--	--	0	NS	NS	NS
Thallium	ug/L	< 0.0003	0.0028	0.0002	0.0002	0.0025	5	0.0013	0.0022	0.0020	0.0017	0.0021	4	< 0.0003	0.0128	0.0010	0.0002	0.0030	10	--	--	--	--	--	0	NS	NS	NS
Tin	ug/L	< 0.030	0.037	0.015	0.015	0.015	5	< 0.030	0.091	0.027	0.015	0.052	4	< 0.030	0.095	0.049	0.015	0.059	10	--	--	--	--	--	0	NS	NS	NS
Titanium	ug/L	0.070	0.889	0.241	0.120	0.351	5	0.101	0.603	0.331	0.162	0.511	4	< 0.040	0.855	0.441	0.141	0.515	10	--	--	--	--	--	0	NS	NS	NS
Vanadium	ug/L	0.041	0.208	0.103	0.087	0.142	5	0.098	0.215	0.145	0.103	0.193	4	0.037	0.233	0.143	0.095	0.165	10	--	--	--	--	--	0	NS	NS	NS
Zinc	ug/L	2	5	3	2	4	5	3	3	3	3	3	4	1	17	6	1	10	10	--	--	--	--	--	0	NS	NS	$120^{M,H}/120^{CC,H}$
Polycyclic Aromatic Hydrocarbons																												
Naphthalene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	1.1^	1.1	NS
Acenaphthylene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	NS	NS	NS
Acenaphthene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	5.8^	5.8	NS
Fluorene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	3^	3	NS
Phenanthrene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	0.4^	0.4	NS
Anthracene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	0.012^	0.012	NS
Acridine	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	4.4^		NS
Fluoranthene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	0.04^	0.04	NS
Pyrene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	0.025^	0.025	NS
Benz[a]anthracene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	0.018^	0.018	NS
Chrysene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	NS	NS	NS
Benzo[b]fluoranthene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	NS	NS	NS
Benzo[k]fluoranthene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	NS	NS	NS
Benzo[a]pyrene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	0.015^	0.015	NS
Indeno[1,2,3-cd]pyrene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	NS	NS	NS
Dibenz[a,h]anthracene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	NS	NS	NS
Quinoline	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	NS	NS	NS
Benzo[g,h,i]perylene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	NS	NS	NS
CCME B(a)P Equivalent	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	NS	NS	NS

--- - not analyzed
NS - not specified
^ - Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME, 2006)
* - Alberta Environment Surface Water Quality Guidelines for use in Alberta (AENV, 1999)
CC - continuous concentration guideline, National Recommended Water Quality Criteria (USEPA, 2006
MC - maximum concentration guideline, National Recommended Water Quality Criteria (USEPA, 2006)
*** - National Recommended Water Quality Criteria (USEPA, 2006)
^^ - indicates value for Inorganic Mercury
1 - value if pH <6.5, Ca <4.0, DOC <2
2 - value if pH ≥6.5, Ca ≥4.0, DOC ≥2
3 - refer to CCME summary table for DO guideline breakdown
4 - refer to USEPA summary table for Ammonia criteria calculations
A - Acute aquatic life guideline
A A - 1 day minimum, acute guideline
a - value if pH>6.5, Ca>4.0, DOC>2
b - dependent on hardness value
C - Chronic Aquatic Life guideline
H - dependent on hardness value
*** - value denotes NO_2-N guideline concentration
Italics - indicates that values exceed specified guideline

Appendix 7C Historical Water Quality in Watercourses in the RSA

Table 7C-1 Water Quality in Watercourses in the Horse and Hangingstone River Basin

Parameter	Unit	Spring, Watercourses (1976 - 1981, 1983)						Summer, Watercourses (1976 - 1983, 2001)						Fall, Watercourses (1976 - 1983, 2001, 2004)						Winter, Watercourses (1973, 1976 - 1982,1989, 2001 and 2002)						AENV Freshwater Aquatic Life*	CCME Water Quality Guidelines - Freshwater^	EPA Freshwater Water Quality***
		Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N			
Field Parameters																												
Temperature	°C	0.0	13.5	5.7	3.0	7.0	17	11.5	24.0	16.5	15.3	18.5	27	2.0	14.0	8.0	3.5	10.3	14	-0.40	5.2	0.0	0.0	0.2	23	NS	NS	NS
pH		7.3	8.4	7.7	7.6	7.9	9	7.6	***9.2***	8.1	8.0	8.4	18	8.0	***9.6***	8.3	8.2	8.4	11	***5.4***	***8.7***	7.7	7.4	7.9	23	6.5-8.5	6.5-9.0	$6.5\text{-}9^{CC}$
Conductivity (EC)	uS/cm	14	600	164	93	270	15	85	1500	180	118	253	23	38	380	150	64	216	12	238	703	330	273	425	20	NS	NS	NS
Dissolved oxygen (DO)	mg/L	7.9	14.8	11.9	9.7	13.0	11	6.7	12.6	9.5	9.2	10.0	26	7.3	13.4	10.9	8.7	11.7	13	10.8	14.5	13.5	12.9	14.4	5	5.0AA	5.5-9.53	NS
Conventional Parameters																												
pH		7.3	8.2	7.9	7.7	8.0	18	***6.2***	8.2	7.7	7.5	7.9	40	***6.0***	8.2	7.6	7.4	7.8	20	7.2	8.6	7.8	7.7	8.0	43	6.5-9	6.5-9.0	$6.5\text{-}9^{CC}$
Conductivity (EC)	uS/cm	130	626	238	168	362	18	27	458	190	140	243	56	23	549	252	174	304	30	150	985	529	330	592	42	NS	NS	NS
Hardness ($CaCO_3$)	mg/L	55.5	138.0	67.2	63.9	114.0	9	9.3	96.6	68.4	60.4	87.0	18	12.0	187.1	86.9	71.2	106.9	8	76.0	479.4	226.4	149.6	264.0	25	NS	NS	NS
Alkalinity ($CaCO_3$)	mg/L	51.2	222.0	94.7	67.0	133.3	18	5.6	184.0	90.6	72.8	103.8	36	3.6	236.0	80.0	66.2	106.0	21	72.1	508.2	234.1	151.2	282.0	42	NS	NS	20^{CC}
Total Dissolved Solids	mg/L	165.0	193.7	179.3	172.2	186.5	2	11.0	130.0	98.3	67.5	113.4	5	< 10.0	199.2	190.0	97.5	194.6	3	80.0	548.5	196.2	149.6	306.4	16	NS	NS	NS
Total Suspended Solids	mg/L	13.0	13.0	13.0	13.0	13.0	1	2.0	2.0	2.0	2.0	2.0	1	5.0	11.0	8.0	6.5	9.5	2	5.0	5.0	5.0	5.0	5.0	1	NS	NS	NS
Turbidity	NTU	1.6	2.9	2.2	1.9	2.6	2	--	--	--	--	--	0	8.1	8.1	8.1	8.1	8.1	1	5.4	16.5	11.0	8.2	13.8	2	NS	NS	NS
Major Ions																												
Carbonate (CO_3)	mg/L	--	--	--	--	--	0	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1	NS	NS	NS
Bicarbonate (HCO_3 ($CaCO_3$))	mg/L	--	--	--	--	--	0	6.8	110.8	70.6	51.2	84.1	4	4.4	239.7	122.1	63.2	180.9	2	87.9	619.6	239.4	204.1	319.5	10	NS	NS	NS
Sodium (Na)	mg/L	7.0	71.0	17.3	12.5	29.9	18	< 0.5	36.0	14.8	12.0	21.3	36	< 0.5	43.0	14.8	12.3	19.4	20	1.7	93.0	38.0	25.9	50.0	36	NS	NS	NS
Potassium (K)	mg/L	0.1	3.0	2.0	1.2	2.3	18	< 0.3	2.1	0.9	0.6	1.3	36	< 0.3	2.4	0.6	0.4	1.0	19	0.1	5.3	2.0	1.1	3.2	35	NS	NS	NS
Calcium (Ca)	mg/L	13.5	52.0	24.7	17.6	34.4	18	4.1	45.5	24.1	18.5	27.0	33	3.5	56.8	21.8	18.8	26.5	20	18.0	118.7	58.4	39.5	65.9	41	NS	NS	NS
Magnesium (Mg)	mg/L	4.2	16.9	8.4	5.4	9.3	18	1.1	13.0	6.9	5.5	7.9	36	0.9	15.1	6.4	5.9	8.3	19	5.3	31.0	16.8	11.6	19.4	35	NS	NS	NS
Chloride (Cl)	mg/L	< 1.0	91.0	7.7	6.9	16.6	18	< 1.0	19.9	8.0	3.5	13.2	36	< 0.5	23.0	9.0	5.0	15.0	21	< 1.0	45.8	16.5	8.1	26.6	43	230**	NS	$860^{MC}/230^{CC}$
Sulphate (SO_4)	mg/L	< 5.0	41.5	16.4	9.9	24.8	18	< 5.0	33.0	14.5	9.7	19.2	33	< 0.5	36.2	11.0	9.0	14.2	21	< 10.0	71.0	31.0	17.2	39.5	43	NS	NS	NS
Nutrients																												
Nitrite (NO_2-N)	mg/L	< 0.003	***0.050***	0.009	0.006	***0.018***	10	< 0.003	***0.022***	0.003	0.002	0.007	25	< 0.003	0.017	0.004	0.002	0.006	13	< 0.100	***0.034***	0.007	0.001	0.013	24	0.018	0.018	NS
Nitrate (NO_3 -N)	mg/L	< 0.003	0.360	0.050	0.002	0.080	9	< 0.003	0.081	0.004	0.002	0.025	23	< 0.003	0.095	0.003	0.002	0.006	9	0.003	1.700	0.292	0.156	0.360	21	NS	2.9	NS
Nitrate + nitrite (NO_3 + NO_2 -N)	mg/L	< 0.01	***0.37***	***0.03***	0.01	***0.08***	17	< 0.10	***0.09***	0.01	0.003	***0.03***	36	< 0.10	***0.15***	0.01	0.01	0.02	21	< 0.10	***1.70***	***0.22***	***0.09***	***0.40***	43	0.018***	NS	NS
Nitrogen - Ammonia (NH_4-N)	mg/L	0.02	0.46	0.08	0.04	0.11	15	< 0.01	0.32	0.04	0.02	0.07	32	< 0.01	0.20	0.03	0.02	0.06	17	< 0.20	1.00	0.08	0.05	0.14	28	1.37 to 2.20	0.015	NS[4]
Nitrogen - Kjeldahl (TKN)	mg/L	0.49	2.18	0.97	0.84	1.35	14	0.54	3.61	0.91	0.77	1.23	26	0.31	9.15	0.95	0.62	1.50	16	0.22	1.30	0.69	0.56	0.94	34	NS	NS	NS
Total nitrogen (TKN+NO_3 + NO_2)	mg/L	< 0.01	0.93	0.47	0.24	0.70	2	0.58	***3.63***	0.93	0.78	***1.23***	26	0.62	0.90	0.76	0.69	0.83	2	***1.07***	***1.07***	***1.07***	***1.07***	***1.07***	1	1.0C	NS	NS
Phosphorus total	mg/L	0.039	***0.410***	***0.130***	0.047	***0.230***	17	< 0.003	***1.300***	***0.068***	0.050	***0.106***	32	0.021	***0.230***	***0.093***	***0.059***	***0.123***	21	< 0.100	***0.443***	***0.070***	***0.051***	***0.103***	39	0.05C	NS	NS
Total organic carbon	mg/L	13	42	16	14	20	17	15	44	25	21	28	31	13	41	25	24	29	18	2	38	18	13	25	28	NS	NS	NS
Dissolved organic carbon	mg/L	6	38	16	14	20	16	14	43	23	20	27	22	13	40	24	23	28	15	2	37	16	12	23	27	NS	NS	NS
Organics																												
Total Phenolics	mg/L	***0.006***	***0.006***	***0.006***	***0.006***	***0.006***	1	--	--	--	--	--	0	***0.010***	***0.010***	***0.010***	***0.010***	***0.010***	1	--	--	--	--	--	0	0.005C	NS	NS
Total recoverable hydrocarbons	mg/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	NS	NS	NS
Total Metals																												
Aluminum (Al)	ug/L	< 20	***680***	***213***	***112***	***447***	3	26	***141***	84	55	***112***	2	43	***291***	***170***	***107***	***231***	3	41	***180***	68	54	***113***	10	5^1/100^2	100a	$750^{MC}/87^{CC}$
Antimony (Sb)	ug/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	1	< 5.0	< 0.2	< 2.6	< 3.8	< 1.4	2	< 0.2	< 6.0	< 3.1	< 1.7	< 4.6	2	< 0.2	< 6.0	< 6.0	< 6.0	< 6.0	10	NS	NS	NS
Arsenic (As)	ug/L	< 0.2	0.8	0.6	0.4	0.7	3	0.5	***6.0***	1.0	0.8	3.5	3	< 10.0	0.4	0.4	0.2	2.7	3	< 10.0	2.0	5.0	3.5	5.0	10	5.0^	5	$340^{MC}/150^{CC}$
Barium (Ba)	ug/L	14.1	14.1	14.1	14.1	14.1	1	12.8	30.5	21.7	17.2	26.1	2	11.9	81.7	46.8	29.3	64.2	2	29.7	106.2	61.6	42.5	79.1	11	NS	NS	NS
Beryllium (Be)	ug/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	1	< 1.0	< 0.2	< 0.6	< 0.8	< 0.4	2	< 0.2	< 0.6	< 0.4	< 0.3	< 0.5	2	< 0.2	< 1.0	< 0.6	< 0.6	< 0.6	10	NS	NS	NS
Boron (B)	ug/L	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	1	< 10.0	45.0	25.0	15.0	35.0	2	< 10.0	60.0	37.9	21.4	48.9	3	17.6	154.8	62.6	34.2	118.6	10	NS	NS	NS
Cadmium (Cd)	ug/L	< 1.00	0.01	***0.26***	***0.13***	***0.38***	2	< 0.200	***0.190***	< 0.005	< 0.103	***0.093***	2	***0.02***	***0.02***	***0.02***	***0.02***	***0.02***	1	< 0.200	0.002	0.005	0.004	0.053	3	HardnessH^	0.017b	$20^{MC,H}/0.25^{CC,H}$
Chromium (Cr)	ug/L	1.0	2.0	1.5	1.3	1.8	2	1.0	1.0	1.0	1.0	1.0	2	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	2	< 1.0	0.8	0.5	0.5	0.5	11	8.9^	8.9	$570^{MC,H}/74^{CC,H}$
Cobalt (Co)	ug/L	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	1	0.5	0.5	0.5	0.5	0.5	2	< 0.3	< 0.8	< 0.6	< 0.4	< 0.7	2	< 0.8	2.0	0.4	0.4	0.4	11	NS	NS	NS
Copper (Cu)	ug/L	< 1.0	0.3	0.4	0.4	0.5	2	0.4	7.0	3.7	2.1	5.4	2	< 1.0	0.3	0.4	0.4	0.5	2	< 1.0	2.0	0.5	0.5	0.5	10	HardnessH	2b	$13^{MC,H}/9^{CC,H}$
Iron (Fe)	ug/L	< 20	< 20	< 20	< 20	< 20	1	100	***3640***	***1870***	***985***	***2755***	2	100	***1700***	***1300***	***850***	***1550***	4	200	***5390***	***1050***	***500***	***2095***	11	300	300	1000CC
Lead (Pb)	ug/L	< 0.3	< 3.0	< 1.7	< 1.0	< 2.3	2	< 0.3	0.5	0.3	0.2	0.4	2	< 0.3	< 2.0	< 1.2	< 0.7	< 1.6	2	< 2.0	***6.2***	1.0	1.0	1.0	10	HardnessH^	2b	$65^{MC,H}/2.5^{CC,H}$
Lithium (Li)	ug/L	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	1	< 4.0	8.0	5.0	3.5	6.5	2	< 4.0	14.7	8.3	5.2	11.5	2	5.0	65.1	18.2	12.5	33.5	10	NS	NS	NS
Manganese (Mn)	ug/L	9.0	9.0	9.0	9.0	9.0	1	100.0	216.0	158.0	129.0	187.0	2	100.0	231.0	165.5	132.8	198.3	2	31.0	586.0	214.0	160.0	372.5	11	NS	NS	NS
Mercury (Hg)	ug/L	< 0.10	***0.30***	***0.05***	***0.05***	***0.05***	16	< 0.20	***0.70***	***0.05***	***0.05***	***0.10***	34	< 0.20	***0.20***	***0.05***	***0.05***	***0.05***	21	< 0.20	***1.70***	***0.05***	***0.05***	***0.05***	36	0.013A/0.005C	0.026^^	$1.4^{MC,H}/0.77^{CC,H}$
Molybdenum (Mo)	ug/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	1	< 0.2	1.0	0.6	0.3	0.8	2	< 0.2	2.3	1.0	0.6	1.7	3	< 0.2	6.4	3.0	2.1	4.3	11	73^	73	NS
Nickel (Ni)	ug/L	0.6	2.0	1.3	1.0	1.7	2	1.1	3.5	2.3	1.7	2.9	2	0.7	2.7	1.7	1.2	2.2	2	< 1.0	6.5	1.4	0.5	2.6	11	HardnessH^	65b	$470^{MC,H}/52^{CC,H}$
Selenium (Se)	ug/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	1	0.2	0.2	0.2	0.2	0.2	1	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	1	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	1	1.0^	1	5^{CC}
Silicon (Si)	ug/L	1330	1330	1330	1330	1330	1	1400	1400	1400	1400	1400	1	2220	2220	2220	2220	2220	1	3840	3840	3840	3840	3840	1	NS	NS	NS
Silver (Ag)	ug/L	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	1	< 0.40	***1.60***	***0.90***	***0.55***	***1.25***	2	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	2	< 0.40	***2.30***	0.05	0.05	***0.16***	10	0.1^	0.1	$3.2^{MC,H}$
Strontium (Sr)	ug/L	22.0	22.0	22.0	22.0	22.0	1	20.0	92.0	56.0	38.0	74.0	2	17.0	197.6	107.3	62.1	152.4	2	83.0	467.6	234.0	181.3	361.0	10	NS	NS	NS
Sulphur (S)	ug/L	700	700	700	700	700	1	400	400	400	400	400	1	300	300	300	300	300	1	1400	1400	1400	1400	1400	1	NS	NS	NS
Thallium (Tl)	ug/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	1	< 0.2	< 0.1	< 0.2	< 0.2	< 0.1	2	< 0.2	< 4.0	< 2.1	< 1.2	< 3.1	2	< 4.0	***13.7***	***2.0***	***2.0***	***7.2***	10	0.8^	0.8	NS
Tin (Sn)	ug/L	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	1	< 1.0	0.9	0.7	0.6	0.8	2	< 3.0	1.0	1.3	1.1	1.4	2	< 3.0	18.4	1.5	1.5	1.5	10	NS	NS	NS
Titanium (Ti)	ug/L	< 10.0	3.0	5.0	4.0	5.0	3	< 10.0	5.9	5.0	4.5	5.2	4	< 50.0	4.0	25.0	9.3	25.0	6	< 50.0	50.0	1.6	0.4	4.7	12	NS	NS	NS
Uranium (U)	ug/L	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	1	< 0.4	0.2	0.2	0.2	0.2	2	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	1	< 0.4	0.8	0.5	0.4	0.7	2	NS	NS	NS
Vanadium (V)	ug/L	< 1.0	6.0	0.5	0.5	2.5	11	< 1.0	14.0	0.5	0.5	1.5	19	< 1.0	4.0	0.5	0.5	2.0	14	< 1.0	5.0	0.5	0.5	0.5	23	NS	NS	NS
Zinc (Zn)	ug/L	< 1	7	4	2	5	2	13	***37***	25	19	***31***	2	3	***33***	18	10	25	2	2	20	3	2	12	11	30^	30	$120^{M,H}/120^{CC,H}$
Zirconium (Zr)	ug/L	0.5	0.5	0.5	0.5	0.5	1	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	1	0.3	0.3	0.3	0.3	0.3	1	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	1	NS	NS	NS

Table 7C-1 Water Quality in Watercourses in the Horse and Hangingstone River Basin

Parameter	Unit	Spring, Watercourses (1976 - 1981, 1983)						Summer, Watercourses (1976 - 1983, 2001)						Fall, Watercourses (1976 - 1983, 2001, 2004)						Winter, Watercourses (1973, 1976 - 1982,1989, 2001 and 2002)						AENV Freshwater Aquatic Life*	CCME Water Quality Guidelines - Freshwater^	EPA Freshwater Water Quality***
		Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N			
Dissolved Metals																												
Aluminum	ug/L	--	--	--	--	--	0	22	38	30	26	34	3	14	14	14	14	14	1	< 10	< 10	< 10	< 10	< 10	1	NS	NS	$750^{MC}/87^{CC}$
Antimony	ug/L	0.3	0.3	0.3	0.3	0.3	1	< 5.0	280.0	2.5	2.0	71.9	4	--	--	--	--	--	0	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	1	NS	NS	NS
Arsenic	ug/L	< 0.5	9.0	0.7	0.3	2.1	9	< 10.0	3.5	0.9	0.7	1.5	16	0.4	2.5	1.2	0.6	2.0	8	< 1.0	6.0	0.6	0.5	1.0	22	NS	NS	$340^{MC}/150^{CC}$
Barium	ug/L	--	--	--	--	--	0	25.8	30.6	25.8	12.9	28.2	2	--	--	--	--	--	0	64.5	64.5	64.5	64.5	64.5	1	NS	NS	NS
Beryllium	ug/L	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	2	< 5.00	0.50	0.38	0.25	1.00	4	--	--	--	--	--	0	< 0.50	< 5.00	< 1.00	< 0.75	< 3.00	3	NS	NS	NS
Bismuth	ug/L	--	--	--	--	--	0	< 0.05	< 7.00	< 5.50	< 3.53	< 7.00	3	--	--	--	--	--	0	0.68	0.68	0.68	0.68	0.68	1	NS	NS	
Boron	ug/L	0.1	0.2	0.2	0.1	0.2	15	30.1	320.0	145.0	120.0	207.5	26	< 50.0	290.0	140.0	87.5	177.5	14	10.0	400.0	225.0	153.3	265.0	24	NS	NS	NS
Cadmium	ug/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	1	< 0.10	< 1.00	< 0.50	< 0.40	< 0.63	4	--	--	--	--	--	0	< 0.10	< 1.00	< 0.55	< 0.33	< 0.78	2	NS	NS	$20^{MC,H}/0.25^{CC,H}$
Chromium	ug/L	--	--	--	--	--	0	< 0.4	< 0.8	< 0.8	< 0.6	< 0.8	3	--	--	--	--	--	0	2.4	5.0	3.7	3.1	4.4	2	NS	NS	$570^{MC,H}/74^{CC,H}$
Cobalt	ug/L	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	2	< 2.0	0.7	0.5	0.3	0.8	4	--	--	--	--	--	0	< 2.0	0.4	0.7	0.6	0.9	2	NS	NS	NS
Copper	ug/L	< 1.0	7.0	1.0	0.8	4.0	3	0.9	2.6	1.9	1.4	2.3	3	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	1	0.7	0.7	0.7	0.7	0.7	1	NS	NS	$13^{MC,H}/9^{CC,H}$
Iron	ug/L	260	390	290	275	340	3	1837	2450	1842	1840	2146	3	1200	1200	1200	1200	1200	1	10	10	10	10	10	1	NS	NS	1000CC
Lead	ug/L	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	1	< 2.0	< 0.1	< 2.0	< 2.0	< 1.1	3	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	1	NS	NS	$65^{MC,H}/2.5^{CC,H}$
Lithium	ug/L	--	--	--	--	--	0	7.7	10.9	8.2	8.0	9.6	3	--	--	--	--	--	0	30.3	30.3	30.3	30.3	30.3	1	NS	NS	NS
Manganese	ug/L	8.0	10.0	10.0	9.0	10.0	3	< 10.0	21.7	13.2	10.3	16.2	4	--	--	--	--	--	0	92.0	230.0	161.0	126.5	195.5	2	NS	NS	NS
Mercury	ug/L	--	--	--	--	--	0	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	1	--	--	--	--	--	0	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	1	NS	NS	$1.4^{MC,H}/0.77^{CC,H}$
Molybdenum	ug/L	--	--	--	--	--	0	< 1.0	1.1	0.5	0.5	0.8	3	--	--	--	--	--	0	4.2	4.2	4.2	4.2	4.2	1	NS	NS	NS
Nickel	ug/L	4.0	7.0	5.0	4.5	6.0	3	< 1.0	9.0	1.7	0.9	4.1	4	--	--	--	--	--	0	3.0	4.2	3.6	3.3	3.9	2	NS	NS	$470^{MC,H}/52^{CC,H}$
Silver	ug/L	--	--	--	--	--	0	< 0.2	< 1.0	< 1.0	< 0.6	< 1.0	3	--	--	--	--	--	0	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	1	NS	NS	$3.2^{MC,H}$
Strontium	ug/L	--	--	--	--	--	0	90.0	120.9	93.2	91.6	107.1	3	--	--	--	--	--	0	330.0	330.0	330.0	330.0	330.0	1	NS	NS	NS
Sulphur	ug/L	--	--	--	--	--	0	< 0.1	< 4.0	< 2.0	< 1.0	< 3.0	2	--	--	--	--	--	0	--	--	--	--	--	0	NS	NS	NS
Thallium	ug/L	--	--	--	--	--	0	< 4.0	5.8	2.0	1.1	3.9	3	--	--	--	--	--	0	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	1	NS	NS	NS
Tin	ug/L	--	--	--	--	--	0	< 0.4	9.2	1.7	0.9	5.5	3	--	--	--	--	--	0	2.0	2.0	2.0	2.0	2.0	1	NS	NS	NS
Titanium	ug/L	--	--	--	--	--	0	0.1	0.1	0.1	0.1	0.1	1	--	--	--	--	--	0	0.7	0.7	0.7	0.7	0.7	1	NS	NS	NS
Vanadium	ug/L	1.0	2.0	1.5	1.3	1.8	2	< 1.0	1.0	0.5	0.5	0.6	4	--	--	--	--	--	0	< 1.0	0.2	0.4	0.3	0.4	2	NS	NS	NS
Zinc	ug/L	< 1	8	2	1	5	3	1	6	3	1	5	4	--	--	--	--	--	0	1	5	3	2	4	2	NS	NS	$120^{M,H}/120^{CC,H}$
Polycyclic Aromatic Hydrocarbons																												
Naphthalene	ug/L	--	--	--	--	--	0	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	1	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	1	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	1	1.1^	1.1	NS
Acephthylene	ug/L	--	--	--	--	--	0	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	1	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	1	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	1	NS	NS	NS
Acenaphthene	ug/L	--	--	--	--	--	0	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	1	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	1	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	1	5.8^	5.8	NS
Fluorene	ug/L	--	--	--	--	--	0	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	1	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	1	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	1	3^	3	NS
Phenanthrene	ug/L	--	--	--	--	--	0	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	1	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	1	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	1	0.4^	0.4	NS
Anthracene	ug/L	--	--	--	--	--	0	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1	0.012^	0.012	NS
Acridine	ug/L	--	--	--	--	--	0	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	1	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	1	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	1	4.4^	NS	NS
Fluoranthene	ug/L	--	--	--	--	--	0	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	1	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	1	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	1	0.04^	0.04	NS
Pyrene	ug/L	--	--	--	--	--	0	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	1	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	1	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	1	0.025^	0.025	NS
Benz[a]anthracene	ug/L	--	--	--	--	--	0	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	1	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1	0.018^	0.018	NS
Chrysene	ug/L	--	--	--	--	--	0	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	1	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	1	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	1	NS	NS	NS
Benzo[b]fluoranthene	ug/L	--	--	--	--	--	0	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	1	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	1	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	1	NS	NS	NS
Benzo[k]fluoranthene	ug/L	--	--	--	--	--	0	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	1	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	1	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	1	NS	NS	NS
Benzo[a]pyrene	ug/L	--	--	--	--	--	0	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	1	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1	0.015^	0.015	NS
Indeno[1,2,3-cd]pyrene	ug/L	--	--	--	--	--	0	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	1	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	1	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	1	NS	NS	NS
Dibenzo[a,h]anthracene	ug/L	--	--	--	--	--	0	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	1	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	1	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	1	NS	NS	NS
Quinoline	ug/L	--	--	--	--	--	0	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	1	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	1	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	1	NS	NS	NS
Benzo[g,h,i]perylene	ug/L	--	--	--	--	--	0	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	1	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	1	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	1	NS	NS	NS
CCME BP Equivalent	ug/L	--	--	--	--	--	0	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1	NS	NS	NS

Notes:

--- - not analyzed
NS - not specified
^ - Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME, 2006)
* - Alberta Environment Surface Water Quality Guidelines for use in Alberta (AENV, 1999)
CC - continuous concentration guideline, National Recommended Water Quality Criteria (USEPA, 2006
MC - maximum concentration guideline, National Recommended Water Quality Criteria (USEPA, 2006)
*** - National Recommended Water Quality Criteria (USEPA, 2006)
^^ - indicates value for Inorganic Mercury
1 - value if pH <6.5, Ca <4.0, DOC <2
2 - value if pH ≥6.5, Ca ≥4.0, DOC ≥2
3 - refer to CCME summary table for DO guideline breakdown
4 - refer to USEPA summary table for Ammonia criteria calculations
A - Acute aquatic life guideline
A A - 1 day minimum, acute guideline
a - value if pH>6.5, Ca>4.0, DOC>2
b - dependent on hardness value
C - Chronic Aquatic Life guideline
H - dependent on hardness value
*** - value denotes NO_2-N guideline concentration
Italics - indicates that values exceed specified guideline

Appendix 7C Historical Water Quality in Watercourses in the RSA

Table 7C-2 Water Quality in Watercourses in the House River Basin

Parameter	Unit	Spring (1984)						Summer, Watercourses (1984, 1985)						Fall (1984)	Winter, Watercourses (1985, 1989 - 1996)						AENV Freshwater Aquatic Life*	CCME Water Quality Guidelines - Freshwater^	EPA Freshwater Water Quality***
		Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N	HOUSE RIVER	Min	Max	Median	25th percentile	75th percentile	N			
Field Parameters																							
Temperature	°C	8.4	8.4	8.4	8.4	8.4	1	13.5	15.2	14.3	13.9	14.8	2	--	< 0.5	0.2	0.2	0.1	0.2	9	NS	NS	NS
pH		7.6	7.6	7.6	7.6	7.6	1	6.4	7.7	7.1	6.7	7.4	2	--	7.0	7.5	7.3	7.1	7.4	9	6.5-8.5	6.5-9.0	6.5-9^{CC}
Conductivity (EC)	uS/cm	70	70	70	70	70	1	122	152	137	130	145	2	--	422	592	480	441	517	9	NS	NS	NS
Dissolved oxygen (DO)	mg/L	9.4	9.4	9.4	9.4	9.4	1	6.4	9.5	7.9	7.2	8.7	2	--	8.1	12.8	10.7	9.8	11.3	9	5.0AA	5.5-9.53	NS
Conventional Parameters																							
pH		8.0	8.0	8.0	8.0	8.0	1	7.3	7.7	7.6	7.5	7.7	3	7.5	7.2	7.9	7.6	7.4	7.7	9	6.5-9	6.5-9.0	6.5-9^{CC}
Conductivity (EC)	uS/cm	307	307	307	307	307	1	98	159	106	102	133	3	137	432	625	504	471	548	8	NS	NS	NS
Hardness ($CaCO_3$)	mg/L	110.0	110.0	110.0	110.0	110.0	1	42.0	58.0	45.0	43.5	51.5	3	59.8	191.0	259.0	215.0	197.0	222.0	9	NS	NS	NS
Alkalinity ($CaCO_3$)	mg/L	106.1	106.1	106.1	106.1	106.1	1	34.5	49.7	49.6	42.1	49.7	3	52.2	189.8	256.0	202.0	191.0	233.0	9	NS	NS	20^{CC}
Total Dissolved Solids	mg/L	176.5	176.5	176.5	176.5	176.5	1	51.0	79.6	54.2	52.6	66.9	3	76.0	264.0	371.0	288.5	267.5	312.8	8	NS	NS	NS
Total Suspended Solids	mg/L	5.0	5.0	5.0	5.0	5.0	1	13.0	13.0	13.0	13.0	13.0	1	--	--	--	--	--	--	0	NS	NS	NS
Turbidity	NTU	5.2	20.0	12.6	8.9	16.3	2	13.5	275.0	144.2	78.9	209.6	2	75.0	7.6	22.0	13.1	9.9	14.8	10	NS	NS	NS
Major Ions																							
Carbonate (CO_3)	mg/L	--	--	--	--	--	0	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1	--	--	--	--	--	--	0	NS	NS	NS
Bicarbonate (HCO_3 ($CaCO_3$))	mg/L	--	--	--	--	--	0	60.6	60.6	60.6	60.6	60.6	1	--	--	--	--	--	--	0	NS	NS	NS
Sodium (Na)	mg/L	18.0	18.0	18.0	18.0	18.0	1	0.9	8.0	4.0	2.5	6.0	3	4.0	23.0	39.0	26.0	24.3	29.5	10	NS	NS	NS
Potassium (K)	mg/L	1.9	1.9	1.9	1.9	1.9	1	< 0.3	0.9	0.6	0.4	0.8	3	0.7	1.9	3.3	2.3	2.1	2.6	9	NS	NS	NS
Calcium (Ca)	mg/L	31.0	31.0	31.0	31.0	31.0	1	12.0	15.0	13.7	12.9	14.4	3	19.0	53.0	69.0	59.0	54.0	61.0	9	NS	NS	NS
Magnesium (Mg)	mg/L	8.0	8.0	8.0	8.0	8.0	1	2.6	5.0	3.0	2.8	4.0	3	3.0	14.0	21.0	16.0	15.0	17.0	9	NS	NS	NS
Chloride (Cl)	mg/L	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	1	< 1.0	1.1	0.5	0.5	0.8	3	2.0	1.2	4.1	2.1	1.8	2.6	10	230**	NS	860^{MC}/230^{CC}
Sulphate (SO_4)	mg/L	53.0	53.0	53.0	53.0	53.0	1	2.2	20.0	13.0	7.6	16.5	3	16.0	44.2	78.0	53.5	50.3	54.8	10	NS	NS	NS
Nutrients																							
Nitrite (NO_2-N)	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	1	< 0.003	0.005	0.004	0.003	0.005	3	0.005	0.003	0.518	0.006	0.005	0.016	8	0.018	0.018	NS
Nitrate (NO_3 -N)	mg/L	--	--	--	--	--	0	0.011	0.011	0.011	0.011	0.011	1	--	--	--	--	--	--	0	NS	2.9	NS
Nitrate + nitrite (NO_3 + NO_2 -N)	mg/L	0.002	0.002	0.002	0.002	0.002	1	0.011	0.038	0.031	0.021	0.035	3	0.080	0.480	0.723	0.566	0.533	0.658	10	0.018***	NS	NS
Nitrogen - Ammonia (NH_4-N)	mg/L	0.01	0.08	0.04	0.02	0.06	2	0.01	0.11	0.03	0.02	0.07	3	0.02	0.17	0.30	0.20	0.17	0.25	4	1.37 to 2.20	0.015	NS^{4}
Nitrogen - Kjeldahl (TKN)	mg/L	0.55	0.85	0.70	0.63	0.78	2	0.74	1.59	1.50	1.12	1.55	3	1.15	0.52	0.98	0.70	0.64	0.79	10	NS	NS	NS
Total nitrogen (TKN+NO_3 + NO_2)	mg/L	0.85	0.85	0.85	0.85	0.85	1	1.601	1.601	1.601	1.601	1.601	1	--	--	--	--	--	--	0	1.0C	NS	NS
Phosphorus, total	mg/L	0.052	0.082	0.067	0.060	0.075	2	0.076	0.720	0.167	0.122	0.444	3	0.400	0.066	0.165	0.113	0.094	0.134	10	0.05C	NS	NS
Total organic carbon	mg/L	--	--	--	--	--	0	--	--	--	--	--	0	--	13	19	16	15	18	2	NS	NS	NS
Dissolved organic carbon	mg/L	15	15	15	15	15	1	22	27	24	23	25	2	24	10	21	16	14	17	10	NS	NS	NS
Organics																							
Total Phenolics	mg/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	--	0	0.005C	NS	NS
Total recoverable hydrocarbons	mg/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	--	0	NS	NS	NS
Total Metals																							
Aluminum (Al)	ug/L	24	24	24	24	24	1	44	44	44	44	44	1	--	80	80	80	80	80	1	5^1/100^2	100a	750^{MC}/87^{CC}
Antimony (Sb)	ug/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	1	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	1	--	--	--	--	--	--	0	NS	NS	NS
Arsenic (As)	ug/L	1.4	6.2	3.8	2.6	5.0	2	0.80	2.10	1.45	1.13	1.78	2	4.8	0.7	1.4	1.0	0.8	1.2	10	5.0^	5	340^{MC}/150^{CC}
Barium (Ba)	ug/L	37.8	37.8	37.8	37.8	37.8	1	53.5	53.5	53.5	53.5	53.5	1	--	46.0	55.0	51.0	50.0	52.0	9	NS	NS	NS
Beryllium (Be)	ug/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	1	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	1	--	< 1	< 1	< 1	< 1	< 1	1	NS	NS	NS
Boron (B)	ug/L	20	20	20	20	20	1	20.0	20.0	20.0	20.0	20.0	1	--	--	--	--	--	--	0	NS	NS	NS
Cadmium (Cd)	ug/L	0.52	2.00	1.26	0.89	1.63	2	< 1.00	2.00	0.50	0.25	1.25	3	2.00	< 1.00	2.00	1.00	0.63	1.75	10	HardnessH^	0.017b	20^{MC,H}/0.25^{CC,H}
Chromium (Cr)	ug/L	2.0	5.0	3.5	2.8	4.3	2	6.0	13.0	6.0	6.0	9.5	3	8.0	< 2.0	6.0	3.0	1.5	3.8	10	8.9^	8.9	570^{MC,H}/74^{CC,H}
Cobalt (Co)	ug/L	< 0.3	< 1.0	< 0.7	< 0.5	< 0.8	2	< 0.3	8.0	4.0	2.1	6.0	3	5.0	< 1.0	4.0	2.0	1.0	2.0	9	NS	NS	NS
Copper (Cu)	ug/L	< 0.2	4.0	2.1	1.1	3.0	2	0.3	46.0	5.0	2.7	25.5	3	8.0	< 1.0	3.0	1.5	1.0	2.0	10	HardnessH	2b	13^{MC,H}/9^{CC,H}
Iron (Fe)	ug/L	--	--	--	--	--	0	640	640	640	640	640	1	--	908	3420	1659	1388	2680	9	300	300	1000CC
Lead (Pb)	ug/L	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	1	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	1	--	< 300	< 300	< 300	< 300	< 300	1	HardnessH^	2b	65^{MC,H}/2.5^{CC,H}
Lithium (Li)	ug/L	< 4	< 4	< 4	< 4	< 4	1	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	1	--	--	--	--	--	--	0	NS	NS	NS
Manganese (Mn)	ug/L	126.0	126.0	126.0	126.0	126.0	1	13.0	320.0	114.0	63.5	217.0	3	284.0	163.0	644.0	289.0	249.3	323.5	10	NS	NS	NS
Mercury (Hg)	ug/L	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	2	< 0.10	< 0.05	< 0.10	< 0.10	< 0.10	< 0.10	10	0.013A/0.005C	0.026^^	1.4^{MC,H}/0.77^{CC,H}
Molybdenum (Mo)	ug/L	< 0.2	< 1.0	< 0.6	< 0.4	< 0.8	2	< 1.0	12.0	0.5	0.3	6.3	3	< 1.0	< 3.0	5.0	2.0	2.0	3.0	10	73^	73	NS
Nickel (Ni)	ug/L	5.5	7.0	6.3	5.9	6.6	2	0.6	20.0	10.0	5.3	15.0	3	14.0	< 1.0	25.0	8.0	5.5	9.0	10	HardnessH^	65b	470^{MC,H}/52^{CC,H}
Selenium (Se)	ug/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	1	0.3	0.3	0.3	0.3	0.3	1	--	--	--	--	--	--	0	1.0^	1	5^{CC}
Silicon (Si)	ug/L	1620	1620	1620	1620	1620	1	3180	3180	3180	3180	3180	1	--	--	--	--	--	--	0	NS	NS	NS
Silver (Ag)	ug/L	0.1	0.1	0.1	0.1	0.1	1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	1	--	--	--	--	--	--	0	0.1^	0.1	3.2^{MC,H}
Strontium (Sr)	ug/L	45	45	45	45	45	1	56.0	56.0	56.0	56.0	56.0	1	--	--	--	--	--	--	0	NS	NS	NS
Sulphur (S)	ug/L	500	500	500	500	500	1	400	400	400	400	400	1	--	--	--	--	--	--	0	NS	NS	NS
Thallium (Tl)	ug/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	1	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	1	--	--	--	--	--	--	0	0.8^	0.8	NS
Tin (Sn)	ug/L	< 1	< 1	< 1	< 1	< 1	1	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	1	--	--	--	--	--	--	0	NS	NS	NS
Titanium (Ti)	ug/L	3	3	3	3	3	1	2.0	2.0	2.0	2.0	2.0	1	--	--	--	--	--	--	0	NS	NS	NS
Uranium (U)	ug/L	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	1	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	1	--	--	--	--	--	--	0	NS	NS	NS
Vanadium (V)	ug/L	< 1	4.0	2.3	1.4	3.1	2	< 1.0	22.0	8.0	4.3	15.0	3	12.0	< 2.0	6.0	3.0	1.3	4.8	10	NS	NS	NS
Zinc (Zn)	ug/L	7	8	7	7	8	2	14	72	22	18	47	3	28	3	23	7	4	9	10	30^	30	120^{M,H}/120^{CC,H}
Zirconium (Zr)	ug/L	2.7	2.7	2.7	2.7	2.7	1	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	1	--	--	--	--	--	--	0	NS	NS	NS

Table 7C-2 Water Quality in Watercourses in the House River Basin

Parameter	Unit	Spring (1984)						Summer, Watercourses (1984, 1985)						Fall (1984)	Winter, Watercourses (1985, 1989 - 1996)						AENV Freshwater Aquatic Life*	CCME Water Quality Guidelines - Freshwater^	EPA Freshwater Water Quality***
		Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N	HOUSE RIVER	Min	Max	Median	25th percentile	75th percentile	N			
Dissolved Metals																							
Aluminum	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	--	0	**NS**	**NS**	**$750^{MC}/87^{CC}$**
Antimony	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	--	0	**NS**	**NS**	**NS**
Arsenic	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	--	0	**NS**	**NS**	**$340^{MC}/150^{CC}$**
Barium	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	--	0	**NS**	**NS**	**NS**
Beryllium	ug/L	--	--	--	--	--	0	<1.0	<1.0	<1.0	<1.0	<1.0	1	--	< 1	< 1	< 1	< 1	< 1	8	**NS**	**NS**	**NS**
Bismuth	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	--	0	**NS**	**NS**	
Boron	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	--	0	**NS**	**NS**	**NS**
Cadmium	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	--	0	**NS**	**NS**	**$20^{MC,H}/0.25^{CC,H}$**
Chromium	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	--	0	**NS**	**NS**	**$570^{MC,H}/74^{CC,H}$**
Cobalt	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	--	0	**NS**	**NS**	**NS**
Copper	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	--	0	**NS**	**NS**	**$13^{MC,H}/9^{CC,H}$**
Iron	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	--	0	**NS**	**NS**	**1000CC**
Lead	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	--	0	**NS**	**NS**	**$65^{MC,H}/2.5^{CC,H}$**
Lithium	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	--	0	**NS**	**NS**	**NS**
Manganese	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	--	0	**NS**	**NS**	**NS**
Mercury	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	--	0	**NS**	**NS**	**$1.4^{MC,H}/0.77^{CC,H}$**
Molybdenum	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	--	0	**NS**	**NS**	**NS**
Nickel	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	--	0	**NS**	**NS**	**$470^{MC,H}/52^{CC,H}$**
Silver	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	--	0	**NS**	**NS**	**$3.2^{MC,H}$**
Strontium	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	--	0	**NS**	**NS**	**NS**
Sulphur	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	--	0	**NS**	**NS**	**NS**
Thallium	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	--	0	**NS**	**NS**	**NS**
Tin	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	--	0	**NS**	**NS**	**NS**
Titanium	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	--	0	**NS**	**NS**	**NS**
Vanadium	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	--	0	**NS**	**NS**	**NS**
Zinc	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	--	0	**NS**	**NS**	**$120^{M,H}/120^{CC,H}$**
Polycyclic Aromatic Hydrocarbons																							
Naphthalene	ug/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	1	--	--	--	--	--	0	--	--	--	--	--	--	0	**1.1^**	**1.1**	**NS**
Acephthylene	ug/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	1	--	--	--	--	--	0	--	--	--	--	--	--	0	**NS**	**NS**	**NS**
Acenaphthene	ug/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	1	--	--	--	--	--	0	--	--	--	--	--	--	0	**5.8^**	**5.8**	**NS**
Fluorene	ug/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	1	--	--	--	--	--	0	--	--	--	--	--	--	0	**3^**	**3**	**NS**
Phenanthrene	ug/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	1	--	--	--	--	--	0	--	--	--	--	--	--	0	**0.4^**	**0.4**	**NS**
Anthracene	ug/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1	--	--	--	--	--	0	--	--	--	--	--	--	0	**0.012^**	**0.012**	**NS**
Acridine	ug/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	1	--	--	--	--	--	0	--	--	--	--	--	--	0	**4.4^**	**NS**	**NS**
Fluoranthene	ug/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	1	--	--	--	--	--	0	--	--	--	--	--	--	0	**0.04^**	**0.04**	**NS**
Pyrene	ug/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	1	--	--	--	--	--	0	--	--	--	--	--	--	0	**0.025^**	**0.025**	**NS**
Benz[a]anthracene	ug/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1	--	--	--	--	--	0	--	--	--	--	--	--	0	**0.018^**	**0.018**	**NS**
Chrysene	ug/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	1	--	--	--	--	--	0	--	--	--	--	--	--	0	**NS**	**NS**	**NS**
Benzo[b]fluoranthene	ug/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	1	--	--	--	--	--	0	--	--	--	--	--	--	0	**NS**	**NS**	**NS**
Benzo[k]fluoranthene	ug/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	1	--	--	--	--	--	0	--	--	--	--	--	--	0	**NS**	**NS**	**NS**
Benzo[a]pyrene	ug/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1	--	--	--	--	--	0	--	--	--	--	--	--	0	**0.015^**	**0.015**	**NS**
Indeno[1,2,3-cd]pyrene	ug/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	1	--	--	--	--	--	0	--	--	--	--	--	--	0	**NS**	**NS**	**NS**
Dibenzo[a,h]anthracene	ug/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	1	--	--	--	--	--	0	--	--	--	--	--	--	0	**NS**	**NS**	**NS**
Quinoline	ug/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	1	--	--	--	--	--	0	--	--	--	--	--	--	0	**NS**	**NS**	**NS**
Benzo[g,h,i]perylene	ug/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	1	--	--	--	--	--	0	--	--	--	--	--	--	0	**NS**	**NS**	**NS**
CCME BP Equivalent	ug/L	< 0.0078	< 0.0078	< 0.0078	< 0.0078	< 0.0078	1	--	--	--	--	--	0	--	--	--	--	--	--	0	**NS**	**NS**	**NS**

Notes:

--- - not analyzed
NS - not specified
^ - Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME, 2006)
* - Alberta Environment Surface Water Quality Guidelines for use in Alberta (AENV, 1999)
CC - continuous concentration guideline, National Recommended Water Quality Criteria (USEPA, 2006
MC - maximum concentration guideline, National Recommended Water Quality Criteria (USEPA, 2006)
*** - National Recommended Water Quality Criteria (USEPA, 2006)
^^ - indicates value for Inorganic Mercury
1 - value if pH <6.5, Ca <4.0, DOC <2
2 - value if pH ≥6.5, Ca ≥4.0, DOC ≥2
3 - refer to CCME summary table for DO guideline breakdown
4 - refer to USEPA summary table for Ammonia criteria calculations
A - Acute aquatic life guideline
A A - 1 day minimum, acute guideline
a - value if pH>6.5, Ca>4.0, DOC>2
b - dependent on hardness value
C - Chronic Aquatic Life guideline
H - dependent on hardness value
*** - value denotes NO_2-N guideline concentration
Italics - indicates that values exceed specified guideline

Appendix 7C Historical Water Quality in Watercourses in the RSA

Table 7C-3 Water Quality in Watercourses in the Upper Christina River Basin

Parameter	Unit	Spring, Watercourses (1998 and 2006)						Summer, Watercourses (1998, 2005, and 2006)						Fall, Watercourses (2005)						Winter, Watercourses (2006)						AENV Freshwater Aquatic Life*	CCME Water Quality Guidelines - Freshwater^	EPA Freshwater Water Quality***
		Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N			
Field Parameters																												
Temperature	°C	3.0	11.2	7.2	5.8	8.2	20	12.7	17.6	15.6	14.6	16.3	24	1.5	7.5	5.2	4.9	6.1	17	0.0	0.8	0.1	0.0	0.6	9	NS	NS	NS
pH		3.5	9.7	6.7	6.2	8.0	18	2.5	9.4	7.4	6.8	9.2	24	6.0	9.6	7.6	7.1	9.6	17	6.5	6.8	6.6	6.5	6.7	9	6.5-8.5	6.5-9.0	$6.5\text{-}9^{CC}$
Conductivity (EC)	uS/cm	12	518	90	35	103	19	27	402	115	80	148	24	50	760	170	110	230	17	243	742	350	317	438	9	NS	NS	NS
Dissolved oxygen (DO)	mg/L	6.7	22.2	11.2	10.4	12.0	20	4.4	13.6	8.9	8.3	9.8	24	7.0	16.6	12.3	11.1	12.6	17	0.8	12.8	6.8	6.0	11.1	9	5.0AA	5.5-9.53	NS
Conventional Parameters																												
pH		7.5	7.5	7.5	7.5	7.5	1	4.4	8.1	7.8	7.6	7.9	18	4.5	8.2	8.1	7.5	8.1	16	7.5	7.9	7.7	7.6	7.8	9	6.5-9	6.5-9.0	$6.5\text{-}9^{CC}$
Conductivity (EC)	uS/cm	444	444	444	444	444	1	28	405	92	77	109	18	27	224	161	65	187	16	246	724	412	359	450	9	NS	NS	NS
Hardness ($CaCO_3$)	mg/L	220.0	220.0	220.0	220.0	220.0	1	5.3	190.0	46.5	41.3	56.9	18	6.5	120.0	80.5	33.5	89.8	16	120.0	300.0	190.0	180.0	220.0	9	NS	NS	NS
Alkalinity ($CaCO_3$)	mg/L	--	--	--	--	--	0	< 0.5	121.0	46.1	36.9	53.3	17	< 0.5	125.0	85.8	31.3	100.4	16	129.0	392.0	219.5	195.5	237.3	9	NS	NS	20^{CC}
Total Dissolved Solids	mg/L	247.0	247.0	247.0	247.0	247.0	1	< 10.0	217.0	51.0	46.3	63.6	18	< 10.0	128.0	88.5	33.8	100.3	16	132.0	421.0	224.0	193.0	245.5	9	NS	NS	NS
Total Suspended Solids	mg/L	1.0	36.0	11.0	6.0	22.5	19	1.0	40.0	9.3	3.0	20.3	18	1.0	24.0	8.0	4.8	12.0	16	3.0	20.0	5.0	3.0	6.0	9	NS	NS	NS
Turbidity	NTU	1.8	20.7	6.4	3.4	12.2	18	1.4	22.9	7.5	2.6	11.5	23	2.5	17.1	12.1	7.8	15.3	13	16.0	127.5	23.7	17.6	42.3	9	NS	NS	NS
Major Ions																												
Carbonate (CO_3)	mg/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	18	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	16	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	9	NS	NS	NS
Bicarbonate (HCO_3 ($CaCO_3$))	mg/L	270.0	270.0	270.0	270.0	270.0	1	< 0.5	246.0	56.5	46.1	68.5	18	< 0.5	153.0	104.5	38.2	122.5	16	158.0	478.0	268.0	238.5	289.8	9	NS	NS	NS
Sodium (Na)	mg/L	16.4	16.4	16.4	16.4	16.4	1	< 0.5	12.7	1.5	1.2	1.9	18	< 0.5	9.1	2.6	1.1	2.9	16	4.4	49.6	9.2	5.4	13.3	9	NS	NS	NS
Potassium (K)	mg/L	2.9	2.9	2.9	2.9	2.9	1	< 0.3	2.1	0.2	0.2	0.2	18	< 0.3	1.1	0.2	0.2	0.5	16	1.1	2.6	1.8	1.4	2.2	9	NS	NS	NS
Calcium (Ca)	mg/L	66.8	66.8	66.8	66.8	66.8	1	1.4	52.3	12.9	11.9	15.8	18	1.7	32.1	23.2	9.6	25.8	16	35.2	79.9	55.1	48.5	62.3	9	NS	NS	NS
Magnesium (Mg)	mg/L	18.1	18.1	18.1	18.1	18.1	1	0.4	14.6	3.4	2.8	4.3	18	0.5	9.0	5.5	2.2	6.7	16	7.5	23.6	14.4	12.8	15.4	9	NS	NS	NS
Chloride (Cl)	mg/L	0.6	0.6	0.6	0.6	0.6	1	0.3	1.9	1.4	1.2	1.5	18	< 0.5	1.2	1.0	0.7	1.1	16	1.2	1.6	1.5	1.3	1.5	9	230**	NS	$860^{MC}/230^{CC}$
Sulphate (SO_4)	mg/L	16.3	16.3	16.3	16.3	16.3	1	< 10.0	14.0	3.8	2.4	5.0	18	< 0.5	4.3	0.3	0.3	2.2	16	< 0.5	24.7	4.5	0.3	10.0	9	NS	NS	NS
Nutrients																												
Nitrite (NO_2-N)	mg/L	--	--	--	--	--	0	< 0.003	0.012	0.002	0.002	0.003	17	< 0.003	0.008	0.002	0.002	0.003	16	<0.003	<0.003	<0.003	<0.003	<0.003	9	0.018	0.018	NS
Nitrate (NO_3-N)	mg/L	--	--	--	--	--	0	0.004	0.088	0.022	0.010	0.035	17	< 0.003	0.117	0.008	0.004	0.053	16	<0.003	0.441	0.096	0.024	0.273	9	NS	2.9	NS
Nitrate + nitrite (NO_3 + NO_2 -N)	mg/L	0.230	0.230	0.230	0.230	0.230	1	< 0.003	0.096	0.021	0.010	0.039	18	< 0.003	0.121	0.009	0.006	0.055	16	<0.003	0.441	0.096	0.024	0.273	9	0.018***	NS	NS
Nitrogen - Ammonia (NH_4-N)	mg/L	0.02	0.24	0.04	0.03	0.05	18	< 0.01	0.07	0.04	0.03	0.05	17	< 0.01	0.08	0.03	0.02	0.04	16	0.18	1.88	0.57	0.33	0.88	9	1.37 to 2.20	0.015	NS^{4}
Nitrogen - Kjeldahl (TKN)	mg/L	0.67	1.29	0.87	0.81	0.95	18	0.41	1.03	0.83	0.77	0.96	17	0.52	1.06	0.73	0.63	0.80	16	0.66	2.63	1.34	0.98	1.97	9	NS	NS	NS
Total nitrogen (TKN+NO_3 + NO_2)	mg/L	0.74	1.53	0.88	0.8375	0.96	16	0.423	1.116	0.865	0.804	0.988	17	0.525	1.181	0.7725	0.64025	0.84	16	1.10	2.63	1.38	1.24	2.21	9	1.0C	NS	NS
Phosphorus, total	mg/L	0.019	0.170	0.067	0.047	0.121	18	0.023	0.258	0.091	0.062	0.120	17	0.023	0.219	0.090	0.053	0.118	16	0.067	0.442	0.100	0.083	0.171	9	0.05C	NS	NS
Total organic carbon	mg/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	NS	NS	NS
Dissolved organic carbon	mg/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	NS	NS	NS
Organics																												
Total Phenolics	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	1	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	1	--	--	--	--	--	0	--	--	--	--	--	0	0.005C	NS	NS
Total recoverable hydrocarbons	mg/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	NS	NS	NS
Total Metals																												
Aluminum (Al)	ug/L	27	466	193	78	293	19	< 10	957	215	74	279	18	19	279	113	54	158	16	14	63	36	24	47	9	5^1/100^2	100a	$750^{MC}/87^{CC}$
Antimony (Sb)	ug/L	< 0.2	0.7	0.1	0.1	0.1	18	< 0.2	0.4	0.1	0.1	0.1	17	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	16	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	9	NS	NS	NS
Arsenic (As)	ug/L	< 0.20	5.90	0.50	0.10	2.85	19	0.20	3.00	1.00	0.65	1.40	18	0.30	3.40	0.80	0.40	1.13	16	< 0.20	1.60	0.80	0.36	1.28	9	5.0^	5	$340^{MC}/150^{CC}$
Barium (Ba)	ug/L	6.6	42.9	23.8	17.4	35.9	18	13.3	52.6	36.4	24.2	50.0	17	9.3	51.9	31.6	23.1	47.4	16	61.2	105.0	71.2	63.3	94.7	9	NS	NS	NS
Beryllium (Be)	ug/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	18	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	17	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	16	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	9	NS	NS	NS
Boron (B)	ug/L	< 10.0	40.0	20.0	10.0	20.0	18	< 10.0	50.0	20.0	10.0	20.0	17	< 10.0	40.0	15.0	5.0	22.5	16	20.0	140.0	55.0	50.0	67.5	9	NS	NS	NS
Cadmium (Cd)	ug/L	< 0.20	0.26	0.13	0.01	0.20	19	< 0.20	0.29	0.08	0.01	0.20	18	< 0.01	0.07	0.03	0.02	0.03	16	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	9	HardnessH^	0.017b	$20^{MC,H}/0.25^{CC,H}$
Chromium (Cr)	ug/L	< 2.0	2.0	1.0	1.0	2.0	19	< 2.0	6.0	2.0	1.0	4.0	18	< 1.0	2.0	0.5	0.5	0.5	16	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	9	8.9^	8.9	$570^{MC,H}/74^{CC,H}$
Cobalt (Co)	ug/L	< 0.3	0.6	0.2	0.2	0.4	18	< 0.3	0.8	0.5	0.3	0.7	17	< 0.3	0.7	0.3	0.2	0.4	16	< 0.3	-0.3	0.2	0.2	0.2	9	NS	NS	NS
Copper (Cu)	ug/L	< 1.0	1.0	0.3	0.1	0.7	19	0.3	3.0	0.7	0.5	1.0	18	< 0.2	0.7	0.3	0.1	0.4	16	< 0.2	0.3	0.1	0.1	0.1	9	HardnessH	2b	$13^{MC,H}/9^{CC,H}$
Iron (Fe)	ug/L	60	60	60	60	60	1	200	2290	910	588	1080	18	98	2860	1755	735	2298	16	40	2220	160	68	500	9	300	300	1000CC
Lead (Pb)	ug/L	< 0.30	0.50	0.15	0.15	0.15	19	< 0.40	0.60	0.15	0.15	0.28	18	< 0.30	< 0.30	< 0.30	< 0.30	< 0.30	16	< 0.30	< 0.30	< 0.30	< 0.30	< 0.30	9	HardnessH^	2b	$65^{MC,H}/2.5^{CC,H}$
Lithium (Li)	ug/L	< 4.0	6.0	2.0	2.0	2.0	18	< 4.0	8.0	2.0	2.0	2.0	17	< 4.0	11.0	5.5	2.0	7.5	16	5.	44.0	13.0	8.3	15.5	9	NS	NS	NS
Manganese (Mn)	ug/L	325.0	325.0	325.0	325.0	325.0	1	< 4.0	150.0	25.5	9.3	54.3	18	19.0	565.0	54.5	38.0	67.5	16	188.0	2470.0	520.0	266.5	673.5	9	NS	NS	NS
Mercury (Hg)	ug/L	< 0.0006	< 0.0006	< 0.0006	< 0.0006	< 0.0006	16	< 0.0500	0.0019	0.0003	0.0003	0.0005	12	< 0.0006	0.0015	0.0003	0.0003	0.0003	16	< 0.0006	< 0.0006	< 0.0006	< 0.0006	< 0.0006	9	0.013A/0.005C	0.026^^	$1.4^{MC,H}/0.77^{CC,H}$
Molybdenum (Mo)	ug/L	< 0.2	1.0	0.1	0.1	0.3	18	< 0.2	0.5	0.1	0.1	0.3	17	< 0.2	0.9	0.2	0.1	0.5	16	< 0.2	0.8	0.1	0.1	0.1	9	73^	73	NS
Nickel (Ni)	ug/L	< 0.5	9.3	1.2	0.8	1.6	19	< 0.5	6.8	1.6	1.2	2.8	18	0.7	2.0	1.1	1.0	1.3	16	0.7	1.7	1.4	1.2	1.6	9	HardnessH^	65b	$470^{MC,H}/52^{CC,H}$
Selenium (Se)	ug/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	18	< 0.2	0.4	0.2	0.2	0.3	16	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	16	< 0.2	0.2	0.1	0.1	0.1	9	1.0^	1	5^{CC}
Silicon (Si)	ug/L	700	3010	2030	1398	2201	18	1100	4070	2760	2420	3140	17	1290	4860	3740	2648	4463	16	3420	9360	6570	5003	7355	9	NS	NS	NS
Silver (Ag)	ug/L	< 0.10	0.90	0.25	0.05	0.50	19	< 0.10	4.20	0.85	0.05	3.03	18	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	16	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	9	0.1^	0.1	$3.2^{MC,H}$
Strontium (Sr)	ug/L	7.0	80.0	38.0	22.5	56.0	18	12.0	130.0	57.0	48.0	69.0	17	10.0	154.0	87.0	39.0	110.8	16	143.0	371.0	211.5	184.0	239.8	9	NS	NS	NS
Sulphur (S)	ug/L	300	2000	675	500	838	18	150	1100	500	400	600	17	200	1900	400	300	1050	16	300	7200	1900	825	3050	9	NS	NS	NS
Thallium (Tl)	ug/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	18	< 0.2	0.2	0.1	0.1	0.1	17	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	16	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	9	0.8^	0.8	NS
Tin (Sn)	ug/L	< 1.0	1.0	0.5	0.5	0.5	18	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	17	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	16	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	9	NS	NS	NS
Titanium (Ti)	ug/L	1.0	12.0	4.0	3.0	6.8	18	2.0	20.0	5.0	3.5	7.0	17	1.0	5.0	3.0	2.0	3.3	16	< 1.0	4.0	2.0	2.0	2.8	9	NS	NS	NS
Uranium (U)	ug/L	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	18	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	17	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	16	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	9	NS	NS	NS
Vanadium (V)	ug/L	< 1.0	10.0	0.5	0.5	0.5	18	< 1.0	2.0	0.5	0.5	1.0	17	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	16	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	9	NS	NS	NS
Zinc (Zn)	ug/L	< 1	37	9	6	13	19	3	53	17	13	25	18	3	25	7	5	9	16	6	14	11	9	13	9	30^	30	$120^{M,H}/120^{CC,H}$
Zirconium (Zr)	ug/L	< 1.0	9.0	0.5	0.4	1.0	18	< 0.2	1.3	0.4	0.1	0.5	17	< 0.2	0.6	0.4	0.2	0.5	16	< 0.2	1.1	0.1	0.1	0.1	9	NS	NS	NS

Table 7C-3 Water Quality in Watercourses in the Upper Christina River Basin

Parameter	Unit	Spring, Watercourses (1998 and 2006)						Summer, Watercourses (1998, 2005, and 2006)						Fall, Watercourses (2005)						Winter, Watercourses (2006)						AENV Freshwater Aquatic Life*	CCME Water Quality Guidelines - Freshwater^	EPA Freshwater Water Quality***
		Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N			
Dissolved Metals																												
Aluminum	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**$750^{MC}/87^{CC}$**
Antimony	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Arsenic	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**$340^{MC}/150^{CC}$**
Barium	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Beryllium	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Bismuth	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	
Boron	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Cadmium	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**$20^{MC,H}/0.25^{CC,H}$**
Chromium	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**$570^{MC,H}/74^{CC,H}$**
Cobalt	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Copper	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**$13^{MC,H}/9^{CC,H}$**
Iron	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**1000CC**
Lead	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**$65^{MC,H}/2.5^{CC,H}$**
Lithium	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Manganese	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Mercury	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**$1.4^{MC,H}/0.77^{CC,H}$**
Molybdenum	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Nickel	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**$470^{MC,H}/52^{CC,H}$**
Silver	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**$3.2^{MC,H}$**
Strontium	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Sulphur	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Thallium	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Tin	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Titanium	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Vanadium	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Zinc	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**$120^{M,H}/120^{CC,H}$**
Polycyclic Aromatic Hydrocarbons																												
Naphthalene	ug/L	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	1	< 0.10	< 0.13	< 0.10	< 0.10	< 0.10	10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	16	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	9	**1.1^**	**1.1**	**NS**
Acephthylene	ug/L	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	1	< 0.10	< 0.13	< 0.10	< 0.10	< 0.10	10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	16	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	9	**NS**	**NS**	**NS**
Acenaphthene	ug/L	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	1	< 0.10	< 0.13	< 0.10	< 0.10	< 0.10	10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	16	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	9	**5.8^**	**5.8**	**NS**
Fluorene	ug/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	1	< 0.05	< 0.06	< 0.05	< 0.05	< 0.05	10	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	16	< 0.05	0.05	0.03	0.03	0.03	9	**3^**	**3**	**NS**
Phenanthrene	ug/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	1	< 0.05	< 0.06	< 0.05	< 0.05	< 0.05	10	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	16	< 0.05	0.31	0.03	0.03	0.03	9	**0.4^**	**0.4**	**NS**
Anthracene	ug/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	10	< 0.01	***0.02***	< 0.01	< 0.01	< 0.01	16	< 0.01	***0.04***	0.01	0.01	0.01	9	**0.012^**	**0.012**	**NS**
Acridine	ug/L	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	1	< 0.20	< 0.25	< 0.20	< 0.20	< 0.20	10	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	16	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	9	**4.4^**	**NS**	**NS**
Fluoranthene	ug/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	1	< 0.04	< 0.05	< 0.04	< 0.04	< 0.04	10	< 0.04	***0.07***	< 0.04	< 0.04	< 0.04	16	< 0.04	***0.36***	0.02	0.02	0.02	9	**0.04^**	**0.04**	**NS**
Pyrene	ug/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	1	< 0.02	< 0.03	< 0.02	< 0.02	< 0.02	10	< 0.02	***0.06***	< 0.02	< 0.02	< 0.02	16	< 0.02	***0.26***	0.01	0.01	0.02	9	**0.025^**	**0.025**	**NS**
Benz[a]anthracene	ug/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1	< 0.05	< 0.06	< 0.05	< 0.05	< 0.05	10	< 0.01	***0.03***	< 0.01	< 0.01	< 0.01	16	< 0.01	***0.10***	0.01	0.01	***0.02***	9	**0.018^**	**0.018**	**NS**
Chrysene	ug/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	1	< 0.05	< 0.06	< 0.05	< 0.05	< 0.05	10	< 0.05	0.07	< 0.05	< 0.05	< 0.05	16	< 0.05	0.10	0.03	0.03	0.03	9	**NS**	**NS**	**NS**
Benzo[b]fluoranthene	ug/L	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	1	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	16	< 0.10	0.13	0.05	0.05	0.05	9	**NS**	**NS**	**NS**
Benzo[k]fluoranthene	ug/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	1	< 0.05	< 0.06	< 0.05	< 0.05	< 0.05	10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	16	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	9	**NS**	**NS**	**NS**
Benzo[a]pyrene	ug/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1	< 0.05	< 0.06	< 0.05	< 0.05	< 0.05	10	< 0.01	***0.04***	< 0.01	< 0.01	< 0.01	16	< 0.01	***0.06***	0.01	0.01	0.005	9	**0.015^**	**0.015**	**NS**
Indeno[1,2,3-cd]pyrene	ug/L	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	1	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	16	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	9	**NS**	**NS**	**NS**
Dibenzo[a,h]anthracene	ug/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	1	< 0.05	< 0.06	< 0.05	< 0.05	< 0.05	10	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	16	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	9	**NS**	**NS**	**NS**
Quinoline	ug/L	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	1	< 0.20	< 0.25	< 0.20	< 0.20	< 0.20	10	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	16	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	9	**NS**	**NS**	**NS**
Benzo[g,h,i]perylene	ug/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	1	< 0.05	< 0.06	< 0.05	< 0.05	< 0.05	10	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	16	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	9	**NS**	**NS**	**NS**
CCME BP Equivalent	ug/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1	< 0.00001	< 0.01	< 0.01	< 0.01	< 0.01	10	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	16	< 0.01	0.08	0.004	0.004	0.004	9	**NS**	**NS**	**NS**

Notes:

--- - not analyzed
NS - not specified
^ - Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME, 2006)
* - Alberta Environment Surface Water Quality Guidelines for use in Alberta (AENV, 1999)
CC - continuous concentration guideline, National Recommended Water Quality Criteria (USEPA, 2006
MC - maximum concentration guideline, National Recommended Water Quality Criteria (USEPA, 2006
*** - National Recommended Water Quality Criteria (USEPA, 2006)
^^ - indicates value for Inorganic Mercury
1 - value if pH <6.5, Ca <4.0, DOC <2
2 - value if pH ≥6.5, Ca ≥4.0, DOC ≥2
3 - refer to CCME summary table for DO guideline breakdowr
4 - refer to USEPA summary table for Ammonia criteria calculations
A - Acute aquatic life guideline
A A - 1 day minimum, acute guideline
a - value if pH>6.5, Ca>4.0, DOC>2
b - dependent on hardness value
C - Chronic Aquatic Life guideline
H - dependent on hardness value
*** - value denotes NO_2-N guideline concentration
Italics - indicates that values exceed specified guideline

Appendix 7C Historical Water Quality in Watercourses in the RSA

Table 7C-4 Water Quality in Watercourses in the Mid-Christina River Basin

Parameter	Unit	Spring, Watercourses (2004 and 2005)						Summer, Watercourses (2004 and 2005)						Fall, Watercourses (2005)						Winter, Watercourses (2005)						AENV Freshwater Aquatic Life*	CCME Water Quality Guidelines - Freshwater^	EPA Freshwater Water Quality***
		Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N			
Field Parameters																												
Temperature	°C	5.2	19.9	7.8	6.9	8.4	8	12.4	21.6	14.8	13.5	16.0	7	2.7	12.8	4.2	3.8	6.8	5	0.1	0.6	0.1	0.1	0.1	5	NS	NS	NS
pH		6.9	7.8	7.6	7.3	7.7	8	7.2	7.9	7.5	7.3	7.5	7	7.4	8.3	7.9	7.8	7.9	5	7.3	7.7	7.5	7.4	7.7	5	6.5-8.5	6.5-9.0	$6.5\text{-}9^{CC}$
Conductivity (EC)	uS/cm	97	230	115	102	153	8	93	277	230	191	244.0	7	223	271	238	228	240	5	518	518	518	518	518	1	NS	NS	NS
Dissolved oxygen (DO)	mg/L	8.3	10.6	9.4	9.0	9.8	8	7.1	10.6	9.0	8.1	9.7	7	9.5	15.1	12.2	12.0	12.8	5	***1.4***	11.2	10.2	9.8	10.5	5	5.0AA	5.5-9.53	NS
Conventional Parameters																												
pH		7.6	8.1	8.0	7.7	8.0	5	7.9	8.1	8.1	8.0	8.1	3	8.1	8.2	8.2	8.1	8.2	2	7.6	7.6	7.6	7.6	7.6	1	6.5-9	6.5-9.0	$6.5\text{-}9^{CC}$
Conductivity (EC)	uS/cm	55	299	184	100	230	5	118	301	274	196	288	3	211	226	219	215	222	2	543	543	543	543	543	1	NS	NS	NS
Hardness ($CaCO_3$)	mg/L	29.0	136.0	82.0	69.0	94.0	9	61.0	139.0	97.0	93.0	117.0	7	108.0	138.0	130.0	119.0	132.0	5	147.0	253.0	152.0	147.0	158.0	5	NS	NS	NS
Alkalinity ($CaCO_3$)	mg/L	26.0	139.0	74.0	66.0	91.0	9	61.0	159.0	97.0	95.5	128.5	7	106.0	143.0	127.5	114.0	138.0	6	147.0	277.0	157.0	152.0	158.0	5	NS	NS	20^{CC}
Total Dissolved Solids	mg/L	75.0	180.0	93.0	80.0	130.0	9	70.0	200.0	98.0	95.0	126.0	7	119.0	240.0	139.5	136.0	143.0	6	149.0	280.0	161.0	155.0	162.0	5	NS	NS	NS
Total Suspended Solids	mg/L	4.0	175.0	14.0	4.0	33.3	8	3.0	740.0	9.0	6.0	13.5	7	6.0	9.0	8.0	7.0	8.5	3	-3.0	7.0	3.5	2.6	4.8	4	NS	NS	NS
Turbidity	NTU	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	NS	NS	NS
Major Ions																												
Carbonate (CO_3)	mg/L	< 5.0	< 0.5	< 5.0	< 5.0	< 5.0	8	< 5.0	< 0.5	< 5.0	< 5.0	< 5.0	7	< 5.0	< 0.5	< 5.0	< 5.0	< 5.0	5	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	5	NS	NS	NS
Bicarbonate (HCO_3 ($CaCO_3$))	mg/L	32.0	169.0	90.8	81.0	111.0	9	74.0	194.0	118.0	116.0	157.5	7	138.0	174.0	168.0	143.0	169.0	5	179.0	338.0	192.0	186.0	192.0	5	NS	NS	NS
Sodium (Na)	mg/L	2.0	11.0	4.0	2.4	7.0	9	2.0	17.0	3.0	3.0	7.2	7	3.0	8.0	6.0	5.3	6.8	6	4.0	22.0	7.0	6.0	9.0	5	NS	NS	NS
Potassium (K)	mg/L	1.0	3.0	1.2	1.0	1.3	9	0.1	1.0	0.7	0.5	0.9	7	< 0.5	1.0	0.8	0.5	0.9	5	1.7	3.0	1.8	1.7	2.1	5	NS	NS	NS
Calcium (Ca)	mg/L	8.0	37.0	21.8	18.1	24.4	9	16.0	37.0	25.6	24.6	32.5	7	29.0	36.6	33.3	31.9	34.7	5	39.6	70.0	40.4	39.8	42.6	5	NS	NS	NS
Magnesium (Mg)	mg/L	2.0	11.0	6.8	5.7	8.1	9	5.0	11.0	8.0	7.7	9.6	7	9.0	11.4	10.7	9.6	10.9	5	11.6	19.0	12.4	11.7	12.5	5	NS	NS	NS
Chloride (Cl)	mg/L	< 1.0	4.0	1.0	0.5	1.3	9	< 1.0	8.0	0.6	0.6	1.3	7	0.9	2.0	1.0	1.0	1.8	6	0.6	1.0	0.8	0.6	0.8	5	230**	NS	$860^{MC}/230^{CC}$
Sulphate (SO_4)	mg/L	< 5.0	13.0	2.9	2.0	3.4	9	< 0.5	9.0	1.2	0.7	3.0	7	0.9	6.0	3.0	2.7	4.1	6	2.0	27.0	2.1	2.0	2.1	5	NS	NS	NS
Nutrients																												
Nitrite (NO_2-N)	mg/L	< 0.003	< 0.050	< 0.050	< 0.050	< 0.005	5	< 0.003	***0.160***	***0.120***	***0.083***	***0.138***	4	< 0.003	< 0.050	< 0.050	< 0.038	< 0.050	4	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	4	0.018	0.018	NS
Nitrate (NO_3-N)	mg/L	< 0.100	0.006	0.050	0.039	0.050	4	< 0.050	0.090	0.048	0.023	0.075	4	< 0.003	< 0.100	< 0.100	< 0.076	< 0.100	4	0.190	0.280	0.235	0.213	0.258	4	NS	2.9	NS
Nitrate + nitrite (NO_3 + NO_2 -N)	mg/L	< 0.100	***0.050***	***0.050***	***0.050***	***0.050***	9	< 0.100	***0.230***	***0.050***	***0.050***	***0.165***	7	< 0.003	< 0.100	< 0.100	< 0.100	< 0.100	6	***0.19***	***0.80***	***0.25***	***0.22***	***0.28***	5	0.018***	NS	NS
Nitrogen - Ammonia (NH_4-N)	mg/L	< 0.05	0.17	0.03	0.03	0.03	8	< 0.05	0.04	0.03	0.03	0.03	7	< 0.05	0.01	0.03	0.03	0.03	5	< 0.05	0.07	0.05	0.05	0.07	5	1.37 to 2.20	0.015	NS^{4}
Nitrogen - Kjeldahl (TKN)	mg/L	< 0.20	1.00	0.80	0.49	0.80	9	0.33	0.90	0.60	0.55	0.70	7	0.40	0.70	0.40	0.40	0.51	5	0.50	5.40	0.60	0.50	0.60	5	NS	NS	NS
Total nitrogen (TKN+NO_3 + NO_2)	mg/L	0.30	0.90	0.65	0.60	0.90	5	0.70	0.90	0.80	0.75	0.85	2	0.70	***1.40***	***1.05***	0.88	***1.23***	2	***6.20***	***6.20***	***6.20***	***6.20***	***6.20***	1	1.0C	NS	NS
Phosphorus, total	mg/L	0.008	***0.184***	***0.072***	0.022	***0.081***	9	0.006	***0.059***	0.026	0.008	0.048	7	0.021	***0.070***	0.043	0.033	0.048	6	0.039	***0.060***	0.040	0.039	***0.059***	5	0.05C	NS	NS
Total organic carbon	mg/L	15	21	19	17	20	4	15	32	21	18	27	3	18	18	18	18	18	1	15	15	15	15	15	1	NS	NS	NS
Dissolved organic carbon	mg/L	12	18	15	14	16	4	13	30	21	17	26	3	15	18	17	16	17	2	13	13	13	13	13	1	NS	NS	NS
Organics																												
Total Phenolics	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	4	< 0.001	***0.008***	***0.008***	0.004	***0.008***	3	< 0.001	***0.010***	***0.005***	0.003	***0.008***	2	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	1	0.005C	NS	NS
Total recoverable hydrocarbons	mg/L	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	4	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	3	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	1	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	1	NS	NS	NS
Total Metals																												
Aluminum (Al)	ug/L	40	***1380***	***230***	88	***893***	8	30	***370***	100	71	***190***	7	< 20.0	50	37	10	50	5	40	***290***	***140***	80	***160***	5	5^1/100^2	100a	$750^{MC}/87^{CC}$
Antimony (Sb)	ug/L	< 5.0	1.7	0.9	0.6	1.4	8	0.5	3.0	0.7	0.7	1.1	7	< 0.2	1.2	0.8	0.1	0.9	5	< 5.0	2.1	1.4	1.1	2.1	5	NS	NS	NS
Arsenic (As)	ug/L	< 1.0	1.1	0.5	0.2	0.8	9	0.5	1.2	0.7	0.6	0.9	7	< 0.2	0.9	0.7	0.6	0.7	5	< 1.0	0.7	0.7	0.6	0.7	5	5.0^	5	$340^{MC}/150^{CC}$
Barium (Ba)	ug/L	7.0	46.7	27.0	22.0	41.5	9	15.0	37.0	34.3	31.7	35.5	7	30.9	38.8	33.5	33.0	34.2	5	50.0	89.0	56.1	50.9	59.5	5	NS	NS	NS
Beryllium (Be)	ug/L	< 1.0	< 0.2	< 1.0	< 1.0	< 1.0	8	< 0.2	< 1.0	< 1.0	< 1.0	< 1.0	7	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	5	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	5	NS	NS	NS
Boron (B)	ug/L	< 20.0	60.0	10.0	10.0	12.5	8	< 20.0	50.0	10.0	10.0	35.0	7	2.0	37.0	20.0	20.0	30.0	5	20.0	120.0	30.0	30.0	30.0	5	NS	NS	NS
Cadmium (Cd)	ug/L	< 0.01	< 1.00	< 0.20	< 0.20	< 0.20	9	< 0.20	***0.30***	***0.10***	***0.10***	***0.10***	7	< 0.01	< 0.20	< 0.20	< 0.20	< 0.02	5	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	5	HardnessH^	0.017b	$20^{MC,H}/0.25^{CC,H}$
Chromium (Cr)	ug/L	< 0.8	2.4	1.0	0.4	2.0	9	< 1.0	3.5	0.4	0.4	0.5	7	< 1.0	0.2	0.4	0.4	0.4	5	1.0	1.3	1.3	1.0	1.3	5	8.9^	8.9	$570^{MC,H}/74^{CC,H}$
Cobalt (Co)	ug/L	< 1.0	1.1	0.4	0.3	0.5	9	< 0.3	0.6	0.2	0.1	0.3	7	< 0.3	0.3	0.2	0.2	0.3	5	< 0.2	0.7	0.3	0.3	0.4	5	NS	NS	NS
Copper (Cu)	ug/L	< 1.0	3.0	1.0	0.5	2.0	9	< 1.0	2.0	1.0	0.5	1.1	7	< 1.0	0.1	0.5	0.1	0.5	5	< 1.0	1.0	0.5	0.5	0.5	5	HardnessH	2b	$13^{MC,H}/9^{CC,H}$
Iron (Fe)	ug/L	80	***2140***	***950***	***308***	***1423***	8	***360***	***718***	***563***	***484***	***640***	7	***440***	***1000***	***847***	***457***	***903***	5	***600***	***1220***	***1100***	***930***	***1120***	5	300	300	1000CC
Lead (Pb)	ug/L	< 0.30	1.10	0.25	0.14	0.60	8	< 0.30	0.50	0.20	0.20	0.35	7	< 0.30	0.10	0.05	0.05	0.10	5	< 0.10	0.40	0.20	0.10	0.20	5	HardnessH^	2b	$65^{MC,H}/2.5^{CC,H}$
Lithium (Li)	ug/L	< 6	12	3	3	3	8	< 6	11	3	3	7	7	< 6	8	3	3	3	5	6	27	7	6	8	5	NS	NS	NS
Manganese (Mn)	ug/L	< 4	145	9	7	29	9	8	84	23	8	30	7	10	55	11	10	16	5	11	108	12	11	12	5	NS	NS	NS
Mercury (Hg)	ug/L	< 0.1000	0.0033	0.0015	0.0007	0.0030	6	< 0.0006	< 0.0006	< 0.0006	< 0.0006	< 0.0006	3	< 0.0006	0.0009	0.0003	0.0003	0.0006	3	< 0.0006	< 0.0006	< 0.0006	< 0.0006	< 0.0006	1	0.013A/0.005C	0.026^^	$1.4^{MC,H}/0.77^{CC,H}$
Molybdenum (Mo)	ug/L	< 1	1	0.2	0.1	0.4	9	< 0.2	1.0	0.3	0.1	0.4	7	< 0.2	0.4	0.1	0.1	0.3	5	< 0.2	1.2	0.1	0.1	0.1	5	73^	73	NS
Nickel (Ni)	ug/L	0.2	65	0.6	0.2	1	9	0.3	65.0	0.7	0.5	1.1	7	< 0.1	110.0	0.3	0.2	0.3	5	0.3	7.7	0.4	0.3	0.4	5	HardnessH^	65b	$470^{MC,H}/52^{CC,H}$
Selenium (Se)	ug/L	< 0.4	< 0.8	< 0.4	< 0.4	< 0.4	7	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	6	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	4	< 0.8	0.5	0.2	0.2	0.4	5	1.0^	1	5^{CC}
Silicon (Si)	ug/L	4300	5000	4650	4475	4825	2	--	--	--	--	--	0	3100	3300	3300	3200	3300	3	5200	5600	5450	5350	5525	4	NS	NS	NS
Silver (Ag)	ug/L	< 0.200	0.007	0.007	0.004	0.100	7	< 0.200	0.001	0.051	0.002	0.100	6	< 0.200	***0.300***	0.100	0.077	***0.150***	4	< 0.2	***0.6***	0.1	0.1	0.1	5	0.1^	0.1	$3.2^{MC,H}$
Strontium (Sr)	ug/L	20.0	171.0	44.1	29.3	56.5	7	50.0	142.0	57.4	54.3	104.9	6	60.7	116.9	80.5	72.4	92.7	4	78.7	316.0	95.9	89.3	98.7	5	NS	NS	NS
Sulphur (S)	ug/L	< 500	700	250	250	475	3	< 500	< 500	< 500	< 500	< 500	3	< 500	< 500	< 500	< 500	< 500	3	500	600	600	575	600	4	NS	NS	NS
Thallium (Tl)	ug/L	< 0.100	0.200	0.050	0.038	0.050	7	< 0.100	0.100	0.038	0.025	0.050	6	< 0.003	< 0.050	< 0.050	< 0.038	< 0.050	4	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	5	0.8^	0.8	NS
Tin (Sn)	ug/L	< 0.2	0.3	0.1	0.0	0.1	6	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	3	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	3	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	4	NS	NS	NS
Titanium (Ti)	ug/L	< 5.0	7.0	2.5	1.3	2.5	7	< 5.0	1.7	2.1	1.6	2.5	6	1.1	3.1	1.7	1.3	2.3	4	< 5.0	1.8	1.4	1.3	1.8	5	NS	NS	NS
Uranium (U)	ug/L	< 0.1	0.2	0.05	0.05	0.125	7	< 0.10	0.50	0.08	0.05	0.25	6	< 0.10	0.10	0.05	0.05	0.06	4	< 0.10	0.20	0.05	0.05	0.05	5	NS	NS	NS
Vanadium (V)	ug/L	< 2.0	910.0	0.8	0.3	25.3	8	0.20	0.70	0.25	0.20	0.45	6	< 0.10	0.30	0.15	0.09	0.23	4	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	5	NS	NS	NS
Zinc (Zn)	ug/L	< 1	***96***	14	4	19	8	5	25	6	5	9	6	3	5	4	4	4	4	-2	25	6	1	6	5	30^	30	$120^{M,H}/120^{CC,H}$
Zirconium (Zr)	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	NS	NS	NS

Table 7C-4 Water Quality in Watercourses in the Mid-Christina River Basin

Parameter	Unit	Spring, Watercourses (2004 and 2005)						Summer, Watercourses (2004 and 2005)						Fall, Watercourses (2005)						Winter, Watercourses (2005)						AENV Freshwater Aquatic Life*	CCME Water Quality Guidelines - Freshwater^	EPA Freshwater Water Quality***
		Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N			
Dissolved Metals																												
Aluminum	ug/L	< 10	20	10	8	15	7	< 10	30	20	9	20	6	8	30	25	17	30	4	10	20	20	20	20	5	**NS**	**NS**	**$750^{MC}/87^{CC}$**
Antimony	ug/L	< 0.8	30.0	1.1	0.7	2.5	7	< 0.4	1.1	0.6	0.6	0.8	6	< 0.4	0.6	0.2	0.2	0.3	4	< 0.8	0.8	0.7	0.4	0.8	5	**NS**	**NS**	**NS**
Arsenic	ug/L	< 0.4	0.6	0.2	0.2	0.5	7	< 0.4	0.9	0.6	0.4	0.9	6	0.6	0.7	0.7	0.7	0.7	4	< 0.4	0.5	0.2	0.2	0.4	5	**NS**	**NS**	**$340^{MC}/150^{CC}$**
Barium	ug/L	6	35	19	12	22	7	15	33	32	28	32	6	28	36	30	29	32	4	46	102	50	48	90	5	**NS**	**NS**	**NS**
Beryllium	ug/L	< 1.00	< 0.50	< 0.75	< 1.00	< 0.50	8	< 0.50	< 1.00	< 0.50	< 0.50	< 0.88	6	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	4	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5	**NS**	**NS**	**NS**
Bismuth	ug/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	3	0.07	0.18	0.1	0.085	0.14	3	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	3	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	4	**NS**	**NS**	
Boron	ug/L	10	56	20	10	30	5	10	55	33	15	51	4	17	37	27	22	32	2	14	126	17	16	72	3	**NS**	**NS**	**NS**
Cadmium	ug/L	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	5	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	4	< 0.10	0.01	0.03	0.02	0.04	2	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	3	**NS**	**NS**	**$20^{MC,H}/0.25^{CC,H}$**
Chromium	ug/L	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	5	< 0.4	1.2	0.4	0.2	0.8	4	0.2	1.0	0.6	0.4	0.8	2	0.6	1.2	1.0	0.8	1.1	3	**NS**	**NS**	**$570^{MC,H}/74^{CC,H}$**
Cobalt	ug/L	< 0.1	0.3	0.2	0.1	0.2	5	< 0.1	0.2	0.1	0.1	0.1	4	0.1	0.1	0.1	0.1	0.1	2	< 0.1	0.2	0.1	0.1	0.2	3	**NS**	**NS**	**NS**
Copper	ug/L	< 0.6	1.3	0.8	0.3	1.0	5	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	4	< 0.1	< 0.6	< 0.4	< 0.2	< 0.5	2	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	3	**NS**	**NS**	**$13^{MC,H}/9^{CC,H}$**
Iron	ug/L	120	610	240	120	256	5	146	320	200	164	253	4	395	640	518	456	579	2	656	680	663	660	672	3	**NS**	**NS**	**1000CC**
Lead	ug/L	< 0.10	0.20	0.05	0.05	0.10	5	< 0.10	0.40	0.15	0.09	0.25	4	0.02	0.10	0.06	0.04	0.08	2	< 0.10	0.10	0.05	0.05	0.08	3	**NS**	**NS**	**$65^{MC,H}/2.5^{CC,H}$**
Lithium	ug/L	2.0	15.0	3.0	2.4	6.0	5	3.5	12.0	8.0	4.6	11.3	4	3.8	8.0	5.9	4.9	7.0	2	5.0	26.0	6.2	5.6	16.1	3	**NS**	**NS**	**NS**
Manganese	ug/L	3	35	10	4	21	5	17	42	22	20	27	4	15	45	30	23	38	2	74	116	81	78	99	3	**NS**	**NS**	**NS**
Mercury	ug/L	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	5	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	4	< 0.04	< 0.10	< 0.07	< 0.06	< 0.09	2	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	3	**NS**	**NS**	**$1.4^{MC,H}/0.77^{CC,H}$**
Molybdenum	ug/L	< 0.1	0.9	0.3	0.1	0.4	5	0.1	0.9	0.5	0.3	0.8	4	0.2	0.5	0.4	0.3	0.4	2	0.3	1.0	0.4	0.4	0.7	3	**NS**	**NS**	**NS**
Nickel	ug/L	< 0.1	1.4	0.3	0.1	0.4	5	0.3	1.0	0.6	0.5	0.7	4	< 0.1	0.6	0.3	0.2	0.5	2	< 0.1	0.4	0.3	0.2	0.4	3	**NS**	**NS**	**$470^{MC,H}/52^{CC,H}$**
Silver	ug/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	5	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	4	< 0.4	0.01	0.10	0.05	0.15	2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	3	**NS**	**NS**	**$3.2^{MC,H}$**
Strontium	ug/L	20.0	173.0	38.5	20.0	60.0	5	50.0	143.0	87.0	52.9	125.8	4	60.7	116.0	88.3	74.5	102.2	2	78.7	293.0	89.3	84.0	191.2	3	**NS**	**NS**	**NS**
Sulphur	ug/L	< 500	< 500	< 500	< 500	< 500	1	< 500	< 500	< 500	< 500	< 500	1	< 500	< 500	< 500	< 500	< 500	1	500	600	550	525	575	2	**NS**	**NS**	**NS**
Thallium	ug/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	5	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	4	< 0.00	< 0.050	< 0.03	< 0.01	< 0.04	2	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	3	**NS**	**NS**	**NS**
Tin	ug/L	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	1	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	1	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	1	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	2	**NS**	**NS**	**NS**
Titanium	ug/L	< 0.3	0.9	0.7	0.6	0.7	5	0.9	1.6	1.2	1.0	1.5	4	0.8	1.1	1.0	0.9	1.0	2	1.0	1.8	1.8	1.4	1.8	3	**NS**	**NS**	**NS**
Vanadium	ug/L	< 0.1	98.0	0.3	0.3	0.4	5	0.1	0.3	0.3	0.2	0.3	4	< 0.1	0.3	0.2	0.1	0.2	2	< 0.1	0.2	0.1	0.1	0.1	3	**NS**	**NS**	**NS**
Zinc	ug/L	< 2	13	2	2	3	5	< 2	9	4	3	5	4	4	4	4	4	4	2	< 2	6	5	3	6	3	**NS**	**NS**	**$120^{M,H}/120^{CC,H}$**
Polycyclic Aromatic Hydrocarbons																												
Naphthalene	ug/L	< 0.10	< 0.01	< 0.01	< 0.03	< 0.01	4	< 0.10	< 0.01	< 0.01	< 0.03	< 0.01	4	< 0.10	< 0.01	< 0.01	< 0.02	< 0.01	5	< 0.01	0.18	0.04	0.03	0.08	4	**1.1^**	**1.1**	**NS**
Acephthylene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	1	--	--	--	--	--	0	**NS**	**NS**	**NS**
Acenaphthene	ug/L	< 0.01	< 0.10	< 0.01	< 0.01	< 0.03	4	< 0.10	< 0.01	< 0.01	< 0.03	< 0.01	4	< 0.01	< 0.10	< 0.01	< 0.01	< 0.02	5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	4	**5.8^**	**5.8**	**NS**
Fluorene	ug/L	< 0.01	< 0.05	< 0.01	< 0.01	< 0.02	4	< 0.05	< 0.01	< 0.01	< 0.02	< 0.01	4	< 0.01	< 0.05	< 0.01	< 0.01	< 0.02	5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	4	**3^**	**3**	**NS**
Phenanthrene	ug/L	< 0.01	< 0.05	< 0.01	< 0.01	< 0.02	4	< 0.05	< 0.01	< 0.01	< 0.02	< 0.01	4	< 0.01	< 0.05	< 0.01	< 0.01	< 0.02	5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	4	**0.4^**	**0.4**	**NS**
Anthracene	ug/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	4	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	4	< 0.01	< 0.02	< 0.01	< 0.01	< 0.01	5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	4	**0.012^**	**0.012**	**NS**
Acridine	ug/L	< 0.01	< 0.20	< 0.01	< 0.01	< 0.06	4	< 0.20	< 0.01	< 0.01	< 0.06	< 0.01	4	< 0.01	< 0.20	< 0.01	< 0.01	< 0.06	4	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	4	**4.4^**	**NS**	**NS**
Fluoranthene	ug/L	< 0.01	< 0.04	< 0.01	< 0.01	< 0.02	4	< 0.04	< 0.01	< 0.01	< 0.02	< 0.01	4	< 0.01	< 0.04	< 0.01	< 0.01	< 0.02	5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	4	**0.04^**	**0.04**	**NS**
Pyrene	ug/L	< 0.01	< 0.02	< 0.01	< 0.01	< 0.01	4	< 0.02	< 0.01	< 0.01	< 0.01	< 0.01	4	< 0.01	< 0.02	< 0.01	< 0.01	< 0.02	5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	4	**0.025^**	**0.025**	**NS**
Benz[a]anthracene	ug/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	4	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	4	< 0.01	< 0.02	< 0.01	< 0.01	< 0.01	5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	4	**0.018^**	**0.018**	**NS**
Chrysene	ug/L	< 0.01	< 0.05	< 0.01	< 0.01	< 0.02	4	< 0.05	< 0.01	< 0.01	< 0.02	< 0.01	4	< 0.01	< 0.05	< 0.01	< 0.01	< 0.02	4	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	4	**NS**	**NS**	**NS**
Benzo[b]fluoranthene	ug/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	3	< 0.10	< 0.01	< 0.01	< 0.03	< 0.01	4	< 0.10	< 0.01	< 0.01	< 0.01	< 0.02	5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	4	**NS**	**NS**	**NS**
Benzo[k]fluoranthene	ug/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	3	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	4	< 0.01	< 0.02	< 0.01	< 0.01	< 0.01	5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	4	**NS**	**NS**	**NS**
Benzo[a]pyrene	ug/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	4	< 0.05	< 0.01	< 0.01	< 0.02	< 0.01	4	< 0.01	< 0.05	< 0.01	< 0.01	< 0.02	5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	4	**0.015^**	**0.015**	**NS**
Indeno[1,2,3-cd]pyrene	ug/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	3	< 0.10	< 0.01	< 0.01	< 0.03	< 0.01	4	< 0.10	< 0.01	< 0.01	< 0.01	< 0.02	5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	4	**NS**	**NS**	**NS**
Dibenzo[a,h]anthracene	ug/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	3	< 0.05	< 0.01	< 0.01	< 0.02	< 0.01	4	< 0.01	< 0.02	< 0.01	< 0.01	< 0.01	5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	4	**NS**	**NS**	**NS**
Quinoline	ug/L	--	--	--	--	--	0	--	--	--	--	--	--	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Benzo[g,h,i]perylene	ug/L	--	--	--	--	--	0	--	--	--	--	--	--	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	1	--	--	--	--	--	0	**NS**	**NS**	**NS**
CCME BP Equivalent	ug/L	--	--	--	--	--	0	--	--	--	--	--	--	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**

Notes:

--- - not analyzed
NS - not specified
^ - Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME, 2006)
* - Alberta Environment Surface Water Quality Guidelines for use in Alberta (AENV, 1999)
CC - continuous concentration guideline, National Recommended Water Quality Criteria (USEPA, 2006
MC - maximum concentration guideline, National Recommended Water Quality Criteria (USEPA, 2006)
*** - National Recommended Water Quality Criteria (USEPA, 2006)
^^ - indicates value for Inorganic Mercury
1 - value if pH <6.5, Ca <4.0, DOC <2
2 - value if pH $\geq$6.5, Ca $\geq$4.0, DOC $\geq$2
3 - refer to CCME summary table for DO guideline breakdown
4 - refer to USEPA summary table for Ammonia criteria calculations
A - Acute aquatic life guideline
A A - 1 day minimum, acute guideline
a - value if pH>6.5, Ca>4.0, DOC>2
b - dependent on hardness value
C - Chronic Aquatic Life guideline
H - dependent on hardness value
*** - value denotes NO_2-N guideline concentration
Italics - indicates that values exceed specified guideline

Appendix 7C Historical Water Quality in Watercourses in the RSA

Table 7C-5 Water Quality in the Lower Christina and Clearwater Rivers

Parameter	Unit	Spring, Watercourses (1976, 1979 - 1981, 1984, 1987, 2000 and 2001)						Summer, Watercourses (1972, 1976 - 1981, 1984, 1987, 1996, 1998, 2001 and 2002)						Fall, Watercourses (1972, 1976 - 1980, 1984, 1987, 1996, 2000, 2001 and 2004)						Winter, Watercourses (1973, 1976 - 1981, 1985, 1988 - 1997, 2000 and 2001)						AENV Freshwater Aquatic Life*	CCME Water Quality Guidelines - Freshwater^	EPA Freshwater Water Quality***
		Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N			
Field Parameters																												
Temperature	°C	1.0	15.9	12.0	9.4	14.7	11	12.5	25.5	17.6	16.4	19.8	29	1.0	14.8	8.0	3.6	12.1	19	< 0.4	0.8	0.1	0.0	0.2	24	**NS**	**NS**	**NS**
pH		6.9	***9.0***	8.0	7.7	8.4	8	7.1	***8.8***	8.0	7.8	8.2	25	7.5	***8.8***	8.1	7.9	8.4	15	6.6	***9.9***	7.5	7.0	7.8	23	**6.5-8.5**	**6.5-9.0**	**$6.5\text{-}9^{CC}$**
Conductivity (EC)	uS/cm	14	770	213	184	276	10	81	662	187	147	271	27	54	820	191	110	283	16	180	1300	316	257	345	20	**NS**	**NS**	**NS**
Dissolved oxygen (DO)	mg/L	9.1	11.5	9.9	9.7	10.9	7	6.3	13.5	9.0	8.2	9.8	28	6.9	13.9	10.2	9.8	12.7	17	***0.3***	13.3	12.3	11.9	12.8	18	**5.0AA**	**5.5-9.53**	**NS**
Conventional Parameters																												
pH		7.3	8.2	7.7	7.4	7.8	14	***6.3***	***9.6***	7.7	7.5	8.0	33	7.2	8.3	7.7	7.3	8.0	25	6.7	8.5	7.6	7.3	7.7	40	**6.5-9**	**6.5-9.0**	**$6.5\text{-}9^{CC}$**
Conductivity (EC)	uS/cm	136	751	196	167	267	14	129	870	212	181	296	33	75	1050	199	169	272	25	199	1390	336	270	397	39	**NS**	**NS**	**NS**
Hardness ($CaCO_3$)	mg/L	38.0	147.0	46.0	44.0	61.9	9	42.0	154.0	61.2	56.5	79.5	22	34.0	164.0	63.0	54.5	71.5	15	47.0	266.0	69.4	64.8	77.3	24	**NS**	**NS**	**NS**
Alkalinity ($CaCO_3$)	mg/L	35.0	155.0	56.3	50.8	65.9	14	45.0	163.0	64.6	57.2	73.3	32	30.0	180.0	62.8	55.3	78.6	25	47.0	259.0	71.1	67.9	76.2	40	**NS**	**NS**	**20^{CC}**
Total Dissolved Solids	mg/L	77.8	450.0	124.3	112.6	135.0	8	80.7	344.0	141.6	103.3	164.1	12	60.0	250.0	145.0	112.6	166.3	10	120.0	790.0	177.0	168.9	191.0	16	**NS**	**NS**	**NS**
Total Suspended Solids	mg/L	3.0	34.0	17.0	14.0	26.0	5	6.0	13.0	11.5	9.0	13.0	4	< 3.0	38.0	12.0	8.0	26.0	5	< 3.0	3.0	3.0	2.3	3.0	3	**NS**	**NS**	**NS**
Turbidity	NTU	4.5	7.0	5.8	5.1	6.4	2	2.8	60.0	17.0	5.4	35.8	8	< 1.0	43.0	4.9	4.0	7.4	7	1.6	5.6	4.8	4.3	5.2	13	**NS**	**NS**	**NS**
Major Ions																												
Carbonate (CO_3)	mg/L	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	3	< 5.0	< 0.5	< 5.0	< 5.0	< 2.8	3	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	2	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	2	**NS**	**NS**	**NS**
Bicarbonate (HCO_3 ($CaCO_3$))	mg/L	42.0	189.0	61.0	51.0	73.5	7	56.0	195.0	75.0	69.8	87.2	12	64.7	134.0	86.0	75.6	96.8	8	57.0	316.0	89.0	85.5	92.4	16	**NS**	**NS**	**NS**
Sodium (Na)	mg/L	10.0	100.0	19.7	14.1	29.0	14	10.0	131.0	20.5	17.0	31.0	33	3.0	166.0	18.0	13.0	25.0	25	19.0	212.0	40.0	31.6	45.5	40	**NS**	**NS**	**NS**
Potassium (K)	mg/L	0.9	3.0	1.1	1.0	1.7	14	0.5	2.5	0.9	0.7	1.0	33	0.5	43.0	0.9	0.5	1.0	23	0.7	3.0	1.1	1.0	1.2	40	**NS**	**NS**	**NS**
Calcium (Ca)	mg/L	10.0	39.0	14.2	11.3	18.1	14	11.5	40.0	16.6	15.0	18.5	33	7.0	55.0	16.8	14.5	18.0	23	12.0	71.0	18.4	16.9	21.0	40	**NS**	**NS**	**NS**
Magnesium (Mg)	mg/L	3.0	12.0	4.5	4.0	5.9	14	3.0	12.2	5.2	5.0	6.7	33	2.0	9.0	5.2	4.6	5.8	23	4.0	22.0	6.5	5.7	7.0	40	**NS**	**NS**	**NS**
Chloride (Cl)	mg/L	9.8	131.0	24.9	16.5	38.5	14	13.0	100.0	24.5	20.0	42.5	33	4.0	***241.0***	23.5	12.2	30.0	25	27.0	***279.0***	54.0	41.6	63.5	40	**230****	**NS**	**$860^{MC}/230^{CC}$**
Sulphate (SO_4)	mg/L	< 5	27.0	7.1	6.0	9.8	14	0.1	31.0	8.0	6.0	10.0	33	2.1	39.0	6.9	5.8	8.0	25	< 3.0	48.0	9.0	7.1	11.1	40	**NS**	**NS**	**NS**
Nutrients																												
Nitrite (NO_2-N)	mg/L	< 0.003	0.016	0.004	0.001	0.007	7	< 0.003	0.012	0.002	0.002	0.003	20	< 0.001	0.009	0.003	0.001	0.005	9	< 0.100	***0.192***	0.004	0.003	0.010	24	**0.018**	**0.018**	**NS**
Nitrate (NO_3 -N)	mg/L	< 0.003	0.177	0.094	0.013	0.172	5	< 0.003	0.029	0.007	0.002	0.015	13	< 0.003	0.006	0.002	0.002	0.003	4	0.126	0.539	0.185	0.131	0.313	10	**NS**	**2.9**	**NS**
Nitrate + nitrite (NO_3 + NO_2 -N)	mg/L	< 0.100	***0.183***	***0.034***	0.005	***0.103***	12	< 0.100	***1.200***	0.010	0.002	***0.034***	32	< 0.100	***0.100***	***0.023***	0.007	***0.050***	24	< 0.100	***0.700***	***0.176***	***0.132***	***0.210***	37	**0.018*****	**NS**	**NS**
Nitrogen - Ammonia (NH_4-N)	mg/L	< 0.050	0.083	0.024	0.010	0.025	12	< 0.050	0.730	0.025	0.016	0.050	29	< 0.500	0.700	0.026	0.014	0.052	20	0.011	0.500	0.082	0.065	0.114	31	**1.37 to 2.20**	**0.015**	**NS^{4}**
Nitrogen - Kjeldahl (TKN)	mg/L	0.330	2.480	0.660	0.549	2.000	11	0.316	2.610	0.770	0.540	1.000	29	0.336	1.680	0.600	0.470	0.850	19	0.320	2.170	0.460	0.355	0.840	35	**NS**	**NS**	**NS**
Total nitrogen (TKN+NO_3 + NO_2)	mg/L	0.33	***2.66***	0.70	0.65	***2.05***	11	0.32	***3.81***	0.78	0.54	***1.01***	30	< 0.20	***1.69***	0.60	0.47	0.81	22	0.40	***2.34***	0.67	0.54	***1.06***	34	**1.0C**	**NS**	**NS**
Phosphorus, total	mg/L	0.031	***0.330***	***0.068***	0.044	***0.079***	14	0.022	***0.400***	***0.063***	0.039	***0.085***	32	0.035	***0.320***	***0.060***	0.050	***0.128***	25	< 0.100	***0.170***	0.049	0.042	***0.056***	38	**0.05C**	**NS**	**NS**
Total organic carbon	mg/L	6	14	10	9	13	12	8	34	13	10	17	25	8	83	17	12	19	16	1	27	7	6	14	27	**NS**	**NS**	**NS**
Dissolved organic carbon	mg/L	5	12	9	7	11	14	7	33	12	8	15	29	6	21	13	9	17	21	1	21	6	5	12	36	**NS**	**NS**	**NS**
Organics																												
Total Phenolics	mg/L	< 0.001	***0.022***	0.001	0.001	***0.015***	5	< 0.001	***0.006***	0.001	0.001	0.002	4	< 0.001	***0.006***	0.002	0.001	***0.006***	5	< 0.001	0.003	0.001	0.001	0.003	5	**0.005C**	**NS**	**NS**
Total recoverable hydrocarbons	mg/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	2	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	3	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	3	**NS**	**NS**	**NS**
Total Metals																												
Aluminum (Al)	ug/L	***310***	***880***	***450***	***410***	***780***	5	< 10	***770***	***395***	***255***	***505***	6	***140***	***730***	***570***	***420***	***675***	6	30	***150***	54	37	***110***	7	**5^1/100^2**	**100a**	**$750^{MC}/87^{CC}$**
Antimony (Sb)	ug/L	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	5	< 5.0	0.6	0.6	0.6	1.6	3	< 5.0	0.1	0.1	0.0	1.3	3	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	3	**NS**	**NS**	**NS**
Arsenic (As)	ug/L	< 1.0	1.0	0.5	0.5	0.6	7	< 5.0	3.2	0.9	0.6	1.3	13	< 1.0	4.0	0.7	0.5	0.9	9	< 1.0	1.0	0.3	0.2	0.4	17	**5.0^**	**5**	**$340^{MC}/150^{CC}$**
Barium (Ba)	ug/L	16.0	36.0	20.0	17.5	22.5	6	17.0	33.0	19.0	18.0	30.0	9	17.0	30.0	19.5	19.0	20.0	6	16.0	64.0	20.0	20.0	22.0	15	**NS**	**NS**	**NS**
Beryllium (Be)	ug/L	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	5	< 1.0	2.0	0.5	0.5	1.0	5	< 1.0	0.2	0.4	0.2	0.5	4	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	5	**NS**	**NS**	**NS**
Boron (B)	ug/L	< 20	130	30	30	40	5	30	80	40	30	50	5	27	50	40	30	50	6	20	240	55	43	105	4	**NS**	**NS**	**NS**
Cadmium (Cd)	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**HardnessH^**	**0.017b**	**$20^{MC,H}/0.25^{CC,H}$**
Chromium (Cr)	ug/L	< 1.0	3.0	0.5	0.4	2.0	7	< 2.0	9.0	1.0	0.5	3.8	12	< 1.0	13.0	1.9	0.8	4.0	8	< 1.0	7.0	2.0	0.5	2.0	17	**8.9^**	**8.9**	**$570^{MC,H}/74^{CC,H}$**
Cobalt (Co)	ug/L	< 1.0	0.6	0.4	0.1	0.5	7	< 1.0	14.0	0.5	0.4	0.8	10	< 1.0	1.1	0.5	0.5	0.6	8	< 1.0	5.0	0.5	0.5	0.5	14	**NS**	**NS**	**NS**
Copper (Cu)	ug/L	< 1.0	2.0	1.0	0.5	1.0	7	< 1.0	***26.0***	2.0	1.0	3.3	12	< 1.0	3.0	0.5	0.5	1.3	8	< 1.0	4.0	1.0	0.5	3.0	17	**HardnessH**	**2b**	**$13^{MC,H}/9^{CC,H}$**
Iron (Fe)	ug/L	***360***	***2350***	***970***	***960***	***2040***	5	40	***2040***	***620***	***355***	***1300***	7	100	***1830***	***1020***	***400***	***1600***	9	***600***	***1050***	***866***	***748***	***925***	16	**300**	**300**	**1000CC**
Lead (Pb)	ug/L	0.2	0.5	0.3	0.2	0.4	5	< 0.4	1.4	0.2	0.1	0.8	5	0.2	0.8	0.3	0.2	0.5	4	0.1	0.5	0.1	0.0	0.2	4	**HardnessH^**	**2b**	**$65^{MC,H}/2.5^{CC,H}$**
Lithium (Li)	ug/L	< 6.0	22.0	6.0	3.0	7.0	5	< 6.0	12.0	6.0	4.0	6.0	5	4.0	9.0	5.5	4.8	6.8	4	< 6.0	38.0	7.5	5.3	16.3	4	**NS**	**NS**	**NS**
Manganese (Mn)	ug/L	39.0	2940.0	57.0	52.5	78.0	7	< 1.0	142.0	75.0	43.0	94.8	12	39.0	92.0	49.0	39.8	64.5	8	22.0	206.0	32.5	28.3	35.5	18	**NS**	**NS**	**NS**
Mercury (Hg)	ug/L	< 0.100	***0.300***	***0.050***	0.004	***0.050***	12	< 0.20	***0.30***	***0.05***	***0.05***	***0.05***	31	< 0.20	***0.80***	***0.05***	***0.03***	***0.05***	22	< 0.10	***0.06***	***0.05***	0.01	***0.05***	37	**0.013A/0.005C**	**0.026^^**	**$1.4^{MC,H}/0.77^{CC,H}$**
Molybdenum (Mo)	ug/L	< 1.0	0.9	0.4	0.2	0.5	7	< 3.0	7.0	0.6	0.5	2.8	11	< 3.0	0.4	0.5	0.3	0.5	10	< 3.0	7.0	1.0	0.5	2.0	16	**73^**	**73**	**NS**
Nickel (Ni)	ug/L	< 1.0	2.0	0.8	0.6	1.4	7	< 0.5	28.0	3.0	0.7	5.3	12	< 1.0	17.0	0.7	0.5	4.6	8	< 1.0	9.7	2.0	1.2	4.5	18	**HardnessH^**	**65b**	**$470^{MC,H}/52^{CC,H}$**
Selenium (Se)	ug/L	< 0.8	***1.1***	0.4	0.4	1.0	5	< 0.4	< 0.8	< 0.4	< 0.4	< 0.6	3	< 0.5	< 0.8	< 0.5	< 0.5	< 0.7	3	< 0.8	***1.1***	0.4	0.4	0.8	3	**1.0^**	**1**	**5^{CC}**
Silicon (Si)	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Silver (Ag)	ug/L	0.005	0.063	0.022	0.009	0.031	5	< 0.100	0.014	0.013	0.005	0.041	5	< 0.100	0.011	0.007	0.003	0.021	4	< 0.100	0.040	0.025	0.008	0.043	4	**0.1^**	**0.1**	**$3.2^{MC,H}$**
Strontium (Sr)	ug/L	50	301	79	70	115	5	71	183	80	79	101	5	58	124	95	74	114	4	80	517	124	101	234	4	**NS**	**NS**	**NS**
Sulphur (S)	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Thallium (Tl)	ug/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	5	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	3	< 0.1	0.07	0.05	0.04	0.06	3	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	3	**0.8^**	**0.8**	**NS**
Tin (Sn)	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Titanium (Ti)	ug/L	3.7	13.8	9.0	8.0	11.0	5	< 10.0	7.0	5.5	4.7	6.3	4	< 50.0	13.0	13.0	11.0	25.0	5	< 50.0	8.0	8.0	4.6	25.0	5	**NS**	**NS**	**NS**
Uranium (U)	ug/L	< 0.1	0.2	0.1	0.1	0.1	5	< 0.1	0.1	0.1	0.1	0.1	3	< 0.1	0.1	0.1	0.1	0.1	3	< 0.1	0.5	0.1	0.1	0.3	3	**NS**	**NS**	**NS**
Vanadium (V)	ug/L	< 2.0	6.0	1.4	0.8	2.1	11	< 2.0	10.0	1.0	0.5	1.4	25	< 2.0	10.0	1.0	0.5	2.7	18	< 2.0	8.0	0.5	0.5	1.0	35	**NS**	**NS**	**NS**
Zinc (Zn)	ug/L	< 1	***102***	8	5	***54***	7	< 4	***96***	5	2	8	10	2	10	5	4	9	7	< 1	***33***	4	1	16	17	**30^**	**30**	**$120^{M,H}/120^{CC,H}$**
Zirconium (Zr)	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**

Table 7C-5 Water Quality in the Lower Christina and Clearwater Rivers

Parameter	Unit	Spring, Watercourses (1976, 1979 - 1981, 1984, 1987, 2000 and 2001)						Summer, Watercourses (1972, 1976 - 1981, 1984, 1987, 1996, 1998, 2001 and 2002)						Fall, Watercourses (1972, 1976 - 1980, 1984, 1987, 1996, 2000, 2001 and 2004)						Winter, Watercourses (1973, 1976 - 1981, 1985, 1988 - 1997, 2000 and 2001)						AENV Freshwater Aquatic Life*	CCME Water Quality Guidelines - Freshwater^	EPA Freshwater Water Quality***
		Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N			
Dissolved Metals																												
Aluminum	ug/L	20	30	30	20	30	5	10	40	40	25	40	3	< 10	10	8	6	9	5	< 10	40	20	13	30	3	**NS**	**NS**	**$750^{MC}/87^{CC}$**
Antimony	ug/L	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	5	< 0.4	< 0.8	< 0.4	< 0.4	< 0.6	3	--	--	--	--	--	3	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	3	**NS**	**NS**	**NS**
Arsenic	ug/L	< 0.5	2.1	0.3	0.2	0.3	9	< 0.4	2.1	0.5	0.2	0.9	12	< 0.4	1.8	0.6	0.6	0.9	9	< 1.0	1.5	0.5	0.3	0.6	20	**NS**	**NS**	**$340^{MC}/150^{CC}$**
Barium	ug/L	12	35	13	12	15	5	13	28	14	14	21	3	--	--	--	--	--	3	12	65	24	18	45	3	**NS**	**NS**	**NS**
Beryllium	ug/L	< 0.5	< 1.0	< 1.0	< 0.5	< 1.0	7	< 0.5	< 5.0	< 1.0	< 0.9	< 1.0	8	< 1.0	0.2	0.5	0.2	0.5	5	< 0.1	< 5.0	< 1.0	< 1.0	< 1.0	15	**NS**	**NS**	**NS**
Bismuth	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	
Boron	ug/L	25	139	35	30	95	8	20	210	86	54	110	11	20	380	65	42	138	10	< 10	236	130	20	150	13	**NS**	**NS**	**NS**
Cadmium	ug/L	< 0.1	0.002	0.05	0.026	0.05	7	< 0.1	< 1	< 0.1	< 0.1	< 0.3	4	< 0.01	< 0.10	< 0.01	< 0.01	< 0.06	3	< 0.10	2.00	0.13	0.05	0.65	4	**NS**	**NS**	**$20^{MC,H}/0.25^{CC,H}$**
Chromium	ug/L	< 0.4	0.8	0.2	0.2	0.5	5	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	3	< 0.4	0.24	0.2	0.17	0.22	3	< 0.4	0.6	0.2	0.2	0.4	3	**NS**	**NS**	**$570^{MC,H}/74^{CC,H}$**
Cobalt	ug/L	< 0.1	0.1	0.05	0.0255	0.05	7	< 2	0.1	0.075	0.05	0.325	4	< 0.1	0.15	0.09	0.07	0.12	3	< 0.10	2.00	0.05	0.05	0.54	4	**NS**	**NS**	**NS**
Copper	ug/L	0.001	1.4	0.7	0.3525	0.95	7	< 0.6	8.4	1.9	0.675	4.35	4	< 0.6	1.2	0.3	0.1525	0.75	3	< 1.0	2.7	0.9	0.5	1.6	4	**NS**	**NS**	**$13^{MC,H}/9^{CC,H}$**
Iron	ug/L	120	820	380	165	560	7	120	260	160	143	193	4	35	340	160	98	250	3	40	790	360	183	565	4	**NS**	**NS**	**1000CC**
Lead	ug/L	< 0.1	0.8	0.05	0.026	0.225	7	< 4.00	0.10	0.08	0.05	0.58	4	< 0.1	0.2	0.1	0.075	0.15	3	< 0.10	4.00	0.15	0.09	1.15	4	**NS**	**NS**	**$65^{MC,H}/2.5^{CC,H}$**
Lithium	ug/L	5.0	23.0	7.0	5.0	7.0	5	5.0	14.0	7.0	6.0	10.5	3	5.0	8.0	7.0	6.0	7.5	3	4.0	37.0	10.0	7.0	23.5	3	**NS**	**NS**	**NS**
Manganese	ug/L	7.0	22.0	15.0	14.0	18.3	6	< 10.0	55.0	18.5	8.0	34.8	4	8.0	11.0	10.0	9.0	10.5	3	2.0	33.0	11.0	6.5	22.0	3	**NS**	**NS**	**NS**
Mercury	ug/L	< 0.10	0.10	0.05	0.05	0.05	5	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	3	< 0.04	< 0.10	< 0.04	< 0.04	< 0.07	3	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	3	**NS**	**NS**	**$1.4^{MC,H}/0.77^{CC,H}$**
Molybdenum	ug/L	0.1	4.0	0.9	0.2	1.4	5	0.3	0.6	0.4	0.4	0.5	3	0.2	0.4	0.2	0.2	0.3	3	< 0.1	0.7	0.3	0.2	0.5	3	**NS**	**NS**	**NS**
Nickel	ug/L	< 0.10	0.90	0.05	0.03	0.50	7	0.30	2.00	0.60	0.38	1.10	4	< 0.10	0.10	0.05	0.05	0.08	3	0.40	4.00	0.70	0.40	1.75	4	**NS**	**NS**	**$470^{MC,H}/52^{CC,H}$**
Silver	ug/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	5	< 0.2	0.3	0.1	0.1	0.2	3	< 0.2	0.01	0.01	0.01	0.05	3	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	3	**NS**	**NS**	**$3.2^{MC,H}$**
Strontium	ug/L	50.0	298.0	77.5	60.0	102.0	5	80.0	176.0	97.2	88.6	136.6	3	77.3	122.0	110.0	93.7	116.0	3	80.0	512.0	160.0	120.0	336.0	3	**NS**	**NS**	**NS**
Sulphur	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Thallium	ug/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	5	< 0.05	0.27	0.03	0.03	0.15	3	0.05	0.10	0.08	0.06	0.09	3	< 0.05	0.17	0.03	0.03	0.10	3	**NS**	**NS**	**NS**
Tin	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Titanium	ug/L	1.1	2.3	1.8	1.5	2.1	5	0.4	2.4	1.7	1.1	2.1	3	0.3	1.8	1.6	1.0	1.7	3	1.5	4.1	2.7	2.1	3.4	3	**NS**	**NS**	**NS**
Vanadium	ug/L	< 1.0	1.0	0.5	0.5	0.7	7	< 0.1	1.0	0.5	0.3	0.7	4	0.5	0.5	0.5	0.5	0.5	3	< 1.0	2.3	0.8	0.5	1.4	4	**NS**	**NS**	**NS**
Zinc	ug/L	< 2	7	1	1	4	5	< 2	28	1	1	15	3	1	6	3	2	5	3	2	118	40	21	79	3	**NS**	**NS**	**$120^{M,H}/120^{CC,H}$**
Polycyclic Aromatic Hydrocarbons																												
Naphthalene	ug/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	2	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	1	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	2	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	1	**1.1^**	**1.1**	**NS**
Acephthylene	ug/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	2	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	1	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	2	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	1	**NS**	**NS**	**NS**
Acenaphthene	ug/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	2	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	1	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	2	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	1	**5.8^**	**5.8**	**NS**
Fluorene	ug/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	2	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	1	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	2	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	1	**3^**	**3**	**NS**
Phenanthrene	ug/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	2	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	1	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	2	0.03	0.03	0.03	0.03	0.03	1	**0.4^**	**0.4**	**NS**
Anthracene	ug/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	2	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	1	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	2	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	1	**0.012^**	**0.012**	**NS**
Acridine	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**4.4^**	**NS**	**NS**
Fluoranthene	ug/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	2	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	1	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	2	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	1	**0.04^**	**0.04**	**NS**
Pyrene	ug/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	2	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	1	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	2	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	1	**0.025^**	**0.025**	**NS**
Benz[a]anthracene	ug/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	2	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	1	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	2	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	1	**0.018^**	**0.018**	**NS**
Chrysene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Benzo[b]fluoranthene	ug/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	2	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	1	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	2	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	1	**NS**	**NS**	**NS**
Benzo[k]fluoranthene	ug/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	2	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	1	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	2	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	1	**NS**	**NS**	**NS**
Benzo[a]pyrene	ug/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	2	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	1	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	2	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	1	**0.015^**	**0.015**	**NS**
Indeno[1,2,3-cd]pyrene	ug/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	2	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	1	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	2	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	1	**NS**	**NS**	**NS**
Dibenzo[a,h]anthracene	ug/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	2	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	1	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	2	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	1	**NS**	**NS**	**NS**
Quinoline	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Benzo[g,h,i]perylene	ug/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	2	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	1	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	2	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	1	**NS**	**NS**	**NS**
CCME BP Equivalent	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**

Notes:

--- - not analyzed
NS - not specified
^ - Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME, 2006)
* - Alberta Environment Surface Water Quality Guidelines for use in Alberta (AENV, 1999)
CC - continuous concentration guideline, National Recommended Water Quality Criteria (USEPA, 2006
MC - maximum concentration guideline, National Recommended Water Quality Criteria (USEPA, 2006
*** - National Recommended Water Quality Criteria (USEPA, 2006)
^^ - indicates value for Inorganic Mercury
[1] - value if pH <6.5, Ca <4.0, DOC <2
[2] - value if pH ≥6.5, Ca ≥4.0, DOC ≥2
[3] - refer to CCME summary table for DO guideline breakdowr
[4] - refer to USEPA summary table for Ammonia criteria calculations
A - Acute aquatic life guideline
A A - 1 day minimum, acute guideline
a - value if pH>6.5, Ca>4.0, DOC>2
b - dependent on hardness value
C - Chronic Aquatic Life guideline
H - dependent on hardness value
*** - value denotes NO_2-N guideline concentration
Italics - indicates that values exceed specified guideline

Appendix 7C Historical Water Quality in Watercourses in the RSA

Table 7C-6 Water Quality in Tributaries to the Lower Christina and Clearwater Rivers

Parameter	Unit	Spring, Watercourses (1976 - 1983, 1988, 1998 and 2005)						Summer, Watercourses (1976 - 1984, 1998, 2004)						Fall, Watercourses (1972, 1976, 1978 - 1982, 2000, 2004, 2005)						Winter, Watercourses (1973, 1976, 1978, 1979, 1980, 1981)						AENV Freshwater Aquatic Life*	CCME Water Quality Guidelines - Freshwater^	EPA Freshwater Water Quality***
		Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N			
Field Parameters																												
Temperature	°C	0.5	8.5	4.0	2.8	7.5	7	5.0	16.8	14.5	12.0	15.9	26	3.5	11.5	6.0	5.0	9.6	9	0.0	2.6	0.5	0.0	0.8	9	NS	NS	NS
pH		6.8	8.0	7.6	7.2	7.9	4	7.0	9.6	8.1	7.6	8.3	18	5.4	8.9	8.1	7.8	8.4	12	7.3	8.7	7.9	7.6	8.1	7	6.5-8.5	6.5-9.0	6.5-9[CC]
Conductivity (EC)	uS/cm	16	581	129	25	174	5	40	1124	210	81	409	22	25	360	65	43	173	7	98	597	160	140	379	7	NS	NS	NS
Dissolved oxygen (DO)	mg/L	6.8	14.8	10.5	9.6	11.6	4	4.9	12.4	8.9	8.3	9.9	21	5.3	11.2	9.4	9.0	10.0	8	9.0	9.3	9.1	9.1	9.2	2	5.0AA	5.5-9.53	NS
Conventional Parameters																												
pH		7.0	7.9	7.3	7.2	7.8	11	6.6	8.3	7.6	7.3	8.0	30	6.7	8.3	7.9	7.4	8.1	21	6.9	7.9	7.3	7.2	7.7	15	6.5-9	6.5-9.0	6.5-9[CC]
Conductivity (EC)	uS/cm	55	516	142	116	148	11	52	650	151	104	309	29	65	805	221	109	346	21	110	474	165	140	188	15	NS	NS	NS
Hardness ($CaCO_3$)	mg/L	32.8	82.0	66.0	49.4	74.0	3	52.0	320.0	180.0	95.3	202.5	12	65.0	263.0	126.0	103.0	162.0	13	210.0	240.0	225.0	217.5	232.5	2	NS	NS	NS
Alkalinity ($CaCO_3$)	mg/L	25.0	72.0	56.5	47.6	59.6	10	19.0	104.0	52.0	42.3	77.0	22	23.8	409.0	103.0	46.7	161.0	21	42.4	94.0	73.8	60.2	76.4	13	NS	NS	20[CC]
Total Dissolved Solids	mg/L	120.0	290.0	120.0	120.0	205.0	3	130.0	374.0	220.0	175.5	244.0	10	90.0	530.0	180.0	150.0	220.0	11	119.0	274.0	238.0	178.5	256.0	3	NS	NS	NS
Total Suspended Solids	mg/L	3.0	30.0	23.0	5.0	25.0	5	< 3.0	27.0	7.0	3.5	10.8	10	< 3.0	38.0	3.0	2.3	8.0	11	--	--	--	--	--	0	NS	NS	NS
Turbidity	NTU	--	--	--	--	--	0	--	--	--	--	--	0	2.0	5.0	3.5	2.8	4.3	2	--	--	--	--	--	0	NS	NS	NS
Major Ions																												
Carbonate (CO_3)	mg/L	< 0.5	< 5.0	< 5.0	< 2.8	< 5.0	3	< 0.5	< 5.0	< 0.5	< 0.5	< 0.5	9	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	4	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	2	NS	NS	NS
Bicarbonate (HCO_3 ($CaCO_3$))	mg/L	69.0	318.0	88.0	78.5	203.0	3	110.0	416.0	257.5	201.8	288.3	10	58.0	499.0	159.0	115.5	224.5	11	271.0	294.0	282.5	276.8	288.3	2	NS	NS	NS
Sodium (Na)	mg/L	1.5	19.5	2.8	2.0	5.5	11	0.9	30.8	2.9	1.7	9.3	30	0.4	97.0	6.0	1.8	16.5	21	1.4	18.4	3.3	2.4	3.9	15	NS	NS	NS
Potassium (K)	mg/L	0.6	2.7	1.2	1.0	1.8	11	0.1	4.3	0.8	0.5	1.3	30	0.1	3.7	1.4	0.4	2.0	21	0.6	2.7	1.1	0.8	1.2	15	NS	NS	NS
Calcium (Ca)	mg/L	4.0	74.9	18.5	13.4	21.8	11	7.1	113.5	21.6	14.9	37.2	30	9.1	63.1	23.9	15.0	35.1	21	14.0	67.3	24.0	21.6	25.8	15	NS	NS	NS
Magnesium (Mg)	mg/L	< 1.0	20.1	4.9	4.1	5.7	11	2.2	32.3	5.6	4.0	12.1	30	2.3	29.0	6.3	4.0	10.9	21	4.0	18.6	6.5	5.7	7.1	15	NS	NS	NS
Chloride (Cl)	mg/L	< 1.0	6.2	0.8	0.7	2.0	11	< 1.0	5.0	0.7	0.5	1.0	30	< 1.0	42.0	1.0	1.0	2.0	21	0.6	5.0	1.0	1.0	1.2	15	230**	NS	860[MC]/230[CC]
Sulphate (SO_4)	mg/L	3.5	18.7	11.3	9.7	15.7	11	4.9	29.5	10.9	8.1	16.8	30	5.6	70.1	12.8	9.5	23.0	21	11.0	21.4	15.4	13.5	16.7	15	NS	NS	NS
Nutrients																												
Nitrite (NO_2-N)	mg/L	< 0.050	0.020	0.010	0.007	0.018	6	< 0.050	0.012	0.005	0.003	0.008	12	0.003	0.007	0.004	0.004	0.006	5	< 0.100	0.015	0.007	0.005	0.011	11	0.018	0.018	NS
Nitrate (NO_3-N)	mg/L	0.057	0.280	0.086	0.057	0.221	5	< 0.050	0.072	0.014	0.011	0.022	12	0.008	0.024	0.017	0.013	0.018	5	0.001	0.545	0.186	0.085	0.220	10	NS	2.9	NS
Nitrate + nitrite (NO_3 + NO_2-N)	mg/L	< 0.10	0.30	0.06	0.05	0.23	9	< 0.10	0.08	0.02	0.003	0.03	22	< 0.10	0.10	0.05	0.03	0.05	20	< 0.10	0.56	0.18	0.11	0.23	15	0.018***	NS	NS
Nitrogen - Ammonia (NH_4-N)	mg/L	< 0.05	0.17	0.03	0.03	0.07	7	< 0.05	0.33	0.03	0.02	0.04	14	< 0.05	0.50	0.03	0.03	0.04	16	0.01	0.40	0.04	0.03	0.07	13	1.37 to 2.20	0.015	NS[4]
Nitrogen - Kjeldahl (TKN)	mg/L	0.40	1.14	0.70	0.57	0.84	7	0.24	1.64	0.60	0.50	0.70	14	0.40	1.48	0.60	0.56	0.80	18	0.40	2.40	0.82	0.64	1.18	12	NS	NS	NS
Total nitrogen (TKN+NO_3 + NO_2)	mg/L	0.63	1.37	0.80	0.68	0.92	7	0.27	1.71	0.60	0.52	0.70	13	0.01	1.52	0.70	0.60	0.90	18	0.51	2.63	0.98	0.70	1.37	11	1.0C	NS	NS
Phosphorus, total	mg/L	0.019	0.115	0.063	0.056	0.079	7	0.017	0.215	0.053	0.045	0.068	14	0.018	0.300	0.049	0.040	0.060	21	< 0.100	0.740	0.080	0.055	0.095	13	0.05C	NS	NS
Total organic carbon	mg/L	11	23	16	15	19	7	10	33	15	13	17	13	9	52	16	14	19	19	5	28	18	16	20	12	NS	NS	NS
Dissolved organic carbon	mg/L	11	20	16	14	18	7	10	33	15	12	16	13	8	46	14	13	19	18	5	28	18	16	19	12	NS	NS	NS
Organics																												
Total Phenolics	mg/L	< 0.001	0.007	0.001	0.001	0.004	5	< 0.001	0.006	0.001	0.001	0.002	10	< 0.001	0.006	0.002	0.001	0.004	12	--	--	--	--	--	0	0.005C	NS	NS
Total recoverable hydrocarbons	mg/L	< 0.5	0.7	0.5	0.4	0.6	2	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	2	< 0.5	2.0	0.3	0.3	1.1	12	--	--	--	--	--	0	NS	NS	NS
Total Metals																												
Aluminum (Al)	ug/L	30	838	200	40	485	5	< 10	200	5	5	58	10	30	1900	100	68	234	12	--	--	--	--	--	0	5^1/100^2	100a	750[MC]/87[CC]
Antimony (Sb)	ug/L	0.05	0.06	0.06	0.05	0.06	2	0.04	0.05	0.05	0.05	0.05	2	< 5.00	0.05	2.50	0.05	2.50	12	--	--	--	--	--	0	NS	NS	NS
Arsenic (As)	ug/L	0.7	1.0	0.8	0.8	0.9	5	< 0.3	1.2	0.6	0.6	0.6	10	< 1.0	0.9	0.5	0.5	0.7	12	--	--	--	--	--	0	5.0^	5	340[MC]/150[CC]
Barium (Ba)	ug/L	30.8	37.5	34.2	32.5	35.8	2	23.8	27.9	25.9	24.8	26.9	2	17.6	55.5	32.3	27.1	39.4	12	--	--	--	--	--	0	NS	NS	NS
Beryllium (Be)	ug/L	0.03	0.04	0.04	0.03	0.04	2	0.01	0.01	0.01	0.01	0.01	2	< 1.00	0.02	0.50	0.02	0.50	12	--	--	--	--	--	0	NS	NS	NS
Boron (B)	ug/L	23.8	33.1	28.5	26.1	30.8	2	26.3	33.4	29.9	28.1	31.6	2	13.0	499.0	38.4	28.3	213.5	11	--	--	--	--	--	0	NS	NS	NS
Cadmium (Cd)	ug/L	< 0.20	1.20	0.10	0.01	0.10	5	< 0.30	2.60	0.38	0.11	1.78	10	< 0.20	0.01	0.10	0.01	0.10	12	--	--	--	--	--	0	HardnessH^	0.017b	20[MC,H]/0.25[CC,H]
Chromium (Cr)	ug/L	0.8	16.0	5.0	1.2	6.0	5	< 3.0	6.0	1.5	1.0	4.8	10	< 0.8	2.9	0.4	0.4	0.5	12	--	--	--	--	--	0	8.9^	8.9	570[MC,H]/74[CC,H]
Cobalt (Co)	ug/L	0.3	0.4	0.3	0.3	0.4	2	0.1	0.1	0.1	0.1	0.1	2	< 0.2	0.8	0.2	0.1	0.3	12	--	--	--	--	--	0	NS	NS	NS
Copper (Cu)	ug/L	< 1.0	4.0	0.8	0.5	0.9	5	< 1.0	5.0	2.0	0.5	2.8	10	< 1.0	3.0	0.6	0.5	1.3	12	--	--	--	--	--	0	HardnessH	2b	13[MC,H]/9[CC,H]
Iron (Fe)	ug/L	40	2730	1040	710	1350	5	< 10	665	145	98	548	10	120	1940	710	600	802	13	< 10	500	160	83	330	3	300	300	1000CC
Lead (Pb)	ug/L	< 0.30	0.40	0.15	0.15	0.28	5	< 0.40	0.60	0.15	0.15	0.15	10	0.08	4.90	0.38	0.13	1.35	12	--	--	--	--	--	0	HardnessH^	2b	65[MC,H]/2.5[CC,H]
Lithium (Li)	ug/L	6.2	7.5	6.9	6.5	7.2	2	6.4	7.5	6.9	6.6	7.2	2	< 6.0	65.0	11.6	8.6	21.3	12	--	--	--	--	--	0	NS	NS	NS
Manganese (Mn)	ug/L	75.5	491.0	88.8	82.2	289.9	3	< 1.0	284.0	151.0	23.8	220.0	10	20.6	307.0	86.4	69.3	210.8	12	143.0	400.0	271.5	207.3	335.8	2	NS	NS	NS
Mercury (Hg)	ug/L	< 0.10	0.01	0.03	0.01	0.05	10	< 0.10	0.20	0.05	0.03	0.05	22	< 0.20	0.50	0.08	0.05	0.10	18	< 0.10	0.20	0.10	0.09	0.10	12	0.013A/0.005C	0.026^^	1.4[MC,H]/0.77[CC,H]
Molybdenum (Mo)	ug/L	0.63	0.68	0.66	0.64	0.67	2	0.71	0.94	0.82	0.76	0.88	2	0.20	1.50	0.43	0.28	0.68	12	--	--	--	--	--	0	73^	73	NS
Nickel (Ni)	ug/L	< 0.60	1.43	0.30	0.25	1.14	5	< 0.50	3.00	0.25	0.25	0.68	10	0.40	6.90	1.70	0.83	4.88	12	--	--	--	--	--	0	HardnessH^	65b	470[MC,H]/52[CC,H]
Selenium (Se)	ug/L	< 0.10	0.13	0.09	0.07	0.11	2	0.13	0.24	0.18	0.15	0.21	2	< 0.80	0.24	0.40	0.24	0.40	12	--	--	--	--	--	0	1.0^	1	5[CC]
Silicon (Si)	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	NS	NS	NS
Silver (Ag)	ug/L	< 0.100	0.200	0.050	0.007	0.200	5	< 0.100	0.001	0.050	0.050	0.050	10	< 0.400	0.005	0.200	0.005	0.200	12	--	--	--	--	--	0	0.1^	0.1	3.2[MC,H]
Strontium (Sr)	ug/L	67.4	90.9	79.2	73.3	85.0	2	96.5	116.0	106.3	101.4	111.1	2	49.8	431.0	141.0	109.9	188.5	12	--	--	--	--	--	0	NS	NS	NS
Sulphur (S)	ug/L	2950	4450	3700	3325	4075	2	--	--	--	--	--	0	2410	3890	3490	3152.5	3657.5	4	--	--	--	--	--	0	NS	NS	NS
Thallium (Tl)	ug/L	0.020	0.025	0.023	0.021	0.024	2	0.003	0.006	0.004	0.004	0.005	2	< 0.100	0.100	0.050	0.009	0.050	12	--	--	--	--	--	0	0.8^	0.8	NS
Tin (Sn)	ug/L	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	2	< 0.03	0.03	0.02	0.02	0.03	2	< 0.40	1.30	0.20	0.08	0.53	12	--	--	--	--	--	0	NS	NS	NS
Titanium (Ti)	ug/L	10.3	14.0	12.2	11.2	13.1	2	1.6	3.1	2.3	2.0	2.7	2	< 0.6	52.1	2.6	2.6	5.7	12	--	--	--	--	--	0	NS	NS	NS
Uranium (U)	ug/L	0.1	0.1	0.1	0.1	0.1	2	0.1	0.1	0.1	0.1	0.1	2	< 0.1	0.8	0.1	0.1	0.4	12	--	--	--	--	--	0	NS	NS	NS
Vanadium (V)	ug/L	< 1.0	2.4	0.5	0.5	1.1	7	< 1.0	4.0	0.5	0.5	0.5	14	< 1.0	3.3	0.5	0.3	0.7	18	< 1	7	1	1	1	12	NS	NS	NS
Zinc (Zn)	ug/L	< 1	16	4	3	5	5	< 1	58	8	4	17	10	1	298	21	7	59	12	--	--	--	--	--	0	30^	30	120[M,H]/120[CC,H]
Zirconium (Zr)	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	NS	NS	NS

Table 7C-6 Water Quality in Tributaries to the Lower Christina and Clearwater Rivers

Parameter	Unit	Spring, Watercourses (1976 - 1983, 1988, 1998 and 2005)						Summer, Watercourses (1976 - 1984, 1998, 2004)						Fall, Watercourses (1972, 1976, 1978 - 1982, 2000, 2004, 2005)						Winter, Watercourses (1973, 1976, 1978, 1979, 1980, 1981)						AENV Freshwater Aquatic Life*	CCME Water Quality Guidelines - Freshwater^	EPA Freshwater Water Quality***
		Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N	Min	Max	Median	25th percentile	75th percentile	N			
Dissolved Metals																												
Aluminum	ug/L	0.58	11.90	6.24	3.41	9.07	2	6.40	7.34	6.87	6.64	7.11	2	6.92	12.90	8.24	7.90	9.41	4	--	--	--	--	--	0	**NS**	**NS**	**$750^{MC}/87^{CC}$**
Antimony	ug/L	0.05	0.06	0.05	0.05	0.05	2	0.04	0.05	0.05	0.05	0.05	2	0.04	0.05	0.05	0.04	0.05	4	--	--	--	--	--	0	**NS**	**NS**	**NS**
Arsenic	ug/L	0.0006	0.6770	0.0014	0.0010	0.2800	7	0.8860	0.9590	0.9225	0.9043	0.9408	2	0.508	0.555	0.529	0.518	0.542	4	--	--	--	--	--	0	**NS**	**NS**	**$340^{MC}/150^{CC}$**
Barium	ug/L	22.6	27.2	24.9	23.8	26.1	2	22.5	25.1	23.8	23.2	24.5	2	20.2	30.7	24.4	21.9	27.3	4	--	--	--	--	--	0	**NS**	**NS**	**NS**
Beryllium	ug/L	0.010	0.011	0.010	0.010	0.011	2	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	2	< 0.003	0.005	0.004	0.003	0.005	4	--	--	--	--	--	0	**NS**	**NS**	**NS**
Bismuth	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	
Boron	ug/L	22	120	50	31	85	7	20	140	55	35	78	14	20	110	50	23	85	10	70	170	115	90	143	12	**NS**	**NS**	**NS**
Cadmium	ug/L	0.003	0.003	0.003	0.003	0.003	2	< 1.000	0.004	0.004	0.003	0.252	3	< 0.002	0.009	0.003	0.001	0.006	4	--	--	--	--	--	0	**NS**	**NS**	**$20^{MC,H}/0.25^{CC,H}$**
Chromium	ug/L	0.17	0.24	0.21	0.19	0.22	2	0.16	0.35	0.25	0.20	0.30	2	0.08	0.23	0.15	0.09	0.21	4	--	--	--	--	--	0	**NS**	**NS**	**$570^{MC,H}/74^{CC,H}$**
Cobalt	ug/L	0.10	0.11	0.10	0.10	0.11	2	0.05	0.08	0.07	0.06	0.07	2	0.07	0.09	0.09	0.08	0.09	4	--	--	--	--	--	0	**NS**	**NS**	**NS**
Copper	ug/L	0.8	0.8	0.8	0.8	0.8	2	0.4	0.4	0.4	0.4	0.4	2	0.4	0.5	0.4	0.4	0.4	4	--	--	--	--	--	0	**NS**	**NS**	**$13^{MC,H}/9^{CC,H}$**
Iron	ug/L	139	222	181	160	201	2	277	447	362	319.5	404.5	2	248	339	267	257	290	4	--	--	--	--	--	0	**NS**	**NS**	**1000CC**
Lead	ug/L	0.04	0.08	0.06	0.05	0.07	2	0.04	0.06	0.05	0.04	0.05	2	0.02	0.06	0.03	0.03	0.04	4	--	--	--	--	--	0	**NS**	**NS**	**$65^{MC,H}/2.5^{CC,H}$**
Lithium	ug/L	5.2	6.3	5.8	5.5	6.0	2	6.4	7.3	6.8	6.6	7.1	2	6.2	9.8	8.0	6.4	9.5	4	--	--	--	--	--	0	**NS**	**NS**	**NS**
Manganese	ug/L	30.6	32.2	31.4	31.0	31.8	2	1.5	12.5	7.0	4.3	9.8	2	32.0	79.5	55.9	35.5	76.3	4	--	--	--	--	--	0	**NS**	**NS**	**NS**
Mercury	ug/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	2	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	2	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	4	--	--	--	--	--	0	**NS**	**NS**	**$1.4^{MC,H}/0.77^{CC,H}$**
Molybdenum	ug/L	0.58	0.65	0.62	0.60	0.63	2	0.70	0.93	0.82	0.76	0.87	2	0.47	0.70	0.51	0.47	0.58	4	--	--	--	--	--	0	**NS**	**NS**	**NS**
Nickel	ug/L	1.12	1.38	1.25	1.19	1.32	2	0.60	0.70	0.65	0.62	0.67	2	0.53	0.79	0.61	0.55	0.69	4	--	--	--	--	--	0	**NS**	**NS**	**$470^{MC,H}/52^{CC,H}$**
Silver	ug/L	< 0.0005	0.0020	0.0011	0.0007	0.0016	2	< 0.0005	0.0015	0.0009	0.0006	0.0012	2	< 0.0005	0.0008	0.0003	0.0003	0.0004	4	--	--	--	--	--	0	**NS**	**NS**	**$3.2^{MC,H}$**
Strontium	ug/L	66.8	85.6	76.2	71.5	80.9	2	95.6	113.0	104.3	100.0	108.7	2	70.9	154.0	96.2	85.5	115.0	4	--	--	--	--	--	0	**NS**	**NS**	**NS**
Sulphur	ug/L	2730.0	4460.0	3595.0	3162.5	4027.5	2	--	--	--	--	--	0	1700	3870	2585	1723	3548	4	--	--	--	--	--	0	**NS**	**NS**	**NS**
Thallium	ug/L	0.010	0.010	0.010	0.010	0.010	2	0.002	0.003	0.002	0.002	0.003	2	< 0.0003	0.007	0.003	0.001	0.005	4	--	--	--	--	--	0	**NS**	**NS**	**NS**
Tin	ug/L	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	2	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	2	< 0.03	0.06	0.05	0.03	0.06	4	--	--	--	--	--	0	**NS**	**NS**	**NS**
Titanium	ug/L	0.82	1.30	1.06	0.94	1.18	2	1.05	1.07	1.06	1.06	1.07	2	0.94	1.35	1.17	1.07	1.25	4	--	--	--	--	--	0	**NS**	**NS**	**NS**
Vanadium	ug/L	0.24	0.31	0.27	0.26	0.29	2	0.27	0.29	0.28	0.27	0.28	2	0.14	0.16	0.15	0.15	0.15	4	--	--	--	--	--	0	**NS**	**NS**	**NS**
Zinc	ug/L	2.8	3.7	3.2	3.0	3.4	2	2.9	3.3	3.1	3.0	3.2	2	0.9	8.2	2.0	1.4	3.8	4	--	--	--	--	--	0	**NS**	**NS**	**$120^{M,H}/120^{CC,H}$**
Polycyclic Aromatic Hydrocarbons																												
Naphthalene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**1.1^**	**1.1**	**NS**
Acephthylene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Acenaphthene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**5.8^**	**5.8**	**NS**
Fluorene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**3^**	**3**	**NS**
Phenanthrene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**0.4^**	**0.4**	**NS**
Anthracene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**0.012^**	**0.012**	**NS**
Acridine	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**4.4^**	**NS**	**NS**
Fluoranthene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**0.04^**	**0.04**	**NS**
Pyrene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**0.025^**	**0.025**	**NS**
Benz[a]anthracene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**0.018^**	**0.018**	**NS**
Chrysene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Benzo[b]fluoranthene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Benzo[k]fluoranthene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Benzo[a]pyrene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**0.015^**	**0.015**	**NS**
Indeno[1,2,3-cd]pyrene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Dibenzo[a,h]anthracene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Quinoline	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
Benzo[g,h,i]perylene	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**
CCME BP Equivalent	ug/L	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	--	--	--	--	--	0	**NS**	**NS**	**NS**

Notes:

--- - not analyzed
NS - not specified
^ - Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME, 2006)
* - Alberta Environment Surface Water Quality Guidelines for use in Alberta (AENV, 1999)
^{CC} - continuous concentration guideline, National Recommended Water Quality Criteria (USEPA, 2006
^{MC} - maximum concentration guideline, National Recommended Water Quality Criteria (USEPA, 2006)
*** - National Recommended Water Quality Criteria (USEPA, 2006)
^^ - indicates value for Inorganic Mercury
^{1} - value if pH <6.5, Ca <4.0, DOC <2
^{2} - value if pH $\geq$6.5, Ca $\geq$4.0, DOC $\geq$2
^{3} - refer to CCME summary table for DO guideline breakdown
^{4} - refer to USEPA summary table for Ammonia criteria calculations
^{A} - Acute aquatic life guideline
$^{A\,A}$ - 1 day minimum, acute guideline
a - value if pH>6.5, Ca>4.0, DOC>2
b - dependent on hardness value
^{C} - Chronic Aquatic Life guideline
^{H} - dependent on hardness value
*** - value denotes NO_2-N guideline concentration
Italics - indicates that values exceed specified guideline

Appendix 7D Water Quality QA/QC Tables

Table 7D-1 Quality Control Sample Results for Duplicate Samples, Field Measured Parameters

Sample Point	Sample Date	Matrix Sample Number	Field Temp °C	Field pH	Field EC uS/cm	Field DO mg/L	Field Turbidity NTU
WB5	05-May-06	4455060505203	10.27	7.16	48	14.69	5.03
WB5 dup	05-May-06	4455060505204	10.27	7.16	48	14.69	5.03
		Method Detection Limit	0.01	0.1	0.3	0.2	0.5
		Absolute Difference*	0	0	0	0	0
		Absolute Relative Percent Difference (RPD)*	0	0	0	0	0
WC9	20-Aug-06	4455060820006	12.66	5.36	81	6.75	9.59
WC9 dup	20-Aug-06	4455060820008	---	---	---	---	8.07
		Method Detection Limit	0.01	0.1	0.3	0.2	0.5
		Absolute Difference*	-	-	-	-	1.52
		Absolute Relative Percent Difference (RPD)*	OK	OK	OK	OK	17

Table 7D-2 Quality Control Sample Results For Duplicate Samples, Routine and Indicator Parameters

Sample Point	Sample Date	Matrix Sample Number	Lab pH	Lab EC uS/cm	Na mg/L	K mg/L	Ca mg/L	Mg mg/L	Mn mg/L	Fe mg/L	Cl mg/L	SO_4 mg/L	HCO_3 mg/L	CO_3 mg/L	OH mg/L	TDS mg/L	Hardness as $CaCO_3$ mg/L	Alkalinity as $CaCO_3$ mg/L
WC9	20-Aug-06	4455060820006	7.3	55	1.0	<0.3	7.6	1.6	0.043	0.85	1.0	2.2	32.3	<0.5	<0.5	30	26	26.5
WC9 dup	20-Aug-06	4455060820008	7.36	55	0.8	<0.3	8.7	1.8	0.055	0.74	1.1	2.3	31	<0.5	<0.5	31	29	25.4
		Method Detection Limit	0.01	0.1	0.3	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.5	0.5	0.2	0.2	0.5
		Absolute Difference*	0.06	0	0.2	---	1.1	0.2	0.012	0.11	0.1	0.1	1.3	---	---	1	3	1.1
		Absolute Relative Percent Difference (RPD)*	1	0	22	OK	13	12	24	14	10	4	4	OK	OK	3	11	4

Table 7D-3 Quality Control Sample Results for Duplicate Samples, TSS and Nutrient Parameters

Sample Point	Sample Date	Matrix Sample Number	TSS mg/L	NO_2+NO_3-N mg/L	NH_4-N mg/L	TKN mg/L	PO_4-P Total mg/L
WC3	07-May-06	4455060507508	30	---	0.03	1.01	0.125
WC3 dup	08-May-06	4455060508011	30	---	0.03	0.82	0.115
		Method Detection Limit (MDL)	1	0.003	0.01	0.05	0.003
		Absolute Difference*	0	---	0	0.19	0.01
		Absolute Relative Percent Difference (RPD)*	0	OK	0	21	8
WC15	06-May-06	4455060506006	9	---	0.05	0.84	0.078
WC15 dup	06-May-06	4455060506008	12	---	0.04	0.88	0.079
		Method Detection Limit (MDL)	1	0.003	0.01	0.05	0.003
		Absolute Difference*	3	---	0.01	0.04	0.001
		Absolute Relative Percent Difference (RPD)*	29	OK	22	5	1
WB5	05-May-06	4455060505203	21	---	0.03	0.86	0.083
WB5 dup	05-May-06	4455060505204	20	---	0.02	1.10	0.080
		Method Detection Limit (MDL)	1	0.003	0.01	0.05	0.003
		Absolute Difference*	1	---	0.01	0.24	0.003
		Absolute Relative Percent Difference (RPD)*	5	OK	***40^***	24	4
WC9	20-Aug-06	4455060820006	6	0.011	0.08	0.75	0.066
WC9 dup	20-Aug-06	4455060820008	7	0.007	0.04	1.17	0.058
		Method Detection Limit (MDL)	1	0.003	0.01	0.05	0.003
		Absolute Difference*	1	0.004	0.04	0.42	0.008
		Absolute Relative Percent Difference (RPD)*	15	***44^***	***67^***	***44^***	13

Notes:
* - non-detectable concentrations are assessed at 95% of the detection limit
--- - difference cannot be calculated because both samples yielded non-detectable results
OK - indicates acceptable reproducibility at non-detectable levels
^ - although the RPD is greater than 30, the concentration difference between duplicate analyses is less than approximately 10 times the MDL and, therefore, the reproducibility of the analysis is deemed acceptable
Italics - indicates RPD values greater than 30 and suggests poor reproducibility

Appendix 7D Water Quality QA/QC Tables

Table 7D-4 Quality Control Sample Results for Duplicate Samples, Total Metals

Sample Point	Sample Date	MSI Sample Number	Al ug/L	Sb ug/L	As ug/L	Ba ug/L	Be ug/L	B ug/L	Cd ug/L	Cr ug/L	Co ug/L	Cu ug/L	Pb ug/L	Li ug/L	Mo ug/L
WC3	07-May-06	4455060507508	309	<0.2	2.6	36.7	<0.2	20	<0.01	1	0.3	0.7	<0.3	<4	0.3
WC3 dup	08-May-06	4455060508011	316	<0.2	6.4	38.2	<0.2	20	0.19	2	0.5	0.3	<0.3	5	0.3
Method Detection Limit			1	0.2	0.2	0.2	0.2	10	0.01	1	0.3	0.2	0.3	4	0.2
Absolute Difference*			7	---	3.8	1.5	---	0	0.18	1	0.2	0.4	---	1.2	0
Absolute Relative Percent Difference (RPD)*			2	OK	***84***	4	OK	0	***181***	***67^***	***50^***	***80^***	OK	27	0
WC15	06-May-06	4455060506006	203	<0.2	0.6	22.7	<0.2	20	0.24	2	0.4	<0.2	<0.3	<4	0.3
WC15 dup	06-May-06	4455060506008	191	<0.2	0.6	21.7	<0.2	20	0.18	2	0.3	<0.2	<0.3	<4	0.3
Method Detection Limit			1	0.2	0.2	0.2	0.2	10	0.01	1	0.3	0.2	0.3	4	0.2
Absolute Difference*			12	---	0	1	---	0	0.06	0	0.1	---	---	---	0
Absolute Relative Percent Difference (RPD)*			6	OK	0	5	OK	0	29	0	29	OK	OK	OK	0
WB5	05-May-06	4455060505203	32	<0.2	<0.2	8.5	<0.2	20	0.22	1	<0.3	<0.2	<0.3	<4	<0.2
WB5 dup	05-May-06	4455060505204	28	<0.2	<0.2	12.5	<0.2	10	0.18	1	<0.3	<0.2	<0.3	<4	<0.2
Method Detection Limit			1	0.2	0.2	0.2	0.2	10	0.01	1	0.3	0.2	0.3	4	0.2
Absolute Difference*			4	---	---	4	---	10	0.04	0	---	---	---	---	---
Absolute Relative Percent Difference (RPD)*			13	OK	OK	***38^***	OK	***67^***	20	0	OK	OK	OK	OK	OK
WC9	20-Aug-06	4455060820006	80	<0.2	0.9	32.5	<0.2	10	<0.01	2	0.5	0.2	<0.3	<4	<0.2
WC9 dup	20-Aug-06	4455060820008	58	<0.2	0.7	30.5	<0.2	<10	<0.01	7	0.4	0.6	<0.3	<4	<0.2
Method Detection Limit			1	0.2	0.2	0.2	0.2	10	0.01	1	0.3	0.2	0.3	4	0.2
Absolute Difference*			22	---	0.2	2	---	0.5	---	5	0.1	0.4	---	---	---
Absolute Relative Percent Difference (RPD)*			***32***	OK	25	6	OK	5	OK	***111^***	22	***100^***	OK	OK	OK

Sample Point	Sample Date	MSI Sample Number	Ni ug/L	Se ug/L	Si ug/L	Ag ug/L	Sr ug/L	S ug/L	Tl ug/L	Sn ug/L	Ti ug/L	U ug/L	V ug/L	Zn ug/L	Zr ug/L
WC3	07-May-06	4455060507508	1.0	<0.2	2160	<0.1	46	900	<0.2	<1	6	<0.4	<1	4.8	0.5
WC3 dup	08-May-06	4455060508011	2.5	<0.2	2020	0.6	43	800	<0.2	<1	8	<0.4	<1	13.8	<1
Method Detection Limit			0.5	0.2	40	0.1	2	200	0.2	1	1	0.4	1	0.6	0.5
Absolute Difference*			1.5	---	140	0.505	3	100	---	---	2	---	---	9	0.025
Absolute Relative Percent Difference (RPD)*			***86^***	OK	7	***145^***	7	12	OK	OK	29	OK	OK	***97^***	5
WC15	06-May-06	4455060506006	1.2	<0.2	2120	0.7	30	700	<0.2	<1	5	<0.4	<1	14.9	2
WC15 dup	06-May-06	4455060506008	1.1	<0.2	2230	0.5	30	600	<0.2	<1	5	<0.4	<1	10.2	1
Method Detection Limit			0.5	0.2	40	0.1	2	200	0.2	1	1	0.4	1	0.6	1
Absolute Difference*			0.1	---	110	0.2	0	100	---	---	0	---	---	4.7	1
Absolute Relative Percent Difference (RPD)*			9	OK	5	***33^***	0	15	OK	OK	0	OK	OK	***37^***	***67^***
WB5	05-May-06	4455060505203	0.9	<0.2	530	0.2	24	<200	<0.2	<1	1	<0.4	<1	5	2.0
WB5 dup	05-May-06	4455060505204	1.3	<0.2	460	0.2	26	300	<0.2	<1	1	<0.4	<1	6	1.6
Method Detection Limit			0.5	0.2	40	0.1	2	200	0.2	1	1	0.4	1	0.6	0.2
Absolute Difference*			0.4	---	70	0	2	110	---	---	0	---	---	1	0.4
Absolute Relative Percent Difference (RPD)*			***36^***	OK	14	0	8	***45^***	OK	OK	0	OK	OK	18	22
WC9	20-Aug-06	4455060820006	0.9	0.3	2230	<0.1	32	<200	<0.2	<1	2	<0.4	<1	32.0	<0.2
WC9 dup	20-Aug-06	4455060820008	0.9	0.3	2150	<0.1	31	200	<0.2	<1	2	<0.4	<1	26.9	<0.2
Method Detection Limit			0.5	0.2	40	0.1	2	200	0.2	1	1	0.4	1	0.6	0.2
Absolute Difference*			0	0	80	---	1	10	---	---	0	---	---	5.1	---
Absolute Relative Percent Difference (RPD)*			0	0	4	OK	3	5	OK	OK	0	OK	OK	17	OK

Notes:

* - non-detectable concentrations are assessed at 95% of the detection limit
--- - difference cannot be calculated because both samples yielded non-detectable results
OK - indicates acceptable reproducibility at non-detectable levels
^ - although the RPD is greater than 30, the concentration difference between duplicate analyses is less than approximately 10 times the MDL and, therefore, the reproducibility of the analysis is deemed acceptable
Italics - indicates RPD values greater than 30 and suggests poor reproducibility

Appendix 7D Water Quality QA/QC Tables

Table 7D-5 Quality Control Sample Results for Duplicate Samples, Polycyclic Aromatic Hydrocarbons

Sample Point	Date	MSI Sample Number	Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Acridine	Fluoranthene	Pyrene	Benz[a]anthracene	Chrysene	Benzo[b]fluoranthene	Benzo[k]fluoranthene	Benzo[a]pyrene	Indeno[1,2,3-cd]pyrene	Dibenz[a,h]anthracene	Quinoline	Benzo[g,h,i]perylene	CCME B(a)P Equivalent
			ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
WC12	09-Feb-06	4455060209303	<0.1	<0.1	<0.1	<0.05	<0.05	<0.01	<0.2	<0.04	0.02	0.02	<0.05	<0.1	<0.05	0.01	<0.1	<0.05	<0.2	<0.05	<0.0078
WC12 dup	09-Feb-06	4455060209305	<0.1	<0.1	<0.1	<0.05	<0.05	<0.01	<0.2	<0.04	<0.02	<0.01	<0.05	<0.1	<0.05	<0.01	<0.1	<0.05	<0.2	<0.05	<0.0078
Method Detection Limit			0.1	0.1	0.1	0.05	0.05	0.01	0.2	0.04	0.02	0.01	0.05	0.1	0.05	0.01	0.1	0.05	0.2	0.05	0.0078
Absolute Difference*			---	---	---	---	---	---	---	---	0.001	0.0105	---	---	---	0.0005	---	---	---	---	---
Absolute Relative Percent Difference (RPD)*			OK	OK	OK	OK	OK	OK	OK	OK	5	***71^***	OK	OK	OK	5	OK	OK	OK	OK	OK
WB6	08-Feb-06	4455060208002	<0.1	<0.1	<0.1	<0.05	<0.05	<0.01	<0.2	<0.04	<0.02	<0.01	<0.05	<0.1	<0.05	<0.01	<0.1	<0.05	<0.2	<0.05	<0.0078
WB6 dup	08-Feb-06	4455060208003	<0.1	<0.1	<0.1	<0.05	<0.05	<0.01	<0.2	<0.04	<0.02	<0.01	<0.05	<0.1	<0.05	<0.01	<0.1	<0.05	<0.2	<0.05	<0.0078
Method Detection Limit			0.1	0.1	0.1	0.05	0.05	0.01	0.2	0.04	0.02	0.01	0.05	0.1	0.05	0.01	0.1	0.05	0.2	0.05	0.0078
Absolute Difference*			---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Absolute Relative Percent Difference (RPD)*			OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK

Notes:

* - non-detectable concentrations are assessed at 95% of the detection limit
--- - difference cannot be calculated because both samples yielded non-detectable results
OK - indicates acceptable reproducibility at non-detectable levels
^ - although the RPD is greater than 30, the concentration difference between duplicate analyses is less than approximately 10 times the MDL and, therefore, the reproducibility of the analysis is deemed acceptable
Italics - indicates RPD values greater than 30 and suggests poor reproducibility

Appendix 7D Water Quality QA/QC Tables

Table 7D-6 Quality Control Sample Results For Blank Samples, Routine and Indicator Parameters

Sample Point	Sample Date	Matrix Sample Number	Lab pH	Lab EC uS/cm	Na mg/L	K mg/L	Ca mg/L	Mg mg/L	Mn mg/L	Fe mg/L	Cl mg/L	SO_4 mg/L	HCO_3 mg/L	CO_3 mg/L	OH mg/L	TDS mg/L	Hardness as $CaCO_3$ mg/L	Alkalinity as $CaCO_3$ mg/L
Trip Blank	08-Aug-05	4455050808004	5.98	1	<0.5	<0.3	<0.3	<0.2	<0.004	<0.01	<0.5	3.6	1.1	<0.5	<0.5	<10	<0.5	0.9
Trip Blank	11-Feb-06	4455060211508	5.84	1	<0.5	<0.3	<0.3	<0.2	<0.004	<0.01	1	<0.5	0.8	<0.5	<0.5	<10	<0.5	0.6
Method Detection Limit			0.01	0.1	0.3	0.3	0.3	0.2	0.004	0.01	0.5	0.2	0.2	0.5	0.5	10	0.5	0.5

Table 7D-7 Quality Control Sample Results For Blank Samples, TSS and Nutrient Parameters

Sample Point	Sample Date	Matrix Sample Number	TSS mg/L	NO_2+NO_3-N mg/L	NH_4-N mg/L	TKN mg/L	PO_4-P Total mg/L
Trip Blank	08-Aug-05	4455050808004	1	<0.003	0.07	<0.05	0.004
Trip Blank	11-Feb-06	4455060211508	<1	0.003	0.05	0.17	0.003
Method Detection Limit (MDL)			1	0.003	0.01	0.05	0.003

Appendix 7D Water Quality QA/QC Tables

Table 7D-8 Quality Control Sample Results For Blank Samples, Total Metals

Sample Point	Sample Date	MSI Sample Number	Al ug/L	Sb ug/L	As ug/L	Ba ug/L	Be ug/L	B ug/L	Cd ug/L	Cr ug/L	Co ug/L	Cu ug/L	Pb ug/L	Li ug/L	Mo ug/L
Field Blank	07-Aug-05	4455050807202	---	---	---	---	---	---	---	---	---	---	---	---	
Trip Blank	08-Aug-05	4455050808004	0.002	<0.0002	<0.0002	0.0011	<0.0002	<0.01	0.08	<0.001	<0.0003	<0.0002	<0.0003	<0.004	<0.0002
Trip Blank	11-Feb-06	4455060211508	0.003	<0.0002	<0.0002	0.0005	<0.0002	<0.01	<0.01	<0.001	<0.0003	<0.0002	<0.0003	<0.004	<0.0002
Method Detection Limit			1	0.2	0.2	0.2	0.2	10	0.01	1	0.3	0.2	0.3	4	0.2

Sample Point	Sample Date	MSI Sample Number	Hg ug/L	Ni ug/L	Se ug/L	Si ug/L	Ag ug/L	Sr ug/L	S ug/L	Tl ug/L	Sn ug/L	Ti ug/L	U ug/L	V ug/L	Zn ug/L	Zr ug/L
Field Blank	07-Aug-05	4455050807202	<0.6	---	---	---	---	---	---	---	---	---	---	---	---	---
Trip Blank	08-Aug-05	4455050808004	<0.6	<0.0005	<0.0002	<0.04	0.0003	<0.002	<0.2	<0.0002	<0.001	<0.001	<0.0004	<0.001	0.0098	<0.0002
Trip Blank	11-Feb-06	4455060211508	---	<0.0005	<0.0002	<0.04	<0.0001	<0.002	<0.2	<0.0002	<0.001	<0.001	<0.0004	<0.001	0.0138	<0.0002
Method Detection Limit			0.6	0.5	0.2	40	0.1	2	200	0.2	1	1	0.4	1	0.6	0.5

Appendix 7D Water Quality QA/QC Tables

Table 7D-9 Quality Control Sample Results For Blank Samples, Polycyclic Aromatic Hydrocarbons

Sample Point	Date	MSI Sample Number	Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Acridine	Fluoranthene	Pyrene	Benz[a]anthracene	Chrysene	Benzo[b]fluoranthene	Benzo[k]fluoranthene	Benzo[a]pyrene	Indeno[1,2,3-cd]pyrene	Dibenz[a,h]anthracene	Quinoline	Benzo[g,h,i]perylene	CCME B(a)P Equivalent
			ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
Field Blank	07-Aug-05	4455050807202	<0.1	<0.1	<0.1	<0.05	<0.05	<0.01	<0.2	<0.04	<0.02	<0.05	<0.05	<0.1	<0.05	<0.05	<0.1	<0.1	<0.2	<0.05	<0.0078
Trip Blank	08-Aug-05	4455050808004	<0.1	<0.1	<0.1	<0.05	<0.05	<0.01	<0.2	<0.04	<0.02	<0.05	<0.05	<0.1	<0.05	<0.05	<0.1	<0.1	<0.2	<0.05	<0.008
Trip Blank	11-Feb-06	4455060211508	<0.1	<0.1	<0.1	<0.05	<0.05	<0.01	<0.2	<0.04	<0.02	<0.01	<0.05	<0.1	<0.05	<0.01	<0.1	<0.1	<0.2	<0.05	<0.0078
Method Detection Limit			0.1	0.1	0.1	0.05	0.05	0.01	0.2	0.04	0.02	0.01	0.05	0.1	0.05	0.01	0.1	0.05	0.2	0.05	0.0078

Appendix 8A: Benthic Invertebrates

TABLE OF CONTENTS

TABLES

FIGURES

8A1 METHODOLOGY

Benthic invertebrate samples were collected in the fall of 2005 (September 27 to October 4). Samples were collected at three waterbody and six watercourse sampling sites in the LSA (Figure 8A-1). Seven sites were located in depositional habitat, typical of waterbodies and watercourses in the area. Two sites were located in erosion habitat. The objective of collecting benthic invertebrate samples was to characterize the benthic invertebrate community in representative habitat areas. The data were used to describe baseline conditions about the availability of food resources for fish and the health of the aquatic ecosystem.

8A1.1 Field Sampling

Sampling points were randomly selected in typical habitat at each of the sampling sites in the selected watercourses or waterbodies. In addition, benthic samples were collected in the fall when biodiversity is generally highest. Samples were collected in depositional sediments using an Ekman grab sampler with a sampling area of 0.023 m^2 and were field sieved to remove fine sediments using a 250 um Nitex mesh netting. Five replicate samples were collected at each site to understand variability among sites.

8A1.1.1 Sample Handling

Benthic invertebrate samples were preserved in 10 percent buffered formalin and stored in properly labelled and sealed containers. Subsequently, samples were stored and shipped in plastic coolers to prevent damage. Samples were shipped to Enviro-Test Laboratories in Winnipeg, Manitoba, for identification and enumeration. Chain of custody forms were used to track samples to ensure they remained secure and prevent samples from being lost or misidentified.

8A1.1.2 Supporting Data

Supporting habitat information was collected at each sampling site to help understand differences in the benthic invertebrate communities among different sampling sites. The supporting data collected at each site included:

- Exact site location (easting and northing using Global Positioning System [GPS], NAD 83, UTM 12);
- Water depth;
- Water velocity (Marsh-McBirney Model 2000 current velocity meter);
- Bankfull and wetted channel width (measuring tape);
- Water quality parameters (temperature, dissolved oxygen (DO), conductance and pH using a field calibrated Quanta Hydrolab multi-meter); and
- General description of the sampling area (e.g., macrophytes, riparian habitat, sediment characteristics).

One additional Ekman grab sample was collected at each site and analyzed for sediment particle size (percent sand, silt and clay) and total organic carbon (TOC). Sediment samples were double bagged in Zip-lock freezer bags and kept cool for storage and shipping. Sediment samples were shipped to an analytical laboratory for analysis.

8A1.2 Laboratory Methods

Benthic invertebrate samples were sorted, identified and enumerated by Enviro-Test Laboratories in Winnipeg, Manitoba.

Each replicate benthic invertebrate sample was sieved using 500 um and 250 um radial sieves to divide replicate samples into fine and coarse fractions. The radial sieve was divided into one eighth or one quarter portions and used to sub-sample each fraction. Coarse and fine fractions were sub-sampled to the same proportion (both to ⅛ or both to ¼). Sub-samples were then transferred to a Petri dish for sorting. Benthic invertebrates were removed with the aid of a zoom stereo-microscope using 20 to 40 power (Enviro-Test, personal communication).

Invertebrates were generally identified to the lowest practical taxon (species for amphipods, leeches and molluscs; genus for insects; family for oligochaetes; major group for nematodes, ostracods, zooplankton and aquatic mites [in this classification, “major group” is defined as a grouping of like organisms at the class or order level where lower level identifications are impractical and the information does not necessarily contribute to the objectives of the study]). Damaged and immature specimens were identified to the lowest practical level that their condition allowed. Laboratory data are presented as numbers of organisms per sample in Table 8A-1 (a, b, c).

8A1.2.1 Laboratory Quality Assurance

Laboratory procedures were conducted by trained individuals and were consistent with methods approved by other monitoring programs (e.g., RAMP, 2006; Environment Canada, 2002). Sorting efficiency was calculated by firstly dividing all samples into groups. A sample was randomly selected from each group and was resorted to look for missed organisms. If sorting efficiency was calculated to be less than 90 percent, all samples in that group were resorted. Sorting efficiency was calculated as:

$$\%E = \frac{N_r}{(N_i + N_r)} \times 100$$

where:

$\%E$ is the calculated sorting efficiency;

N_r is the number of organisms found in a sample during resorting; and

N_i is the number of organisms found during initial sorting.

Sorting efficiency was calculated to be greater than 90 percent (Table 8A-2) in most resorted samples. The one exception was for a sample with very few organisms where two small chironomidae larvae were found on resort. Because only ten organisms were found in the initial sorting, sorting efficiency for this sample was calculated to be 80 percent.

Benthic invertebrate abundance data are tallied on laboratory data sheets and transferred to electronic format. Electronic data are validated by comparing electronic spreadsheets containing invertebrate abundances with laboratory sheets.

8A1.3 Historic Data

A literature review of historic data was done to obtain background benthic invertebrate data for the study areas. Many previously documented studies including industry and government reports, EIAs and RAMP data were compiled in the Review of Historical Benthic Invertebrate Data for Rivers and Streams in the Oil Sands Region (Golder, 2003). Other documents (including MEG Energy, 2005; Nexen, 2006; Rio Alto, 2002) were reviewed to augment the historic benthic invertebrate database.

8A1.4 Data Analysis

Benthic invertebrate abundances were summarized as numbers of organisms per square metre. The number of benthic invertebrate taxa (identified to the lowest practical level) was termed taxonomic richness.

Historic benthic invertebrate data for the RSA was compiled from literature reviews. To reduce the possibility of transcription errors and decrease the amount of time to obtain historic data, electronic data files were obtained whenever possible (e.g., Golder, 2003). Other sources included environmental reports submitted to AENV (e.g., previous EIAs conducted in the area). Historic data were evaluated for their suitability to be included with Project data (e.g., comparability of mesh sieve sizes and sampling equipment; season when samples were collected). Historic data that were included with Project data were used to provide a regional context to describe the Project data.

The Project benthic invertebrate data and any suitable historic data were summarized in terms of principal components to identify variability in the benthic invertebrate community residing in the LSA. Principal components analysis (PCA) can be used to incorporate large amounts of data (e.g., benthic invertebrate abundances for each family present) into a few workable variables termed factors. The most important factors are used to build a two dimensional ordination plot to investigate affiliations (or principal components) among samples.

Principal component analysis was conducted in Systat ver. 11. Variables used for the analysis input included major benthic invertebrate taxon (Order), family or sub-family/tribe (for Chironomidae). The smaller groups were combined into an assemblage collectively termed Other. Initial tests indicated that sieve mesh size strongly influenced PCA results; therefore, only samples collected using 250 um sieve mesh were included in the analysis.

The PCA analysis was run on a correlation matrix calculated from the variables after the data were log transformed (ZAR, 1999) using the following calculation:

$$transformation = Ln(x+1)$$

where:

Ln is the natural log of 10 and x is the abundance for each taxon.

Biological data are commonly transformed so they are normally distributed, an assumption required to do various statistical analyses. Component factors were saved and used in ordination plots to visually examine how sample sites were grouped.

8A1.4.1 Data Quality

The benthic invertebrate data were graphed and inspected for outliers and potential errors and taxonomic names were checked for spelling. Non-benthic invertebrates including terrestrial insects, adults and pupa were removed from the data set. Any incorrect data were removed or corrected.

Data files were kept electronically and systematically processed. Each series of steps was saved on subsequent worksheets in Microsoft Excel® files to allow calculation checks and validation of the results.

8A1.4.2 Community Characterization

The benthic invertebrate community was characterized using community variables, including numbers of organisms per square metre, taxonomic richness, and community composition. Richness was presented as the total number of taxa (identified to the lowest practical level) and number of families among replicates at a site. The abundance data among sites were presented graphically. Common invertebrates (invertebrates comprising more than one percent of the total abundance) were presented in tabular format. Major groups of invertebrates were presented in stacked bar graphs to show major differences in community composition.

The relationship between habitat and benthic community variables was investigated. Spearman rank correlation coefficients were used to identify associations between physical variables with adequate variability (e.g., fine sediments, flow velocity, TOC, etc.) and benthic community variables (abundance/m^2, richness, etc.). Scatter plots showing significant associations between habitat variables and benthic community variables were used to determine if any relationships appeared biologically important for further review.

8A2 RESULTS

8A2.1 Habitat

Benthic invertebrate samples were collected between September 27 and October 4, 2005 (Tables 8A-1a, b and c). Samples were collected at two locations in the Christina River at sites WCL1 and WCL11 (Table 8A-1a). Erosional and depositional habitat was sampled at WCL11. Stream width at WCL11 was variable. The erosional sample was collected in a side channel as it flowed around the outside of an island situated in the middle of the river. This wetted width of this channel was approximately 15 m. The mean depth was about 0.2 m and stream velocity was about 0.33 m/s. The depositional sample was collected in an area where the river began to widen; wetted width was approximately 35 m. Replicates were obtained along the left downstream side of the river where mean depths were about 0.5 m. Stream flows in this area were slow and non-measurable.

A small tributary (WCL6) and two headwater tributaries (WCC3 and WCH3) of the Christina River were sampled (Table 8A-1b). The wetted width in the tributary watercourses ranged between 4 m and 12 m, and samples were collected in sediment in water between 0.47 m and 0.64 m deep. Current velocities in the areas where these samples were collected ranged from non-measurable to 0.33 m/s. Three lakes in the study area were also sampled (LL2, LH1 and LL4; Table 8A-1c). Samples were collected at depths ranging from within the littoral zone to more than 4 m.

Water quality among the sampling sites was variable (Table 8A-3). Water temperatures in the Christina River and its tributaries ranged from just above freezing to 7.5ºC. Water temperature in the lakes was similar. The pH levels from all sampling sites ranged from 5.2 to 9.5; the lowest level was measured in unnamed waterbody LH1, whereas the highest value was recorded in the Christina River at Site WCL1. Conductance among all sites ranged between 49 uS/cm and 261 uS/cm. Most sites were well aerated with DO levels greater than 10 mg/L; however, in waterbody LL2, DO at the bottom of the water column was less than 1 mg/L. Samples at this site were collected in the pelagic zone, which may account for low DO levels.

The amount of total carbon in sediments at depositional sites ranged from about 1.1 percent by weight in the Christina River to almost 20 percent by weight in two of the unnamed waterbodies (Sites LL2 and LH1; Figure 8A-1). Sediments at depositional sampling sites at watercourse locations were generally similar and were composed mainly of sand. The exception was in the headwater tributary at WCH3 where sediment was composed mainly of clay. Waterbody sediments at sites LL2 and LL4 were composed mainly of clay, and sediment at site LH1 had proportionally more sand. Substrates at the erosional locations were composed mainly of gravel and cobble.

8A2.2 Benthic Invertebrates-Watercourses

The site with the lowest mean abundance was in one of the headwater tributaries to the Christina River at Site WCC3, which had about 9,300 organisms/m^2 (Table 8A-4c; Figure 8A-2). The site with the greatest mean abundance was Site WCL6 with 56,000 organisms/m^2. Mean abundances at the erosional sites was approximately 18,700 organisms/m^2 (WCL11) and 13,900 organisms/m^2 (WCL1).

The two erosional sites (WCL11 and WCL1) had greater numbers of taxa (identified to lowest practical level) than the depositional sites (Tables 8A-4a and 8A-4e; Figure 8A-2). Sites WCL11 and WCL1 had 44 taxa and 36 taxa, respectively. The number of taxa identified in samples from depositional habitats ranged from 12 to 29. The percent dominance of the most dominant taxon was lowest at the two erosional sites, about 19 percent at each. Among the depositional sites, percent dominance ranged between 18 and 53 percent.

Community composition at the two erosional habitat sites on the Christina River was composed mainly of the combined group of Ephemeroptera, Trichoptera and Plecoptera (ETP taxa) (Tables 8A-4a and 8A-4e; Figure 8A-3). Members from this group observed in the erosional habitat samples included the common net spinner caddisfly (Hydrpsychidae), small minnow mayfly (Baetidae), the flatheaded mayfly (Heptageniidae), spiney crawler mayfly (Ephemerellidae), perlodid stolefly (Perlodidae), humpless casemakers (Brachycentridae), and the green stonefly (chloroperlidae). Other common invertebrates included, nematode, the riffle beetle (Elmidae), aquatic worm (Oligochaeta), the clubtailed dragonfly (Gomphidae) and various fly larvae (Diptera). The most common midge (Chironomidae) larvae were Orthocladiinae.

The most common groups found in the depositional habitat samples included midges, aquatic worms and non-chironimid flies (Diptera) (Tables 8A-4b,c,d and f; Figure 8A-3). The most common aquatic worms included Tubuficidae and Lumbriculidae. The midge community was dominated by Chironomini and Tanypodinae. Other common invertebrates observed in depositional habitat samples included fingernail clams (Sphaeriidae), biting midges (Ceratopogonidae), nematodes, and seed shrimp (Ostracoda).

8A2.3 Benthic Invertebrates-Waterbodies

Mean abundances of benthic invertebrates among the three waterbody samples were low and ranged between 350 organisms/m^2 and about 1,750 organisms/m^2 (Tables 8A-4g, h and i; Figure 8A-2). Richness was similarly low compared to the watercourse sites with the number of taxa ranging between 7 and 17. The percent abundance of the most common taxon in the waterbody samples was between 23 percent and 39 percent.

All three of the waterbody sites were dominated by midge larvae; however, the second most common group was different among each of the waterbodies (Tables 8A-4g, h and i; Figure 8A-3). Aquatic worms were very common in samples from Site LL2, non-Chironomid flies were common in samples from Site LL4. Other groups including copepods, nematodes, leaches (Hirudinea), non-biting midges and small squaregill mayflies (Caenidae) were common in samples from Site LH1.

Midge composition at Sites LL2 and LL4 was composed largely of members of Tanypodinae; whereas, Tanytarsini was the most dominant group at Site LH1 (Table 8A-4g, h and i; Figure 8A-3). Chironomini were common at all three waterbody sites.

8A2.4 Regional Community Structure

Mean abundance of benthic invertebrates in regional waterbodies was variable (Table 8A-5). Abundance in regional waterbodies ranged from about 350 organisms/m^2 to more than 68,000 organisms/m^2, while richness ranged between 5 taxa and 32 taxa (lowest practical level). Mean abundance in regional watercourses ranged between 2 organisms/m^2 and 63,000 organisms/m^2 while richness ranged between 2 taxa and 44 taxa (lowest practical level). Overall, abundances of large groups and taxonomic richness were slightly higher among depositional watercourse sites than either erosional watercourses or waterbodies.

In waterbodies and in depositional watercourse habitats, community composition was often dominated by midge larvae (Chironomini, Tanytarsini, Orthocladiinae and Tanypodinae) and aquatic worms (Lumbriculidae, Naididae, and Tubuficidae; Table 8A-5). Ephemoptera, Plecoptera and Trichoptera made up the largest contribution to community composition in erosional watercourse habitats.

Results from principal component analysis indicate 54 percent of the variance in the data is explained by the first two components (Figure 8A-4; Table 8A-6). An additional 9 percent of the variance was explained by the third component. Results appear to suggest community composition is strongly influenced by habitat type. Taxonomic groups that are generally considered typical of communities found in erosional areas (Trichoptera, Ephemeroptera, and Plecoptera) and the taxonomically diverse groups labeled “non-Chironomid Diptera” and “Other” had high positive loadings on the first principal component (PC-1). This can be seen in the ordination plot where the erosional sites are clustered to the right of the plot. Three large taxonomic groups (Tanypodinae, Ostracoda, Molluska and the midge Chironommini) and one smaller group (Hirudinea) had high positive loadings on PC-2.

Benthic invertebrate communities sampled in lake bottom substrates and depositional watercourse habitat in 2005 generally appeared similar to regional benthic invertebrate communities sampled in similar habitats in the past (Table 8A-6; Figure 8A-4). However, two watercourse sites had higher PC-1 values than other depositional sites. Site WCL11 from the Christina River and Site WCL6 from a smaller tributary to the Christina River had a larger proportion of “uncommon taxa” (organisms comprising less than 1 percent of overall abundance) than the other depositional sites and waterbodies. In addition, these two sites had greater mean abundances and richness than other depositional watercourses and waterbody sites in the region.

The samples from the two erosional sites appeared similar to the regional benthic invertebrate communities sampled in the past (Table 8A-6; Figure 8A-4). The community at WCL11 from the Christina River had a somewhat higher PC-1 score that the other sites. This is likely because samples from this site were highly diverse with 44 taxa.

8A2.5 Benthic Invertebrate Diversity

Benthic invertebrate diversity measured as Shannon-Weaver Diversity (Shannon, 1948; Zar, 1999) and Simpson's Diversity (Simpson, 1949; Lydy et al., 2000; Simpson's Diversity was presented as D-1 or Simpson's Diversity Index) in fall 2005 was similar to slightly higher than diversity in regional data (Table 8A-5). Diversity in depositional watercourse habitat samples from 2005 was similar to regional depositional data; however, diversity in waterbody samples and erosional watercourse samples was slightly higher than seen in regional data. Additionally, communities in erosional watercourses had higher diversity measures than communities in depositional watercourses. Diversity was generally greater in the watercourses than in the waterbodies.

Regional diversity in watercourses and waterbodies, as indicated by richness, was variable and reflected the level of sampling intensity and sampling techniques used in different reports (Table 8A-7). The Hangingstone and Christina Rivers have been studied in several works and consequently more taxa have been recorded from these watercourses. A total of 114 taxa (identified to the lowest practical level) have been identified in the Christina River and 106 taxa have been identified in the Christina River tributaries. Small watercourses in the northern part of the RSA had a total of 55 taxa identified in historic reports. A total of 63 taxa were identified in small waterbodies in the RSA. Less information was available for Christina Lake where only 16 taxa were identified.

The numbers of taxa observed in samples from the LSA in the fall or 2005 were within ranges reported in the historic literature (Table 8A-7). The numbers of taxa identified in the Christina River and its tributaries were 74 taxa and 63 taxa, respectively. A total of 37 taxa were identified from samples collected in waterbodies located in the LSA. The fall 2005 richness values include the taxa identified in standard area samples (samples collected with an Ekman and Niell sampler) and samples collected with a D-frame kick-net used to sample for diversity.

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Table 8A-1a Abundances of Organisms Collected in Benthic Invertebrate Samples from the Kai Kos Dehseh Project, Fall 2005

Major Group	Family [sub-family/tribe]	Genus species	Christina River WCL11[e] A	B	C	D	E	Kick-net	Christina River WCL11[d] A	B	C	D	E	Kick-net	Christina River WCL1 A	B	C	D	E	Kick-net
Nematoda		-	18	16	72	0	576	0	6	0	0	24	0	0	80	144	48	80	0	0
Oligochaeta	Lumbriculidae	*Lumbriculus sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Lumbriculus variegatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Naididae	(i/d)	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0
		Nais communis	6	0	8	0	0	0	0	0	0	0	0	0	56	0	0	0	0	0
		Stylaria lacustris	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0	0	0	0
		Nais sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	112	0	0	0	0
		Pristina sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Vejdovskyella sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Uncinais uncinata	0	0	0	0	0	0	0	0	0	0	0	0	72	0	0	0	0	0
	Tubificidae	i/d	8	0	40	32	40	8	35	40	664	488	96	536	0	0	24	16	0	0
Hirudinea	Erpobdellidae	i/d	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Glossiphoniidae	*Glossiphonia complanata*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Helobdella elongata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Helobdella stagnalis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gastropoda	Ancylidae	*Ferrissia sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Lymnaeidae	*Lymnaea sp.*	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0
	Physidae	*Physa sp.*	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0
	Planorbiidae	*Gyraulus sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Valvatidae	*Valvata tricarinata*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pelecypoda	Sphaeriidae	*Sphaerium sp.*	0	0	0	0	8	0	7	8	0	16	8	0	0	0	8	0	0	0
Hydracarina		(i/d)	0	0	0	0	0	0	0	0	0	0	0	56	0	0	0	0	0	0
	Eremaidae	*Hydrozetes sp.*	0	0	0	0	0	0	0	0	0	24	0	0	0	0	0	0	0	0
	Hydrachnidae	*Hydrachna sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Hygrobatidae	*Hygrobates sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0	0
		Megapus sp.	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Lebertiidae	*Lebertia sp.*	0	0	8	0	16	0	0	0	0	0	0	0	0	0	0	0	0	0
	Limnesiidae	*Limnesia sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mideopsidae	*Mideopsis sp.*	2	0	0	0	8	0	0	0	0	0	0	0	0	0	0	16	1	0
Ostracoda		-	0	0	0	0	0	0	0	24	16	40	0	8	0	0	0	0	0	0
Copepda	Harpacticoida	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Amphipoda	Gammaridae	*Gammarus sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Talitridae	*Hyalella azteca*	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0
Collembola		-	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0
	Poduridae	*Podura aquatica*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sminthuridae	*Sminthurides sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera		i/d	0	0	0	0	0	0	0	0	0	0	0	256	0	0	0	0	0	0
	Baetidae	i/d	0	0	0	0	0	0	0	0	0	0	0	16	0	0	0	0	0	0
		Baetis sp.	92	88	232	144	304	24	0	0	0	0	0	0	112	352	400	136	12	480
		Callibaetis sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Caenidae	*Caenis sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Ephemerellidae	i/d	0	0	0	0	0	0	0	0	0	0	0	112	0	0	0	0	0	0
		Attenella sp.	0	0	0	0	0	0	0	0	0	0	0	56	0	0	0	0	0	0
		Ephemerella sp.	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Seratella sp.	84	40	104	72	136	8	0	0	0	0	0	48	112	232	88	296	8	96
	Ephemeridae	*Hexagenia sp.*	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0
		Hexagenia limbata	0	0	0	0	0	0	1	0	0	0	0	0	80	144	48	80	0	0
	Heptageniidae	i/d	10	16	240	80	184	56	0	0	0	0	0	0	0	0	0	0	0	0
		Heptagenia sp.	0	0	0	0	0	0	0	0	0	0	0	288	40	112	64	976	4	24
		Stenacron sp.	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0
	Leptophlebiidae	i/d	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0
		Leptophlebia sp.	0	0	0	0	0	128	0	0	0	0	0	40	0	0	0	0	0	0
		Paraleptophlebia sp.	0	0	0	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Oligoneuriidae	*Isonychia sp.*	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0
Odonata-Anisoptera	Gomphidae	*Ophiogomphus sp.*	6	0	96	8	112	0	0	0	0	0	0	0	0	0	0	0	0	0
Plecoptera		i/d	0	0	0	88	88	8	0	0	0	0	0	0	0	0	0	0	0	0
	Chloroperlidae	i/d	14	8	112	0	32	0	0	0	0	0	0	16	0	0	0	0	0	0
	Perlidae	*Acroneuria sp.*	0	0	0	0	16	0	0	0	0	0	0	40	40	56	24	136	8	0
		Claassenia sp.	2	0	8	8	8	0	0	0	0	0	0	0	0	0	0	0	0	0

Major Group	Family [sub-family/tribe]	Genus species	Christina River WCL11[e] A	B	C	D	E	Kick-net	Christina River WCL11[d] A	B	C	D	E	Kick-net	Christina River WCL1 A	B	C	D	E	Kick-net
Plecoptera	Perlodidae	*Isogenoides sp.*	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Isoperla sp.	34	24	112	24	64	0	0	0	0	0	0	320	0	0	0	0	0	0
		Megarcys sp.	2	0	0	0	0	0	0	0	0	0	0	0	24	40	48	56	0	16
		Skwala sp.	0	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Pteronarcyidae	*Pteronarcella sp.*	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0
		Pteronarcys sp.	2	0	16	0	8	0	0	0	0	0	0	0	0	0	0	0	0	8
	Taeniopterygidae	*Taeniopteryx sp.*	0	0	0	0	0	0	0	0	0	0	0	0	8	16	0	16	0	8
Hemiptera	Corixidae	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
		Callicorixa sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Sigara sp.	0	0	0	0	0	8	0	0	0	0	0	728	0	0	0	0	0	0
	Notonectidae	*Notonecta sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
Trichoptera	Brachycentridae	*Brachycentrus sp.*	6	0	72	64	80	0	0	0	0	0	0	0	0	0	0	0	0	0
	Glossosomatidae	*Glossosoma sp.*	0	0	0	16	32	0	0	0	0	0	0	0	0	16	0	0	0	24
	Hydropsychidae	*Arctopsyche sp.*	0	0	8	0	0	0	0	0	0	0	0	0	0	16	0	0	0	0
		Cheumatopsyche sp.	0	0	24	0	16	0	0	0	0	0	0	0	0	72	40	8	1	0
		Hydropsyche sp.	46	192	472	72	640	8	0	0	0	0	0	112	0	0	0	0	0	0
	Hydroptilidae	*Agraylea sp.*	4	0	16	0	24	0	0	0	0	0	0	0	56	280	184	72	3	0
		Hydroptila sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0	0	0	0
		Oxyethira sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Lepidostomatidae	*Lepidostoma sp.*	0	0	0	0	0	0	0	0	0	0	0	48	0	0	0	0	0	0
	Limnephilidae	i/d	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Apatania sp.	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Limnephilus sp.	0	0	0	0	0	120	0	0	0	0	0	0	0	0	0	0	0	0
		Protoptila sp.	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	8
	Phryganeidae	*Agrypnia sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Psychomyiidae	*Psychomyia sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Rhyacophilidae	*Rhyacophila sp.*	2	0	16	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0
Coleoptera	Dytiscidae	*Agabus sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Laccophilus sp.	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0
		Rhantus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Uvarus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Elmidae	*Optioservus sp.*	42	80	336	0	200	0	0	0	0	0	0	72	0	0	0	0	0	8
	Gyrinidae	*Gyrinus sp.*	0	0	0	0	0	72	0	0	0	0	0	480	32	72	24	136	3	0
Diptera	Ceratopogonidae	-	0	0	8	0	0	0	1	0	96	8	8	0	0	0	0	0	0	40
	Chironomidae	i/d	2	24	32	8	72	40	0	16	8	8	0	16	0	0	0	0	0	0
	[Chironomini]	-	2	0	0	0	32	0	0	0	0	0	0	0	0	0	8	32	6	0
	[Chironomini]	*Chironomus sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	1	8
		Cryptochironomus sp.	0	0	0	0	0	0	6	24	24	120	16	0	0	0	0	0	0	0
		Cryptotendipes sp.	0	0	0	0	0	0	0	0	0	0	0	32	0	0	0	0	0	0
		Dicrotendipes sp.	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0
		Microtendipes sp.	0	0	8	0	0	0	0	0	0	0	0	0	16	16	8	0	0	0
		Paralauterborniella sp.	0	0	0	0	0	0	75	8	288	224	8	0	0	0	0	0	0	0
		Polypedilum sp.	0	0	8	16	24	40	4	8	264	144	48	0	8	0	0	0	0	0
		Stictochironomus sp.	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0
	[Tanytarsini]	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Cladotanytarsus sp.	2	0	8	8	16	8	0	0	0	0	0	8	0	0	0	8	0	0
		Tanytarsus sp.	10	0	8	16	24	32	0	8	24	32	0	16	0	8	8	16	3	72
	[Psuedochironomini]	*Pseudochironomus sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	[Diamesinae]	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	1	0
		Potthastia sp.	0	8	0	0	0	0	0	0	0	0	0	0	16	16	0	8	3	0
	[Orthocladiinae]	-	2	0	0	0	0	0	0	0	0	0	0	0	0	24	0	0	1	0
		Corynoneura sp.	0	0	0	0	0	0	0	0	0	0	0	8	8	0	0	0	3	16
		Cricotopus sp.	2	0	16	0	0	0	0	0	0	0	8	24	32	200	144	88	11	48
		Epoicocladius sp.	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0
		Eukiefferiella sp.	24	72	120	32	184	0	1	0	0	328	8	136	40	80	56	24	8	208
		Thienemanniella sp.	0	0	0	0	0	0	0	0	0	0	0	104	0	0	0	8	2	72
	[Prodiamesinae]	*Monodiamesa sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	8	0	0

Major Group	Family [sub-family/tribe]	Genus species	Christina River WCL11(e) A	B	C	D	E	Kick-net	Christina River WCL11(d) A	B	C	D	E	Kick-net	Christina River WCL1 A	B	C	D	E	Kick-net
Diptera	[Tanypodinae]	*Ablabesmyia sp.*	0	0	8	0	0	0	0	8	0	0	0	24	8	0	0	0	0	0
		Clinotanypus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Procladius sp.	0	0	0	0	0	0	2	0	16	0	0	56	0	0	0	0	0	0
		Tanypus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Empididae	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Chelifera sp.	0	0	0	0	0	0	0	8	0	0	0	64	0	0	0	0	0	0
		Hemerodromia sp.	58	248	704	88	488	16	0	0	0	0	0	0	8	0	24	16	2	328
	Simuliidae	*Simulium sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32
	Tabanidae	*Chrysops sp.*	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Tipulidae	*Hexatoma sp.*	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	16	0	16
		Pilaria sp.	0	0	0	0	0	0	0	0	0	0	0	0	160	0	0	0	0	0
Total			**484**	**840**	**2,928**	**808**	**3,456**	**584**	**138**	**160**	**1,416**	**1456**	**200**	**3,776**	**936**	**1,904**	**1,208**	**2,200**	**81**	**1,528**

Note(s):
- = not identified to this level
(i/d) = immature or damaged specimen
e – erosional stream habitat
d – depositional stream habitat

Table 8A-1b Abundances of Organisms Collected in Benthic Invertebrate Samples from the Kai Kos Dehseh Project, Fall 2005

	Family		Unnamed Watercourse WCC3						Unnamed Watercourse WCH3							Unnamed Watercourse WCL6					
Major Group	[sub-family/tribe]	Genus species	A	B	C	D	E	Kick -net	A	B	C	D	E	Kick-net	A	B	C	D(1)	D(2)	E	Kick-net
Nematoda		-	0	72	0	8	8	176	0	0	0	0	0	0	8	24	88	56	8	112	0
Oligochaeta	Lumbriculidae	*Lumbriculus sp.*	0	0	0	0	0	0	0	0	24	8	0	40	0	0	0	8	0	0	64
		Lumbriculus variegatus	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0
	Naididae	(i/d)	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0
		Nais communis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Stylaria lacustris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Nais sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Pristina sp.	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0
		Vejdovskyella sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Uncinais uncinata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Tubificidae	i/d	0	8	8	0	8	48	208	64	56	128	120	56	8	8	0	16	8	24	192
Hirudinea	Erpobdellidae	i/d	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0
	Glossiphoniidae	*Glossiphonia complanata*	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0
		Helobdella elongata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Helobdella stagnalis	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gastropoda	Ancylidae	*Ferrissia sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Lymnaeidae	*Lymnaea sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Physidae	*Physa sp.*	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	64
	Planorbiidae	*Gyraulus sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Valvatidae	*Valvata tricarinata*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pelecypoda	Sphaeriidae	*Sphaerium sp.*	0	0	0	8	16	0	16	8	8	8	40	40	0	40	16	72	8	0	128
Hydracarina		(i/d)	0	0	0	0	0	32	0	0	0	0	0	0	0	0	0	0	0	0	0
	Eremaidae	*Hydrozetes sp.*	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	64
	Hydrachnidae	*Hydrachna sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0
	Hygrobatidae	*Hygrobates sp.*	0	0	0	0	8	16	0	0	0	0	0	0	0	0	0	0	0	0	0
		Megapus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Lebertiidae	*Lebertia sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0	0	0	0	64
	Limnesiidae	*Limnesia sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0
	Mideopsidae	*Mideopsis sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ostracoda		-	0	0	0	8	8	96	0	0	0	0	0	8	72	40	24	0	8	8	0
Copepda	Harpacticoida	-	0	0	0	0	0	16	0	0	0	0	0	0	8	24	0	0	0	0	64
Amphipoda	Gammaridae	*Gammarus sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Talitridae	*Hyalella azteca*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	320
Collembola		-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Poduridae	*Podura aquatica*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	320
	Sminthuridae	*Sminthurides sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	64
Ephemeroptera		i/d	0	0	0	0	0	0	0	0	0	0	0	56	8	8	0	0	0	0	192
	Baetidae	i/d	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	192
		Baetis sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	128
		Callibaetis sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	64
	Caenidae	*Caenis sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Ephemerellidae	i/d	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Attenella sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Ephemerella sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Seratella sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Ephemeridae	*Hexagenia sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Hexagenia limbata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Heptageniidae	i/d	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Heptagenia sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Stenacron sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Leptophlebiidae	i/d	0	0	0	0	0	160	0	0	0	0	0	0	0	0	0	0	0	0	0
		Leptophlebia sp.	0	0	0	0	0	216	0	0	0	0	0	8	0	0	0	0	0	0	192
		Paraleptophlebia sp.	0	0	0	0	0	24	0	0	0	0	0	0	0	0	0	0	0	0	128
	Oligoneuriidae	*Isonychia sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Odonata-Anisoptera	Gomphidae	*Ophiogomphus sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plecoptera		i/d	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0
	Chloroperlidae	i/d	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Perlidae	*Acroneuria sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Claassenia sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Major Group	Family [sub-family/tribe]	Genus species	Unnamed Watercourse WCC3						Unnamed Watercourse WCH3							Unnamed Watercourse WCL6					
			A	B	C	D	E	Kick-net	A	B	C	D	E	Kick-net	A	B	C	D(1)	D(2)	E	Kick-net
Plecoptera	Perlodidae	*Isogenoides sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Isoperla sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Megarcys sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Skwala sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Pteronarcyidae	*Pteronarcella sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Pteronarcys sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Taeniopterygidae	*Taeniopteryx sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hemiptera	Corixidae	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Callicorixa sp.	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0
		Sigara sp.	8	0	0	0	0	16	0	0	0	0	0	56	0	0	0	0	0	0	0
	Notonectidae	*Notonecta sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	64
Trichoptera	Brachycentridae	*Brachycentrus sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Glossosomatidae	*Glossosoma sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Hydropsychidae	*Arctopsyche sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Cheumatopsyche sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Hydropsyche sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	128
	Hydroptilidae	*Agraylea sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Hydroptila sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Oxyethira sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	64
	Lepidostomatidae	*Lepidostoma sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Limnephilidae	i/d	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0
		Apatania sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Limnephilus sp.	0	0	0	0	0	0	0	0	0	0	16	88	0	16	0	0	0	0	640
		Protoptila sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Phryganeidae	*Agrypnia sp.*	0	0	0	0	0	8	0	0	0	0	0	8	0	0	0	0	0	0	128
	Psychomyiidae	*Psychomyia sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Rhyacophilidae	*Rhyacophila sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coleoptera	Dytiscidae	*Agabus sp.*	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	64
		Laccophilus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Rhantus sp.	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0
		Uvarus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Elmidae	*Optioservus sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Gyrinidae	*Gyrinus sp.*	0	0	0	0	0	0	0	0	0	0	0	24	0	0	0	0	0	0	512
Diptera	Ceratopogonidae	-	0	16	8	0	0	0	40	40	16	16	0	8	0	0	0	48	8	24	0
	Chironomidae	i/d	0	8	24	0	32	8	0	0	0	0	0	8	0	24	56	32	0	64	0
	[Chironomini]	-	32	0	0	8	0	16	0	0	0	0	0	0	0	0	0	0	0	0	0
		Chironomus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Cryptochironomus sp.	0	16	16	0	0	0	0	0	0	0	8	0	0	16	8	24	0	16	1,728
		Cryptotendipes sp.	0	0	0	0	96	0	0	0	0	0	0	0	0	0	0	0	0	8	0
		Dicrotendipes sp.	0	0	0	0	0	24	0	0	0	0	0	0	0	0	0	0	8	0	0
		Microtendipes sp.	0	8	0	8	0	0	0	0	0	0	0	8	0	16	0	0	32	16	0
		Paralauterborniella sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Polypedilum sp.	0	16	40	0	32	0	0	0	0	0	0	8	0	16	0	32	0	0	0
		Stictochironomus sp.	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	16	0	8	0
	[Tanytarsini]	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Cladotanytarsus sp.	0	0	0	0	56	104	0	0	0	0	0	0	0	632	0	488	328	0	10,688
		Tanytarsus sp.	8	8	0	8	168	72	32	0	0	24	0	16	768	560	1040	376	392	544	30,272
	[Psuedochironomini]	*Pseudochironomus sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0	0	0	0	0
	[Diamesinae]	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Potthastia sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	[Orthocladiinae]	-	8	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Corynoneura sp.	0	0	0	0	0	56	0	0	8	0	0	200	0	8	0	8	0	0	17,984
		Cricotopus sp.	0	0	0	0	56	88	8	0	16	0	0	40	0	48	0	96	24	32	7,616
		Epoicocladius sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Eukiefferiella sp.	0	0	32	0	80	0	0	0	0	0	0	0	0	280	184	0	8	168	13,248
		Thienemanniella sp.	0	8	0	0	0	32	0	0	0	0	0	0	0	0	0	0	0	0	6,912
	[Prodiamesinae]	*Monodiamesa sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	[Tanypodinae]	*Ablabesmyia sp.*	0	0	0	0	0	16	0	0	8	0	0	24	0	96	0	144	32	24	2,368
		Clinotanypus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Procladius sp.	8	40	0	16	32	16	64	32	16	32	16	72	8	64	32	32	0	48	512
		Tanypus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Major Group	Family [sub-family/tribe]	Genus species	Unnamed Watercourse WCC3						Unnamed Watercourse WCH3							Unnamed Watercourse WCL6					
			A	B	C	D	E	Kick-net	A	B	C	D	E	Kick-net	A	B	C	D(1)	D(2)	E	Kick-net
	Empididae	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	8	64
		Chelifera sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Hemerodromia sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Simuliidae	*Simulium sp.*	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	320
	Tabanidae	*Chrysops sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Tipulidae	*Hexatoma sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Pilaria sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total			**64**	**208**	**128**	**80**	**600**	**1272**	**368**	**152**	**160**	**216**	**200**	**808**	**888**	**1960**	**1448**	**1456**	**872**	**1,120**	**95,552**

Note(s):
- = not identified to this level
(i/d) = immature or damaged specimen

Table 8A-1c Abundances of Organisms Collected in Benthic Invertebrate Samples from the Kai Kos Dehseh Project, Fall 2005

	Family		Unnamed Waterbody LL2								Unnamed waterbody LH1								Unnamed Waterbody LL4							
Major Group	[sub-family/tribe]	Genus species	A	B	C	D(1)	D(2)	E	Kick-net	A(1)	A(2)	B(1)	B(2)	C(1)	C(2)	D(1)	D(2)	E(1)	E(2)	Kick-net	A	B	C	D	E	Kick-net
Nematoda		-	0	0	0	0	0	0	0	1	0	16	8	1	0	1	0	0	0	3	1	0	0	0	1	8
Oligochaeta	Lumbriculidae	*Lumbriculus sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Lumbriculus variegatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Naididae	(i/d)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Nais communis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0
		Stylaria lacustris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	55	0	0	0	0	0	0
		Nais sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Pristina sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Vejdovskyella sp.	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Uncinais uncinata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Tubificidae	i/d	0	0	24	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Hirudinea	Erpobdellidae	i/d	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Glossiphoniidae	*Glossiphonia complanata*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Helobdella elongata	0	0	0	0	0	0	0	0	0	16	0	0	0	0	0	0	1	0	0	0	0	0	0	0
		Helobdella stagnalis	0	0	0	0	0	0	0	0	0	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gastropoda	Ancylidae	*Ferrissia sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
	Lymnaeidae	*Lymnaea sp.*	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Physidae	*Physa sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Planorbiidae	*Gyraulus sp.*	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Valvatidae	*Valvata tricarinata*	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pelecypoda	Sphaeriidae	*Sphaerium sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydracarina		(i/d)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
	Eremaidae	*Hydrozetes sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Hydrachnidae	*Hydrachna sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Hygrobatidae	*Hygrobates sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Megapus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Lebertiidae	*Lebertia sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Limnesiidae	*Limnesia sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mideopsidae	*Mideopsis sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ostracoda		-	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copepda	Harpacticoida	-	0	0	0	0	0	0	0	0	0	32	56	0	0	0	0	0	0	2	0	0	0	0	0	56
Amphipoda	Gammaridae	*Gammarus sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
	Talitridae	*Hyalella azteca*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Collembola		-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Poduridae	*Podura aquatica*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sminthuridae	*Sminthurides sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera		i/d	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Baetidae	i/d	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Baetis sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Callibaetis sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0
	Caenidae	*Caenis sp.*	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	2	0	0	0	0	0	8
	Ephemerellidae	i/d	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Attenella sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Ephemerella sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Seratella sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Ephemeridae	*Hexagenia sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Hexagenia limbata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Heptageniidae	i/d	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Heptagenia sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Stenacron sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Leptophlebiidae	i/d	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Leptophlebia sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Paraleptophlebia sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Oligoneuriidae	*Isonychia sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Odonata-Anisoptera	Gomphidae	*Ophiogomphus sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Major Group	Family [sub-family/tribe]	Genus species	Unnamed Waterbody LL2								Unnamed waterbody LH1								Unnamed Waterbody LL4							
			A	B	C	D(1)	D(2)	E	Kick-net	A(1)	A(2)	B(1)	B(2)	C(1)	C(2)	D(1)	D(2)	E(1)	E(2)	Kick-net	A	B	C	D	E	Kick-net
Plecoptera		i/d	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Chloroperlidae	i/d	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Perlidae	*Acroneuria sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Claassenia sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Perlodidae	*Isogenoides sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Isoperla sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Megarcys sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Skwala sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Pteronarcyidae	*Pteronarcella sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Pteronarcys sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Taeniopterygidae	*Taeniopteryx sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hemiptera	Corixidae	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Callicorixa sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Sigara sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
	Notonectidae	*Notonecta sp.*	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Brachycentridae	*Brachycentrus sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Glossosomatidae	*Glossosoma sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Hydropsychidae	*Arctopsyche sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Cheumatopsyche sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Hydropsyche sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Hydroptilidae	*Agraylea sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Hydroptila sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
		Oxyethira sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
	Lepidostomatidae	*Lepidostoma sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Limnephilidae	i/d	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Apatania sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Limnephilus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
		Protoptila sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Phryganeidae	*Agrypnia sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Psychomyiidae	*Psychomyia sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Rhyacophilidae	*Rhyacophila sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coleoptera	Dytiscidae	*Agabus sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Laccophilus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Rhantus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Uvarus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Elmidae	*Optioservus sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Gyrinidae	*Gyrinus sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diptera	Ceratopogonidae	-	0	0	8	0	0	0	0	0	0	16	0	0	0	0	0	0	0	0	2	3	3	6	2	0
	Chironomidae	i/d	0	0	0	0	0	0	0	0	1	0	16	1	0	0	0	0	1	0	0	0	0	0	0	16
	[Chironomini]	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0
		Chironomus sp.	2	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Cryptochironomus sp.	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	4	0	0	0	0	0	0
		Cryptotendipes sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	4	0	2	0
		Dicrotendipes sp.	0	0	0	0	0	0	0	2	0	24	16	1	0	2	3	0	0	4	0	0	0	0	0	16
		Microtendipes sp.	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Paralauterborniella sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Polypedilum sp.	0	0	0	0	0	0	0	0	1	0	0	1	0	1	3	0	0	2	0	0	0	0	0	0
		Stictochironomus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	[Tanytarsini]	-	0	0	0	0	0	0	0	1	0	0	8	0	0	0	0	0	0	1	0	0	0	0	0	8
		Cladotanytarsus sp.	0	0	0	0	0	0	0	2	0	0	0	0	4	0	0	0	0	24	0	0	0	0	1	0
		Tanytarsus sp.	1	0	0	0	0	0	0	2	16	8	24	5	16	2	5	11	8	72	0	0	0	0	0	24
	[Psuedochironomini]	*Pseudochironomus sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	[Diamesinae]	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Potthastia sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	[Orthocladiinae]	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
		Corynoneura sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
		Cricotopus sp.	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	1	1	6	0	0	0	0	0	8
		Epoicocladius sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Eukiefferiella sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0

Major Group	Family [sub-family/tribe]	Genus species	Unnamed Waterbody LL2								Unnamed waterbody LH1								Unnamed Waterbody LL4							
			A	B	C	D(1)	D(2)	E	Kick-net	A(1)	A(2)	B(1)	B(2)	C(1)	C(2)	D(1)	D(2)	E(1)	E(2)	Kick-net	A	B	C	D	E	Kick-net
Diptera		*Thienemanniella sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	[Prodiamesinae]	*Monodiamesa sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	[Tanypodinae]	*Ablabesmyia sp.*	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	1	0	0	0	0	0	8
		Clinotanypus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
		Procladius sp.	0	1	0	0	0	0	0	1	1	8	0	0	0	2	3	3	2	0	2	1	3	1	3	0
		Tanypus sp.	0	0	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Empididae	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Chelifera sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Hemerodromia sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Simuliidae	*Simulium sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Tabanidae	*Chrysops sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Tipulidae	*Hexatoma sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Pilaria sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total			**4**	**4**	**64**	**0**	**1**	**0**	**4**	**9**	**20**	**144**	**152**	**10**	**20**	**10**	**14**	**15**	**13**	**209**	**7**	**7**	**11**	**7**	**9**	**152**

Note(s):
- = not identified to this level
(i/d) = immature or damaged specimen

Table 8A-2 Laboratory Benthic Invertebrate Sorting Quality Assurance Data

Sample Number	Total number of organisms	Number of Organisms found on Re-sort	Sorting Efficiency
L330175-9	161	15	90.7
L330175-18	80	0	100.0
L330175-30[a]	10	2	80.0
L330175-47	424	31	92.7
L330175-57	7	0	100.0

(a) Two small (immature) organisms were found in the resort for L330175-30; because only ten organisms were found in the original sample replicate, sorting efficiency was only 80%.

Table 8A-3 Benthic Invertebrate Habitat Characteristics at Sites Sampled September 27 to October 4, 2005

Variable	Unit	Christina River WCL11	Christina River WCL11	Unnamed Watercourse WCC3	Unnamed Watercourse WCH3	Christina River WCL1	Unnamed Watercourse WCL6	Unnamed Waterbody LL2	Unnamed Waterbody LH1	Unnamed Waterbody LL4
Sample date	-	Sept 27, 2005	Sept 27, 2005	Oct 1, 2005	Sept 29, 2005	Oct 3, 2005	Sept 27, 2005	Oct 4, 2005	Oct 1, 2005	Oct 4, 2005
Easting (UTM NAD 83)	-	482530	482530	470537	477346	474996	484353	481557	477282	452795
Northing (UTM NAD 83)	-	6175634	6175634	6190691	6223969	6185412	6184817	6183650	6228505	6196335
Habitat type	-	erosional	depositional	depositional	depositional	erosional	depositional	depositional	depositional	depositional
Wetted channel width	m	15.0 [c]	35.0	9.2	12 [c]	19.5	4.1	- [a]	-	-
Mean water depth	m	0.22	0.51	0.640	0.47	0.20	0.55	4.40	1.68	1.89
Mean current velocity	m/s	0.33	nm	0.33	0.01	0.43	nm	-	-	-
Macrophyte cover	%	0	0	0	0	0	25	0	-	-
Algae Cover cover		60-95	-	0	0	> 90	0	0	0	0
Field Water Quality [b]										
Dissolved oxygen	mg/L	11.0	16.6	11.2	10.0	14.2	10.8	0.5	11.5	12.2
Conductance	µS/c	250	197	80	49	180	261	157	-	97
pH	-	6.5	7.1	6.0	8.9	9.5	7.4	6.4	5.2	7.3
Water temperature	C°	1.0 [d]	7.5	6.2	4.4	4.4	4.0	7.6	6.5	3.3
Turbidity	NTU		-	15.54	-	17.06	2.46	3	3.25 [e]	9.7
Substrate										
Total carbon	%	-	1.1	13.4	7.6	-	4.4	19.4	19.8	9.9
Sand	%	-	67	51	19	-	61	25	58	21
Silt	%	-	23	9	22	-	23	23	10	15
Clay	%	-	10	40	59	-	17	52	32	64
Fines (<2mm)	%	5	-	-	-	10	-	-	-	-
Small Gravel (3-16mm)	%	10	-	-	-	20	-	-	-	-
Gravel (17-64mm)	%	40	-	-	-	25	-	-	-	-
Cobble (65-256mm)	%	40	-	-	-	35	-	-	-	-
Boulder (>256mm)	%	5	-	-	-	10	-	-	-	-
Bedrock	%	0	-	-	-	0	-	-	-	-

[a] no data or not applicable
[b] Waterbody water quality data taken from bottom of water column
[c] estimate of width
[d] estimate slightly above freezing
[e] secchi depth in metres
nm = non-measurable

Table 8A-4a Common Benthic Invertebrates at WCL11 in the Christina River, Fall 2005

Christina River (WCL11) Erosional Habitat				
Major Group	**Family (sub-family/tribe)**	**Genus/species**	**Mean abundance**	**Percent of total**
Diptera	Epididae	Hemerodromia sp.	3,489	18.6
Trichoptera	Hydropsychidae	Hydropsyche sp.	3,128	16.7
Ephemeroptera	Baetidae	Baetis sp.	1,892	10.1
Nematoda	-	-	1,500	8.0
Coleoptera	Elmidae	Optioservus sp.	1,448	7.7
Ephemeroptera	Heptageniidae	i/d	1,166	6.2
Ephemeroptera	Ephemerellidae	Seratella sp.	959	5.1
Diptera	[Orthocladinae]	Eukiefferiella sp.	950	5.1
Plecoptera	Perlodidae	Isoperla sp.	568	3.0
Odonata-Anisoptera	Gomphidae	Ophiogomphus sp.	488	2.6
Trichoptera	Brachycentridae	Brachycentrus sp.	488	2.6
Plecoptera	Plecoptera	i/d	387	2.1
Plecoptera	Chloroperlidae	i/d	365	1.9
Diptera	Chironomidae	i/d	304	1.6
Oligochaeta	Tubuficidae	-	264	1.4
Total percent for common taxa				92.9
Mean total abundance (standard error)				18,735(6,783)
Total richness (lowest practical level)				44

Note(s):
(i/d) specimen was immature or damaged
"-" not identified to this level

Table 8A-4b Common Benthic Invertebrates at WCL11 in the Christina River, Fall 2005

Christina River (WCL11) Depositional Habitat				
Major Group	**Family (sub-family/tribe)**	**Genus/species**	**Mean abundance**	**Percent of total**
Oligochaeta	Tubuficidae	-	11,378	39.3
Diptera	[Chironomini]	Paralauterborniella sp.	5,186	17.9
Diptera	[Chironomini]	Polypedilum sp.	4,025	13.9
Diptera	[Orthocladinae]	Eukiefferiella sp.	2,898	10.0
Diptera	[Chironomini]	Cryptochironomus sp.	1,634	5.6
Diptera	Ceratopogonidae	Ceratopogonidae	972	3.4
Ostracoda	-	-	688	2.4
Diptera	[Tanytarsini]	Tanytarsus sp.	550	1.9
Pelecypoda	Sphaeriidae	Sphaerium sp.	335	1.2
Total percent for common taxa				95.5
Mean total abundance (standard error)				28,982(13,386)
Total richness (lowest practical level)				19

Note(s):
(i/d) specimen was immature or damaged
"-" not identified to this level

Table 8A-4c Common Benthic Invertebrates at WCC3 in the Christina River, Fall 2005

Christina River (WCC3) Depositional Habitat				
Major Group	**Family (sub-family/tribe)**	**Genus/species**	**Mean abundance**	**Percent of total**
Diptera	[Tanytarsini]	Tanytarsus sp.	1,651	17.8
Diptera	[Orthocladinae]	Eukiefferiella sp.	963	10.4
Diptera	[Chironomini]	Cryptotendipes sp.	826	8.9
Diptera	[Tanypodinae	Procladius sp.	826	8.9
Nematoda	-	-	757	8.1
Diptera	[Chironomini]	Polypedilum sp.	757	8.1
Diptera	Chironomidae	i/d	550	5.9
Diptera	[Tanytarsini]	Cladotanytarsus sp.	482	5.2
Diptera	[Orthocladinae]	Cricotopus sp.	482	5.2
Diptera	[Chironomini]	-	344	3.7
Diptera	[Chironomini]	Cryptochironomus sp.	275	3.0
Oligochaeta	Tubuficidae	-	206	2.2
Pelecypoda	Sphaeriidae	Sphaerium sp.	206	2.2
Diptera	Ceratopogonidae	Ceratopogonidae	206	2.2
Ostracoda	-	-	138	1.5
Diptera	[Chironomini]	Microtendipes sp.	138	1.5
Diptera	[Orthocladinae]	i/d	138	1.5
Total percent for common taxa				96.3
Mean total abundance (standard error)				9,288(4,266)
Total richness (lowest practical level)				19

Note(s):
(i/d) specimen was immature or damaged
"-" not identified to this level

Table 8A-4d Common Benthic Invertebrates at WCH3 in Unnamed River, Fall 2005

Unnamed River (WCH3) Depositional Habitat				
Major Group	**Family (sub-family/tribe)**	**Genus/species**	**Mean abundance**	**Percent of total**
Oligochaeta	Tubuficidae	-	4,954	52.6
Diptera	[Tanypodinae	Procladius sp.	1,376	14.6
Diptera	Ceratopogonidae	-	963	10.2
Pelecypoda	Sphaeriidae	Sphaerium sp.	688	7.3
Diptera	[Tanytarsini]	Tanytarsus sp.	482	5.1
Oligochaeta	Lumbriculidae	Lumbriculus sp.	275	2.9
Diptera	[Orthocladinae]	Cricotopus sp.	206	2.2
Trichoptera	Limnephilidae	Limnephilus sp.	138	1.5
Total percent for common taxa				96.4
Mean total abundance (standard error)				9,426(1,680)
Total richness (lowest practical level)				12

Note(s):
(i/d) specimen was immature or damaged
"-" not identified to this level

Table 8A-4e Common Benthic Invertebrates at WCL1 in the Christina River, Fall 2005

Christina River (WCL1) Erosional Habitat				
Major Group	**Family (sub-family/tribe)**	**Genus/species**	**Mean abundance**	**Percent of total**
Ephemeroptera	Heptageniidae	i/d	2,631	18.9
Ephemeroptera	Baetidae	Baetis sp.	2,226	16.0
Ephemeroptera	Ephemerellidae	Seratella sp.	1,619	11.6
Trichoptera	Hydropsychidae	Hydropsyche sp.	1,309	9.4
Diptera	[Orthocladinae]	Cricotopus sp.	1,045	7.5
Nematoda	-	-	774	5.6
Coleoptera	Elmidae	Optioservus sp.	587	4.2
Plecoptera	Chloroperlidae	i/d	581	4.2
Diptera	[Orthocladinae]	Eukiefferiella sp.	458	3.3
Plecoptera	Perlodidae	Isoperla sp.	370	2.7
Diptera	Tipulidae	Pilaria sp.	352	2.5
Trichoptera	Hydropsychidae	Arctopsyche sp.	266	1.9
Oligochaeta	Naididae	Nais sp.	246	1.8
Oligochaeta	Naididae	Uncinais uncinata	158	1.1
Total percent for common taxa				92.9
Mean total abundance (standard error)				13,924(4,112)
Total richness (lowest practical level)				36

Note(s):
(i/d) specimen was immature or damaged
"-" not identified to this level

Table 8A-4f Common Benthic Invertebrates at WCL6 in Unnamed Watercourse, Fall 2005

Unnamed Watercourse (WCL6) Depositional Habitat				
Major Group	**Family (sub-family/tribe)**	**Genus/species**	**Mean abundance**	**Percent of total**
Diptera	[Tanytarsini]	Tanytarsus sp.	28,346	50.1
Diptera	[Tanytarsini]	Cladotanytarsus sp.	8,944	15.8
Diptera	[Orthocladinae]	Eukiefferiella sp.	5,470	9.7
Nematoda	-	-	2,270	4.0
Diptera	[Tanypodinae	Ablabesmyia sp.	1,789	3.2
Diptera	[Tanypodinae	Procladius sp.	1,445	2.6
Diptera	Chironomidae	i/d	1,376	2.4
Ostracoda	-	-	1,273	2.2
Diptera	[Orthocladinae]	Cricotopus sp.	1,204	2.1
Pelecypoda	Sphaeriidae	Sphaerium sp.	826	1.5
Total percent for common taxa				93.6
Mean total abundance (standard error)				56,588(7,910)
Total richness (lowest practical level)				29

Note(s):
(i/d) specimen was immature or damaged
"-" not identified to this level

Table 8A-4g Common Benthic Invertebrates at LL2 in Unnamed Waterbody, Fall 2005

Unnamed Waterbody (LL2)				
Major Group	**Family (sub-family/tribe)**	**Genus/species**	**Mean abundance**	**Percent of total**
Oligochaeta	Tubuficidae	-	206	33.1
Diptera	[Tanypodinae	Tanypus sp.	206	33.1
Oligochaeta	Naididae	Vejdovskyella sp.	69	11.0
Diptera	Ceratopogonidae	-	69	11.0
Diptera	[Chironomini]	Chironomus sp.	47	7.6
Gastropoda	Valvatidae	Valvata tricarinata	9	1.4
Diptera	[Tanytarsini]	Tanytarsus sp.	9	1.4
Diptera	[Tanypodinae	Procladius sp.	9	1.4
Total percent for common taxa				100.0
Mean total abundance (standard error)				624(533)
Total richness (lowest practical level)				8

Note(s):
(i/d) specimen was immature or damaged
"-" not identified to this level

Table 8A-4h Common Benthic Invertebrates at LH1in Unnamed Waterbody, Fall 2005

Unnamed Waterbody (LH1)				
Major Group	**Family (sub-family/tribe)**	**Genus/species**	**Mean abundance**	**Percent of total**
Diptera	[Tanytarsini]	Tanytarsus sp.	417	23.8
Copepoda	Harpacticoida	-	378	21.6
Diptera	[Chironomini]	Dicrotendipes sp.	206	11.8
Nematoda	-	-	116	6.6
Diptera	[Tanypodinae	Procladius sp.	86	4.9
Diptera	Chironomidae	i/d	82	4.7
Hirudinea	Glossiphonidae	Helobdella elongata	73	4.2
Hirudinea	Glossiphonidae	Helobdella stagnalis	69	3.9
Diptera	Ceratopogonidae	-	69	3.9
Diptera	[Orthocladinae]	Cricotopus sp.	43	2.5
Diptera	[Tanytarsini]	i/d	39	2.2
Ephemeroptera	Caenidae	Caenis sp.	34	2.0
Diptera	[Chironomini]	Microtendipes sp.	34	2.0
Diptera	[Tanypodinae	Ablabesmyia sp.	34	2.0
Diptera	[Chironomini]	Polypedilum sp.	26	1.5
Diptera	[Tanytarsini]	Cladotanytarsus sp.	26	1.5
Total percent for common taxa				99.0
Mean total abundance (standard error)				1,750(1,154)
Total richness (lowest practical level)				17

Note(s):
(i/d) specimen was immature or damaged
"-" not identified to this level

Table 8A-4i Common Benthic Invertebrates at LL4 in Unnamed Waterbody, Fall 2005

Unnamed Waterbody (LL4)				
Major Group	**Family (sub-family/tribe)**	**Genus/species**	**Mean abundance**	**Percent of total**
Diptera	Ceratopogonidae	-	138	39.0
Diptera	[Tanypodinae]	Procladius sp.	86	24.4
Diptera	[Chironomini]	Cryptotendipes sp.	69	19.5
Nematoda	-	-	17	4.9
Diptera	[Chironomini]	-	17	4.9
Amphipoda	Gammaridae	Gammarus sp.	9	2.4
Diptera	[Tanytarsini]	Cladotanytarsus sp.	9	2.4
Diptera	[Tanypodinae	Clinotanypus sp.	9	2.4
Total percent for common taxa				100.0
Mean total abundance (standard error)				353(34)
Total richness (lowest practical level)				7

Note(s):
(i/d) specimen was immature or damaged
“-“ not identified to this level

Table 8A-5 **Regional Historic Benthic Invertebrate Data South of Fort McMurray Including Samples Collected in Fall, 2005**

											Community Composition (percent abundance)									
Waterbody/ Watercourse	Study:	Map Site	Sampling Month	Sampling Year	Seive Mesh (µm)	Habitat	Total Abundance	Richness (lowest level)	Simpson's Diversity Index	Shannon Weaver Diversity Index	Oligochaeta	Mollusks	Ephemeroptera	Plecoptera	Trichoptera	Chironomini	Tanytarsini	Orthocladiinae	Tanypodinae	Other
Watercourse																				
Hangingstone R	Tripp and Tsui (1980)[a]	1	Aug	1978	600	erosional	2679	23	0.58	1.14	45.7	0.1	1.2	0.0	0.3	0.3	0.1	49.3	1.1	1.8
Hangingstone R	Tripp and Tsui (1980)	2	Aug	1978	600	erosional	829	22	0.88	2.52	4.7	0.0	14.8	6.3	58.3	0.7	0.0	11.8	0.0	3.4
Hangingstone R	Tripp and Tsui (1980)	2	Oct	1978	600	erosional	317	16	0.78	2.02	3.5	0.0	65.6	23.3	3.8	0.0	0.0	1.9	0.0	1.9
Hangingstone R	Tripp and Tsui (1980)	3	Aug	1978	600	erosional	185	19	0.91	2.61	14.1	0.0	26.5	8.1	26.5	0.0	12.4	5.9	0.0	6.5
Hangingstone R	Tripp and Tsui (1980)	3	Oct	1978	600	erosional	298	13	0.88	2.28	16.8	0.0	39.6	11.4	22.8	0.0	0.0	0.0	0.0	9.4
Hangingstone R	Tripp and Tsui (1980)	4	Aug	1978	600	depositional	726	33	0.92	2.97	6.1	0.0	43.9	12.3	5.6	5.2	8.3	7.7	2.6	8.3
Hangingstone R	Tripp and Tsui (1980)	4	Oct	1978	600	depositional	739	13	0.77	1.86	0.0	0.0	71.7	10.4	7.4	0.0	0.0	0.0	0.0	10.4
Hangingstone R	Tripp and Tsui (1980)	5	Aug	1978	600	erosional	51	5	0.78	1.53	0.0	0.0	45.1	21.6	21.6	0.0	0.0	11.8	0.0	0.0
Hangingstone R	Tripp and Tsui (1980)	5	Oct	1978	600	erosional	205	12	0.85	2.16	8.3	0.0	63.4	14.1	8.3	0.0	0.0	0.0	0.0	5.9
Hangingstone R	Tripp and Tsui (1980)	6	Aug	1978	600	erosional	285	26	0.95	3.06	6.7	0.0	10.2	16.8	16.8	13.0	6.7	13.3	0.0	16.5
Hangingstone R	Tripp and Tsui (1980)	6	Oct	1978	600	erosional	517	12	0.56	1.41	8.7	0.0	7.5	6.6	67.1	1.2	0.0	0.0	0.0	8.9
Hangingstone R	Tripp and Tsui (1980)	7	Aug	1978	600	erosional	712	25	0.92	2.82	1.5	0.0	6.7	20.4	31.2	0.0	2.1	20.2	0.0	17.8
Hangingstone R	Tripp and Tsui (1980)	7	Oct	1978	600	erosional	1076	32	0.92	2.92	2.0	0.0	16.2	26.0	29.9	0.0	1.4	7.2	0.0	17.2
Hangingstone R	Tripp and Tsui (1980)	8	Aug	1978	600	erosional	204	15	0.88	2.40	0.0	0.0	3.4	0.0	3.9	18.1	28.9	27.0	2.0	16.7
Hangingstone R	Tripp and Tsui (1980)	8	Oct	1978	600	erosional	1127	20	0.77	1.94	5.9	0.0	7.9	1.1	69.1	1.0	0.0	0.0	0.0	15.0
Hangingstone R	Tripp and Tsui (1980)	9	Aug	1978	600	depositional	1651	27	0.79	2.11	0.7	0.0	52.0	3.4	0.0	1.6	1.8	27.4	0.0	13.1
Hangingstone R	Tripp and Tsui (1980)	9	Oct	1978	600	depositional	3268	20	0.62	1.50	0.0	0.0	67.5	5.3	0.0	0.3	1.0	11.3	0.0	14.4
Christina R	Tripp and Tsui (1980)	13	Aug	1978	600	erosional	1373	29	0.86	2.47	0.3	0.0	34.5	10.2	9.1	1.6	14.9	24.3	2.7	2.5
Christina R	Tripp and Tsui (1980)	13	Oct	1978	600	erosional	410	14	0.85	2.18	11.0	0.0	58.8	5.6	12.2	4.1	0.0	0.0	1.5	6.8
Christina R	Tripp and Tsui (1980)	14	Aug	1978	600	erosional	1109	23	0.80	2.59	1.0	0.4	10.1	2.0	21.8	3.7	41.0	6.6	9.7	3.7
Christina R	Tripp and Tsui (1980)	14	Oct	1978	600	erosional	757	12	0.72	1.75	25.9	0.0	62.9	6.6	1.6	0.8	0.8	0.0	0.0	1.5
Christina R	Tripp and Tsui (1980)	15	Aug	1978	600	erosional	2111	27	0.85	2.32	0.9	0.0	7.4	2.7	28.2	1.2	29.3	7.2	2.3	20.8
Christina R	Tripp and Tsui (1980)	15	Oct	1978	600	erosional	1369	26	0.90	2.58	1.6	0.0	52.7	10.3	25.1	1.7	1.6	4.5	0.8	1.7
Christina R	Tripp and Tsui (1980)	16	Aug	1978	600	erosional	643	27	0.94	2.99	8.7	0.0	30.0	3.6	18.4	11.5	4.7	11.7	4.7	6.8
Christina R	Tripp and Tsui (1980)	16	Oct	1978	600	erosional	1188	15	0.51	1.30	3.3	0.0	84.8	3.8	5.7	0.0	0.0	0.9	0.5	1.0
Gregoire R	Tripp and Tsui (1980)	10	Aug	1978	600	erosional	312	19	0.90	2.56	7.1	0.0	40.1	21.8	10.9	1.9	0.0	3.8	1.9	12.5
Gregoire R	Tripp and Tsui (1980)	11	Aug	1978	600	depositional	486	13	0.87	2.29	0.0	0.0	4.5	4.5	13.6	13.6	31.9	4.5	0.0	27.4
Gregoire R	Tripp and Tsui (1980)	12	Aug	1978	600	depositional	513	16	0.59	1.58	3.3	0.0	2.3	2.3	79.9	3.3	0.0	6.6	0.0	2.1
Cameron Cr	Tripp and Tsui (1980)	17	Aug	1978	600	erosional	1848	20	0.62	1.60	3.0	0.0	10.2	6.0	75.5	0.6	0.0	1.2	0.0	3.6
Prairie Cr	Tripp and Tsui (1980)	18	Aug	1978	600	depositional	498	10	0.60	1.39	13.5	60.6	4.6	0.0	0.0	0.0	2.2	0.0	0.0	19.1
Saline Cr	Tripp and Tsui (1980)	19	Aug	1978	600	erosional	119	5	0.62	1.16	32.8	0.0	52.1	0.0	0.0	15.1	0.0	0.0	0.0	0.0
Saline Cr	Tripp and Tsui (1980)	20	Aug	1978	600	erosional	179	12	0.88	2.28	6.1	0.0	27.9	15.6	27.9	0.0	0.0	12.8	0.0	9.5
Saprae Cr	Tripp and Tsui (1980)	21	Aug	1978	600	erosional	387	14	0.86	2.22	1.6	0.0	39.0	17.3	36.2	0.0	0.0	1.6	1.6	2.8
Saprae Cr	Tripp and Tsui (1980)	22	Aug	1978	600	erosional	194	15	0.87	2.34	3.1	0.0	28.9	14.4	41.2	0.0	3.1	3.1	3.1	3.1
Saprae Cr	Tripp and Tsui (1980)	23	Aug	1978	600	depositional	401	26	0.93	2.96	0.0	0.0	8.5	5.5	19.7	1.5	1.5	22.2	1.5	39.7
Surmont Cr	Tripp and Tsui (1980)	24	Aug	1978	600	depositional	4128	16	0.71	1.69	1.6	0.0	2.2	0.0	0.5	16.1	2.7	48.9	7.5	20.4
Surmont Cr	Tripp and Tsui (1980)	25	Aug	1978	600	erosional	213	16	0.86	2.40	0.0	0.0	13.6	55.9	5.6	5.6	2.8	13.6	2.8	0.0
Surmont Cr	Tripp and Tsui (1980)	26	Aug	1978	600	erosional	592	26	0.88	2.67	9.5	0.0	5.9	2.9	19.9	37.8	0.0	4.9	7.6	11.5
Cottonwood Cr	Gulf (1979) [a]	27	Aug	1978	850	erosional	374	19	0.81	2.03	0.3	0.0	1.1	20.3	3.5	0.0	0.0	29.1	7.8	38.0
Cottonwood Cr	Gulf (2001)	52	Aug	1998	250	erosional	36843	30	0.86	2.38	23.1	0.0	18.1	3.6	34.9	0.1	2.8	2.1	0.0	15.3
Cottonwood Cr	Gulf (2001)	27	Aug	1998	250	erosional	5830	32	0.90	2.66	1.5	0.3	18.2	2.1	18.9	7.2	8.2	24.0	0.9	18.5
Unnamed Tributary to Cottonwood Cr	Gulf (1979)	28	Aug	1978	850	erosional	288	15	0.75	1.72	2.1	0.0	2.1	16.7	0.3	0.0	0.0	27.4	6.3	45.1
Unnamed Tributary to Cottonwood Cr	Gulf (1979)	29	Aug	1978	850	erosional	953	16	0.62	1.54	0.5	0.0	62.5	24.2	4.0	0.0	0.0	3.7	0.0	5.0
Unnamed Tributary to Cottonwood Cr	Gulf (1979)	30	Aug	1978	850	erosional	207	9	0.40	0.97	6.3	0.0	1.0	7.2	1.0	0.0	0.0	77.3	2.9	4.3
Unnamed Tributary to Cottonwood Cr	Gulf (1979)	31	Aug	1978	850	depositional	55	10	0.74	1.60	36.4	1.8	0.0	0.0	9.1	0.0	0.0	1.8	7.3	43.6
Meadow Cr	Gulf (1979)	32	Aug	1978	850	erosional	584	24	0.85	2.42	1.7	0.0	15.9	5.8	27.4	0.0	0.0	3.1	1.2	44.9
Meadow Cr	Gulf (1979)	33	Aug	1978	850	erosional	1217	24	0.88	2.46	0.1	0.0	38.9	45.9	4.7	0.0	0.0	3.5	0.2	6.6
Meadow Cr	Gulf (2001)	55	Aug	1998	250	erosional	62726	32	0.85	2.13	0.4	0.3	1.1	0.0	0.6	12.8	20.3	27.6	3.8	33.2
Meadow Cr	Gulf (2001)	56	Aug	1998	250	erosional	13402	33	0.88	2.57	0.1	0.0	20.8	15.6	43.9	0.0	1.4	1.0	0.2	17.0
Meadow Cr	Long Lake II	60	August	2005	250	depositional	396	9	0.80	1.84	34.8	0.0	0.0	0.0	0.0	52.2	4.3	8.7	0.0	0.0
Lake 8	PetroCan (2002)	40	May	2001	500	depositional	215	6	0.79	1.66	0.0	53.3	6.7	0.0	0.0	13.3	6.7	0.0	20.0	0.0
Lake 10	PetroCan (2002)	41	May	2001	500	depositional	229	5	0.50	1.04	0.0	68.8	0.0	0.0	0.0	6.3	12.5	0.0	0.0	12.5
Lake 11	PetroCan (2002)	42	May	2001	500	depositional	2666	21	0.83	2.19	0.0	18.8	0.0	0.0	1.1	35.5	8.1	3.2	23.1	10.2
Lake 12	PetroCan (2002)	43	May	2001	500	depositional	358	15	0.88	2.45	28.0	4.0	4.0	0.0	0.0	16.0	12.0	16.0	12.0	8.0
Surmont Lake	PetroCan (2002)	44	May	2001	500	depositional	731	12	0.87	2.20	11.8	7.8	0.0	0.0	0.0	27.5	13.7	0.0	5.9	33.3
Kinosis Creek	Gulf (1979)	34	Aug	1978	850	depositional	59	3	0.53	0.81	0.0	0.0	0.0	0.0	0.0	0.0	0.0	54.2	0.0	45.8
Kettle R	Gulf (1979)	35	Aug	1978	850	erosional	687	25	0.88	2.45	0.7	0.0	6.4	32.2	41.8	0.0	0.0	4.7	1.0	13.2
Kettle R	Gulf (1979)	36	Aug	1978	850	erosional	6	5	0.93	1.56	0.0	0.0	16.7	16.7	0.0	0.0	0.0	16.7	0.0	50.0
South Kettle River	Gulf (1979)	37	Aug	1978	850	erosional	386	20	0.90	2.53	0.0	0.3	5.2	2.6	51.6	0.0	0.0	14.5	3.6	22.3
Tributary to the Christina R	Gulf (1979)	38	Aug	1978	850	depositional	25	5	0.66	1.18	0.0	8.0	0.0	0.0	0.0	0.0	0.0	36.0	4.0	52.0
Tributary to the Christina R	Gulf (1979)	39	Aug	1978	850	depositional	2	2	1.00	0.69	0.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0
Sawbones Creek	MEG (2005)	47	August	2004	250	depositional	21758	24	0.80	1.94	1.0	25.8	0.0	0.0	0.0	0.7	18.2	0.8	12.4	41.1
Unnamed Trib to East Shore	MEG (2005)	48	August	2004	250	depositional	12375	28	0.86	2.34	0.7	39.5	0.7	0.0	0.1	10.1	2.1	0.0	4.2	42.6
Kettle R	Gulf (2001)	54	Aug	1998	250	erosional	39413	24	0.67	1.47	0.1	0.3	0.4	0.1	0.2	6.7	45.0	5.5	3.6	38.0
Robert Creek	Long Lake II	61	August	2005	250	depositional	6889	27	0.91	2.75	14.1	1.2	5.2	0.0	1.2	17.5	0.0	5.2	21.5	34.0
Christina River	NAOSC	WCL-11	oct	2005	240	erosional	18735	44	0.90	2.718	1.7	0.1	21.7	8.2	21.3	1.1	1.1	5.3	0.1	39.4
Christina River	NAOSC	WCL-11	sept	2005	240	depositional	28982	19	0.78	1.909	39.3	1.2	0.5	0.0	0.0	37.4	1.9	10.5	0.8	8.5
Christina River	NAOSC	WCC-3	Sept	2005	240	depositional	9288	19	0.92	2.704	2.2	2.2	0.0	0.0	0.0	25.2	23.0	17.8	8.9	20.7
Unnamed Watercourse	NAOSC	WCH-3	Oct	2005	240	depositional	9425.6	12	0.68	1.623	56.2	7.3	0.0	0.0	2.2	0.7	5.1	2.9	15.3	10.2
Unnamed Watercourse	NAOSC	WCL-1	Oct	2005	240	erosional	13924	36	0.90	2.710	4.7	0.1	46.6	7.5	12.2	0.9	0.7	11.5	0.1	15.7
Unnamed Watercourse	NAOSC	WCL-6	Sept	2005	240	depositional	56588	29	0.71	1.866	0.9	1.5	0.2	0.0	0.2	2.6	65.9	12.0	5.7	11.1

Waterbody/ Watercourse	Study:	Map Site	Sampling Month	Sampling Year	Seive Mesh (µm)	Habitat	Total Abundance	Richness (lowest level)	Simpson's Diversity Index	Shannon Weaver Diversity Index	Community Composition (percent abundance)									
											Oligochaeta	Mollusks	Ephemeroptera	Plecoptera	Trichoptera	Chironomini	Tanytarsini	Orthocladiinae	Tanypodinae	Other
Waterbody																				
Christina Lake	MEG (2005)	45	August	2004	250	depositional	5475	10	0.60	1.27	1.6	5.5	0.0	0.0	0.0	3.9	1.8	0.0	3.1	84.0
Christina Lake	MEG (2005)	46	August	2004	250	depositional	946	9	0.65	1.50	19.7	1.5	0.0	0.0	0.0	1.5	0.0	13.6	0.0	63.6
Unnamed Waterbody 6	MEG (2005)	49	August	2004	250	depositional	3904	21	0.93	2.80	25.6	0.2	0.0	0.0	0.2	31.3	13.2	0.0	5.9	23.6
Unnamed Waterbody 7	MEG (2005)	50	August	2004	250	depositional	4618	17	0.84	2.11	5.6	26.4	3.7	0.0	0.0	24.2	9.3	1.9	17.9	11.0
Unnamed Waterbody 12	MEG (2005)	51	August	2004	250	depositional	3191	16	0.79	1.89	0.0	38.3	0.0	0.0	0.0	1.3	2.7	0.0	10.2	47.4
Horse Lake	Long Lake II	62	September	2005	250	depositional	1419	5	0.08	0.22	0.0	0.0	0.6	0.0	0.0	95.8	0.0	0.0	0.0	3.6
Unnamed Lake (WB4)	Long Lake II	63	September	2005	250	depositional	2838	32	0.90	2.76	23.9	5.5	2.1	0.0	0.3	18.2	15.8	2.1	4.8	27.3
Lake 49	Long Lake II	64	September	2005	250	depositional	68843	14	0.12	0.36	1.8	0.0	0.0	0.0	0.0	1.2	0.0	0.1	1.0	95.9
Long Lake (south)	Long Lake II	65	September	2005	250	depositional	2468	14	0.89	2.34	10.5	0.3	10.5	0.0	0.0	9.8	17.4	0.0	33.4	18.1
Kinosis Lake	Long Lake II	66	September	2005	250	depositional	8333	15	0.81	1.86	22.5	7.7	0.0	0.0	0.0	16.9	0.2	0.0	5.0	47.7
Unnamed Lake	NAOSC	LL-2	October	2005	240	depositional	624	8	0.75	1.59	44.1	1.4	0.0	0.0	0.0	7.6	1.4	0.0	34.5	11.0
Unnamed Lake	NAOSC	LH-1	October	2005	240	depositional	1750	17	0.87	2.37	0.2	0.0	2.0	0.0	0.0	15.7	27.5	2.5	6.9	45.2
Unnamed Lake	NAOSC	LL-4	October	2005	240	depositional	353	7	0.75	1.60	0.0	0.0	0.0	0.0	0.0	24.4	2.4	0.0	26.8	46.3

[a] Data for analysis was obtainedin Ramp (2003) because the original reference was unavailable

Table 8A-6 Summary of Principal Component Analysis Results for Benthic Invertebrates in the Region

Taxon	Component Loadings [a]		
	PC-1	**PC-2**	**PC-3**
Trichptera	**0.837**	-0.304	0.122
Orthocladiinae	**0.813**	-0.000	-0.095
Ephemeroptera	**0.806**	-0.224	0.218
Diptera	**0.782**	0.117	-0.127
Plecoptera	**0.698**	-0.590	0.237
Other	**0.645**	0.349	0.518
Tanytarsini	**0.629**	0.342	-0.372
Ostracoda	0.043	**0.857**	-0.014
Tanypodinae	0.216	**0.782**	-0.277
Mollusk	0.210	**0.743**	-0.202
Hirudinea	-0.157	**0.715**	0.435
Chironomini	0.103	**0.714**	-0.054
Nematoda	0.137	0.440	0.589
Odonata	0.398	0.064	0.058
Oligochaeta	0.358	0.259	-0.387
Amphioda	-0.472	0.399	0.327
Eigenvalue	**4.577**	**4.085**	**1.468**
Percent Variance Explained	**28.7**	**25.5**	**9.2**

Note(s):
Component Loadings greater than 0.6 are bolded

Table 8A-7 Historic Presence Data for Invertebrates in the Kai Kos Dehseh Regional Study Area

Major Group	Family [sub-family/tribe]	Genus species	Common Names	Hangingstone River [a]	Small Water-courses [a, b]	Christina River [a, c]	Christina River Tributaries [a,c,d,e,f,]	Christina Lake [f]	Small Water-bodies [c,f,g]	Christina River [h] (2005)	Tributaries and Headwaters of the Christina River [h] (2005)	Unnamed Waterbodies in the Christina River Watershed [h] (2005)
Cnidaria - Hydrozoa		-	Hydra						P			
Nematoda		-	Nematode	P	P	P	P	P	P	P	P	P
Oligochaeta		-	Aquatic Worms	P	P	P	P					
	Enchytaeidae	-		P		P			P			
	Lumbriculidae	-				P	P		P		P	P
	Naididae	-		P		P	P	P	P	P	P	P
	Tubificidae	-		P		P	P	P	P	P	P	P
Hirudinea		-	Leeches				P					
	Erpobdellidae	-				P	P		P	P		
		Dina parva		P								
		Erpobdella punctata					P		P			
		Nephelopsis obscura		P			P		P			
	Glossiphoniidae	-				P						
		Glossiphonia complanata		P		P	P		P		P	
		Helobdella					P					
		Helobdella elongata										P
		Helobdella stagnalis		P			P		P	P		P
		Theromyzon							P			
	Hirudinidae	*Haemopsis*					P					
Gastropoda		-	Snails	P								
	Ancylidae	*Ferrissia*	Limpets	P		P			P			P
		Ferrissia rivularis				P						
	Lymnaeidae	*Lymnaea*	Pond snails				P			P		P
		Stagnicola				P						
	Physidae	*Physa*	Bladder snails			P	P		P	P	P	
	Planorbidae	*Armiger*	Rams horn snails				P					
		Armiger crista							P			
		Gyraulus					P		P			P
		Helisoma					P		P			
	Valvatidae	*Valvata*	-				P					
		Valvata sincera					P		P			
		Valvata tricarinata					P					P
Pelecypoda	Sphaeriidae	-	Fingernail clams				P	P	P			
		Sphaerium sp.								P	P	
		Pisidium			P		P		P			
		Pisidium / Sphaerium				P						
	Unionidae	*Lampsilis radiata*	Unionid mussels			P						
Hydracarina		-	Aquatic mites	P		P	P		P	P	P	P
Ostracoda		-	Seed shrimp	P		P	P	P	P	P	P	P
Copepoda - Harpacticoida		-	Freshwater shrimp	P		P	P	P	P	P	P	P

Major Group	Family [sub-family/tribe]	Genus species	Common Names	Hangingstone River (a)	Small Water-courses (a, b)	Christina River (a, c)	Christina River Tributaries (a,c,d,e,f,)	Christina Lake (f)	Small Water-bodies (c,f,g)	Christina River (h) (2005)	Tributaries and Headwaters of the Christina River (h) (2005)	Unnamed Waterbodies in the Christina River Watershed (h) (2005)
Amphipoda		-	Scuds	P								
	Gammaridae	*Gammarus*					P	P	P			P
		Gammarus lacustris			P		P		P			
	Talitridae	*Hyalella*					P					
		Hyalella azteca		P	P	P	P	P	P	P	P	
Ephemeroptera		-	Mayflies	P						P	P	
	Ameletidae	*Ameletus*	-	P	P	P	P					
	Ametropodidae	*Ametropus neavei*	-			P						
	Baetidae	-	Small minnow mayflies		P	P	P			P	P	
		Baetis		P	P	P	P			P	P	
		Brachycercus					P					
		Callibaetis					P				P	P
		Centroptilum		P	P							
		Pseudocloeon		P		P	P					
	Baetiscidae	*Baetisca*	Armoured mayflies			P						
	Caenidae	*Caenis*	Small squaregill mayflies				P		P			P
		Brachycercus prudens				P						
	Ephemerellidae	-	Spiny crawler mayflies				P			P		
		Attenella sp.								P		
		Drunella					P					
		Ephemerella		P		P	P			P		
		Ephemerella inermis		P		P	P					
		Ephemerella spinifera		P	P	P	P					
		Serratella					P			P	P	
	Ephemeridae	*Hexagenia*	Common burrower				P			P		
		Hexagenia limbata				P	P			P		
	Heptageniidae	-	Flatheaded mayflies	P			P			P	P	
		Cinygma					P					
		Cinygmula		P			P					
		Epeorus		P			P					
	Heptageniidae	*Heptagenia*		P	P	P	P			P		
		Stenacron sp.								P	P	
		Rhithrogena		P	P	P	P					
		Stenonema		P		P	P					
	Leptohyphidae	*Tricorythodes*	Little stout crawlers			P						
		Tricorythodes minutus		P								
	Leptophlebiidae	-	Prong-gilled mayflies			P				P		
		Leptophlebia		P		P				P	P	
		Paraleptophlebia		P	P		P			P	P	

Major Group	Family [sub-family/tribe]	Genus species	Common Names	Hangingstone River [a]	Small Water-courses [a, b]	Christina River [a, c]	Christina River Tributaries [a,c,d,e,f,]	Christina Lake [f]	Small Water-bodies [c,f,g]	Christina River [h] (2005)	Tributaries and Headwaters of the Christina River [h] (2005)	Unnamed Waterbodies in the Christina River Watershed [h] (2005)
Ephemeroptera	Metretopodidae	*Metretopus borealis*	Cleftfoot minnow mayflies	P								
	Oligoneuriidae	*Isonychia sp.*	Brush-legged mayflies							P		
	Siphlonuridae	-	Primative mayflies	P			P					
		Parameletus		P								
		Siphlonurus					P					
Odonata-Anisoptera		-	Dragonflies	P			P					
	Aeshnidae	*Aeshna interupta*	Darners		P							
	Corduliidae	*Cordulia*	Emeralds				P		P			
		Epitheca					P		P			
		Somatochlora							P			
	Gomphidae	*Gomphus*	Clubtails			P						
		Ophiogomphus		P		P				P		
Plecoptera		-	Stoneflies	P		P	P			P	P	
	Capniidae	*Capnia*	Small winter stoneflies				P					
		Capnia/Eucapnopsis		P		P	P					
	Capniidae/Leuctridae	*Capniidae/Leuctridae*	-				P					
	Chloroperlidae	-	Green Stoneflies				P			P	P	
		Hastaperla			P	P	P					
		Alloperla/Hastaperla		P	P	P	P					
	Leuctridae	*Leuctra*	Rolled-winged stonefly	P								
	Nemouridae	*Nemoura*	Spring Stoneflies		P		P					
		Nemoura cinctipes		P	P		P					
		Zapada					P					
	Perlidae	*Acroneuria*	Common Stoneflies	P			P			P		
		Claassenia				P	P			P		
		Claassenia sabulosa		P								
	Perlodidae	-	Perlodid Stoneflies	P		P	P					
		Arcynopteryx		P	P	P	P					
		Isogenoides			P		P			P		
		Isoperla		P		P	P			P	P	
		Megarcys sp.								P		
		Skwala					P			P		
	Pteronarcyidae	*Pteronarcella*	Giant Stoneflies	P			P			P	P	
		Pteronarcella regularis		P	P	P						
		Pteronarcys		P		P				P	P	
		Pteronarcys dorsata		P								
	Taeniopterygidae	*Taeniopteryx*	Winter Stoneflies	P		P					P	

Major Group	Family [sub-family/tribe]	Genus species	Common Names	Hangingstone River (a)	Small Water-courses (a, b)	Christina River (a, c)	Christina River Tributaries (a,c,d,e,f,)	Christina Lake (f)	Small Water-bodies (c,f,g)	Christina River (h) (2005)	Tributaries and Headwaters of the Christina River (h) (2005)	Unnamed Waterbodies in the Christina River Watershed (h) (2005)
Megaloptera	Sialidae	*Sialis*	Alder flies				P					
Trichoptera		-	Caddisflies	P			P					
	Apataniidae	*Apatania*	-	P			P					
	Brachycentridae	*Amiocentrus*	Humpless casemaker caddisflies		P							
		Brachycentrus		P	P	P	P			P	P	
		Micrasema					P					
	Glossosomatidae	-	Saddle casemaker caddisflies				P					
		Glossosoma		P	P		P			P	P	
	Hydropsychidae	-	Common netspinner caddisflies	P		P	P		P			
		Arctopsyche		P	P	P	P			P	P	
		Cheumatopsyche			P	P	P			P		
		Hydropsyche		P	P	P	P			P	P	
	Hydroptilidae	-	Purse casemaker caddisflies			P	P					
		Agraylea					P			P	P	
		Hydroptila					P					P
		Neotrichia					P					
		Orthotrichia				P	P					
		Oxyethira					P				P	P
	Lepidostomatidae	*Lepidostoma*	Bizarre caddisflies	P	P	P	P			P		
	Leptoceridae	-	Longhorned caddisflies			P	P					
		Ceraclea				P						
		Oecetis				P	P		P			
		Triaenodes							P			
	Limnephilidae	-	Northern caddisflies								P	
		Apatania sp.								P		
		Glyphopsyche irrorata			P							
		Hesperophylax					P					
		Lenarchus			P		P					
		Limnephilus					P			P	P	P
		Limnephilus/Philarctus							P			
		Nemotaulius					P					
		Onocosmoecus		P								
		Protoptila sp.								P		
		Psychoglypha					P					
		Pycnopsyche				P				P		
	[Limnephilini]	-				P						
	Philopotamidea	*Wormaldia*	Fingernet caddisflies				P					
	Phryganeidae	*Agrypnia*	Giant caddisflies				P		P	P	P	
		Ptilostomis			P		P					

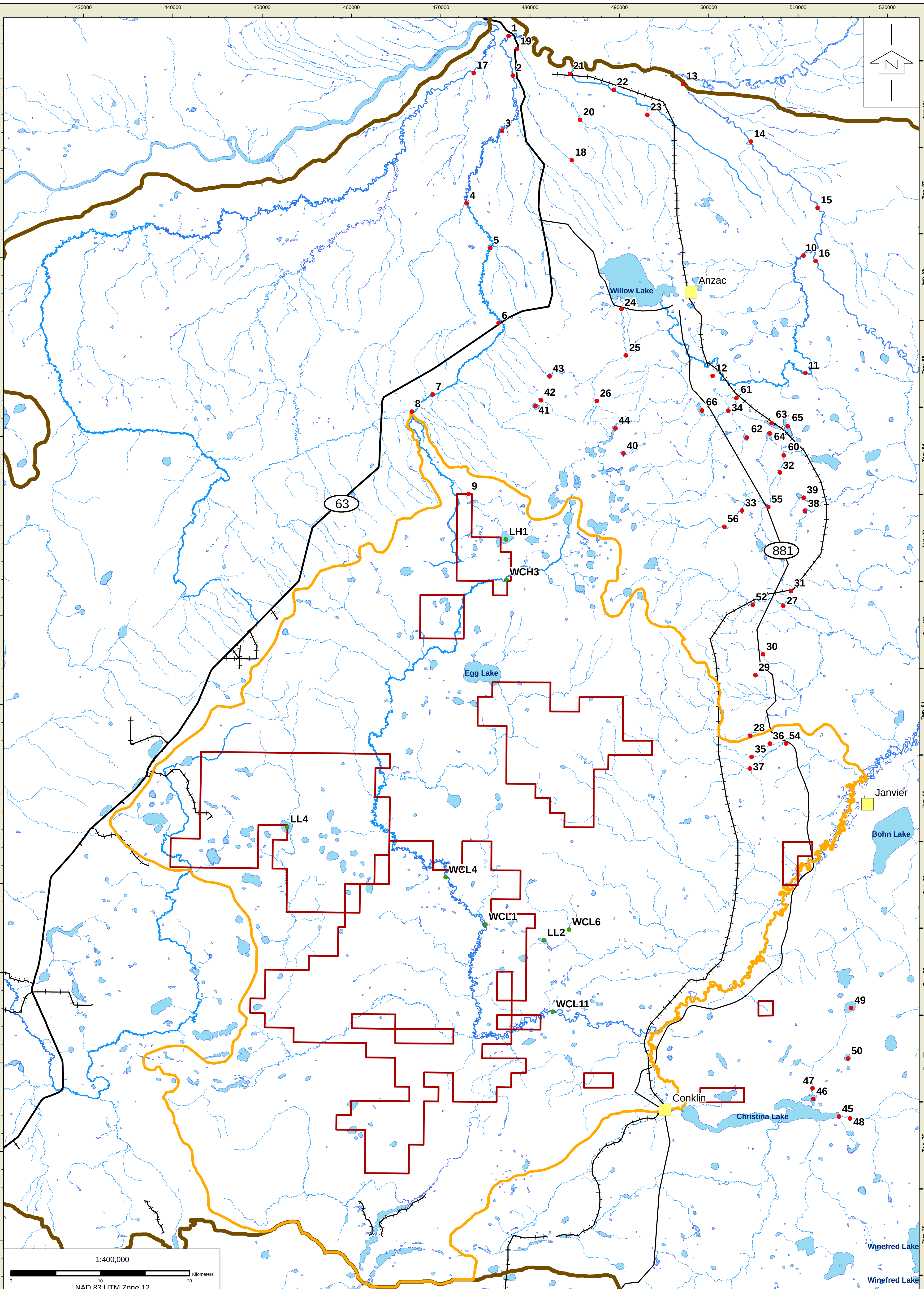
Major Group	Family [sub-family/tribe]	Genus species	Common Names	Hangingstone River (a)	Small Water-courses (a, b)	Christina River (a, c)	Christina River Tributaries (a,c,d,e,f,)	Christina Lake (f)	Small Water-bodies (c,f,g)	Christina River (h) (2005)	Tributaries and Headwaters of the Christina River (h) (2005)	Unnamed Waterbodies in the Christina River Watershed (h) (2005)
Trichoptera	Polycentropodidae	*Neureclipsis*	Tubemaker caddisflies				P					
		Nyctiophylax					P					
		Polycentropus					P					
	Psychoglypha	*Psychoglypha*	Northern casemaker				P					
	Psychomyiidae	*Psychomyia*	Net-tube caddisflies		P	P	P				P	
		Psychomyia flavida		P								
	Rhyacophilidae	*Rhyacophila*	Freeliving caddisflies				P			P		
Hemiptera	Corixidae	-	Water boatman				P					P
		Callicorixa sp.									P	
		Sigara		P	P	P				P	P	P
		Sigara washingtonensis		P								
	Notonectidae	*Notonecta sp.*	Backswimmers								P	P
Coleoptera		-	Beetles	P								
	Chrysomelidae	*Donacia*	Leaf beetles				P					
	Dytiscidae	-	Predacious diving beetles				P					
		Agabus		P			P				P	
		Laccophilus sp.								P		
		Oreodytes					P					
		Rhantus sp.									P	
		Uvarus sp.									P	
	Elmidae	-	Riffle beetles				P					
		Dubiraphia		P		P						
		Optioservus		P	P	P				P	P	
	Gyrinidae	*Gyrinus*	Whirligig beetles				P			P	P	
	Haliplidae	*Brychius*	Crawling water beetles				P					
		Haliplus					P					
Collembola	Collembola	-	Springtalis				P			P	P	
Diptera		-	True Flies									
	Athericidae	-	Watersnipe flies	P								
		Atherix		P		P	P					
	Anthomyiidae	*Limnophora*	Root maggot flies	P	P							
		Lispe		P								
	Ceratopogonidae [Ceratopogoninae]	-	Biting midges	P	P	P	P	P	P	P	P	P
		(i/d)				P	P		P			
		Bezzia/Palpomyia							P			
		Culicoides		P								
		Palpomyia			P							
		Probezzia							P			
	[Dasyheleinae]	*Dasyhelea*				P						
	[Forcipomyiinae]	*Atrichopogon*				P						
		Forcipomyia				P						
	Chironomidae	-	True midges	P			P			P	P	P
	[Chironominae]	-	Blood worms				P		P			
	[Chironomini]	-				P	P		P	P	P	P
		Chironomus		P	P	P	P	P	P			P
		Cladopelma					P		P			

Major Group	Family [sub-family/tribe]	Genus species	Common Names	Hangingstone River [a]	Small Water-courses [a, b]	Christina River [a, c]	Christina River Tributaries [a,c,d,e,f,]	Christina Lake [f]	Small Water-bodies [c,f,g]	Christina River [h] (2005)	Tributaries and Headwaters of the Christina River [h] (2005)	Unnamed Waterbodies in the Christina River Watershed [h] (2005)
		Cryptochironomus		P		P	P		P	P	P	P
		Cryptotendipes							P	P	P	P
		Demicryptochironomus		P	P	P						
		Dicrotendipes							P	P	P	P
		Einfeldia							P			
		Endochironomus							P			
		Glyphtotendipes					P		P			
		Harnischia				P	P					
		Lauterborniella agrayloides							P			
		Microtendipes				P	P		P	P	P	P
		Pagastiella					P		P			
		Parachironomus					P		P			
		Paracladopelma		P	P	P	P					
		Paralauterborniella		P	P	P	P			P		
		Paratendipes				P						
		Phaenopsectra		P		P	P		P			
		Polypedilum		P		P	P		P	P	P	P
		Polypedilum fallax		P		P						
		Robackia				P						
		Saetheria				P	P					
		Sergentia						P				
		Stictochironomus		P		P	P			P	P	
		Tribelos				P			P			
	[Chironomini/Tanytarsini]	*Chironomini/ Tanytarsini*					P					
	[Tanytarsini]	-			P	P	P					P
		Cladotanytarsus		P		P	P		P	P	P	P
		Micropsectra		P		P	P	P				
		Paratanytarsus		P		P	P		P			
		Rheotanytarsus		P	P	P	P					
		Stempellinella				P	P					
		Tanytarsus		P	P	P	P	P	P	P	P	P
		Zavrelia		P								
		Micropsectra / Tanytarsus				P						
	[Diamesinae]	-									P	
		Diamesa		P								
		Potthastia		P	P					P	P	
		Pottastia longimana gr.				P	P					
		Pseudodiamesa		P			P					
	[Pseudochironomini]	*Pseudochironomus*							P		P	
	[Orthocladiinae]	-		P		P	P		P	P	P	P
		Brillia		P	P	P	P					
		Corynoneura					P		P	P	P	P
		Cricotopus/Orthocladius				P	P		P			
		Cricotopus		P	P	P	P	P		P	P	P
		Epoicocladius				P				P		

Major Group	Family [sub-family/tribe]	Genus species	Common Names	Hangingstone River [(a)]	Small Water-courses [(a, b)]	Christina River [(a, c)]	Christina River Tributaries [(a,c,d,e,f,)]	Christina Lake [(f)]	Small Water-bodies [(c,f,g)]	Christina River [(h)] (2005)	Tributaries and Headwaters of the Christina River [(h)] (2005)	Unnamed Waterbodies in the Christina River Watershed [(h)] (2005)
		Eukiefferiella		P	P	P				P	P	P
		Heterotrissocladius				P						
		Heterotrissocladius marcidus			P		P					
		Metriocnemus		P		P						
		Nanocladius		P			P					
		Orthocladius		P	P	P	P					
		Parakiefferiella		P		P						
		Parametriocnemus		P	P	P						
		Paratrichocladius		P								
		Psectrocladius					P		P			
		Pseudosmittia				P						
		Orthocladius							P			
		Rheocricotopus		P			P					
		Rheosmittia				P	P					
		Smittia				P						
		Syncricotopus		P								
		Synorthocladius		P			P					
		Thienemanniella		P	P	P	P			P	P	
		Tvetenia				P		P				
	[Orthocladiinae/ Diamesinae]	*Orthocladiinae/ Diamesinae*					P					
	[Prodiamesinae]	*Monodiamesa*		P			P				P	
		Odontomesa		P			P					
		Prodiamesa					P					
	[Tanypodinae]	-	Predacious midges			P	P		P			
		Ablabesmyia		P		P			P	P	P	P
		Clinotanypus					P		P			P
		Labrundinia							P			
		Nilotanypus				P						
		Procladius				P	P	P	P	P	P	P
		Tanypus sp.										P
		Thienemannimyia		P	P	P	P					
	Culicidae	-	Mosquitoes									
	[Culicinae]	-					P					
	Dolichopodidae	-	Long legged flies			P						
		Rhaphium		P		P						
	Dixidae	*Dixa*	Dixid midges		P							
	Empididae	-	Dance flies	P			P				P	
		Chelifera		P			P			P		
		Oreogeton					P					
		Wiedemannia		P								
		Hemerodromia		P	P	P	P			P	P	
	Ephydridae	-	Shore flies			P	P					
	Psychodidae	*Pericoma*	Moth flies			P	P					
	Ptychopteridae	-	Phantom crane flies				P					

Major Group	Family [sub-family/tribe]	Genus species	Common Names	Hangingstone River [(a)]	Small Water-courses [(a, b)]	Christina River [(a, c)]	Christina River Tributaries [(a,c,d,e,f,)]	Christina Lake [(f)]	Small Water-bodies [(c,f,g)]	Christina River [(h)] (2005)	Tributaries and Headwaters of the Christina River [(h)] (2005)	Unnamed Waterbodies in the Christina River Watershed [(h)] (2005)
	Simuliidae	-	Black flies				P					
		Simulium		P	P	P	P			P	P	
	Stratiomyidae	*Stratiomyidae*	Soldier flies				P					
	Tabanidae	-	Deer flies	P			P					
		Chrysops			P	P	P		P	P		
		Tabanus					P					
	Tipulidae	-	Crane flies				P			P	P	
		Antocha		P			P					
		Dicranota		P			P					
		Erioptera				P						
		Hexatoma			P	P	P			P	P	
		Limnophila		P		P	P					
		Limnophora					P					
		Ormosia		P								
		Pilaria sp.									P	
		Pseudolimnophila					P					
		Tipula		P		P	P					
Total Richness (lowest practical level)				106	55	114	161	16	63	74	63	37
Total Richness (major groups)			**Oligochaeta**	4	1	5	3	2	4	2	3	3
			Mollusks	2	1	6	8	1	7	3	2	4
			Ephemeroptera	20	8	17	19	0	1	11	6	2
			Plecoptera	15	7	11	13	0	0	9	5	0
			Trichoptera	10	11	14	28	0	5	13	9	3
			Chironomini	9	4	16	14	2	15	7	6	6
			Tanytarsini	6	3	8	6	2	3	2	2	2
			Orthocladiinae	14	7	16	11	2	4	5	4	3
			Tanypodinae	2	1	5	3	1	4	2	2	4
			Other	24	12	16	56	6	20	20	24	10

Note(s)
- = not identified to this level
(i/d) = immature or damaged
P = invertebrate presence was recorded
(a) Tripp and Tsui, 1980
(b) Assorted small tributaries north of the Nexen Long Lake South Lease site
(c) Nexen, 2006
(d) Gulf, 1979
(e) Gulf, 2001
(f) MEG, 2005
(g) PetroCan, 2002
(h) includes sample replicates and kick-net samples for diversity from fall 2005 sampling program



Legend

- North American Lease Boundary
- Regional Study Area
- Local Study Area
- Lake
- Stream
- Road
- Railroad
- Town
- Historic Sampling Site
- Project Sampling Site

Project Location

Title:

BENTHIC INVERTEBRATE SAMPLING SITES SOUTH OF FT. MC MURRAY (See Table 8A-5 For Detail)

NORTH AMERICAN OIL SANDS CORPORATION

Approved: DJ	Revision Date: May 22, 2007	
File: Benthic_Invertebrate_Sampling_Sites_South_Ft_Mac_20070522.mxd		
Drawn by: JC	Checked: LZ	Fig. No.: 8A-1

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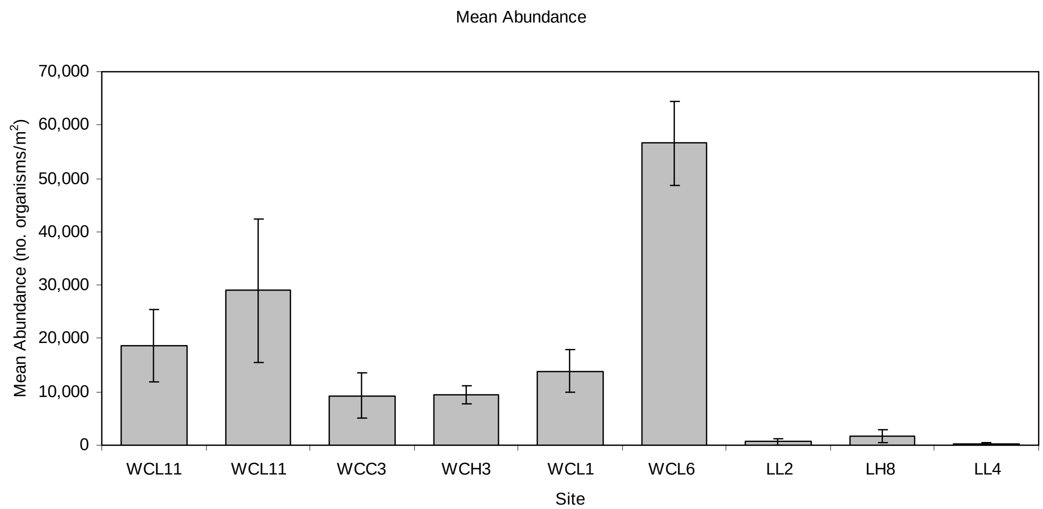
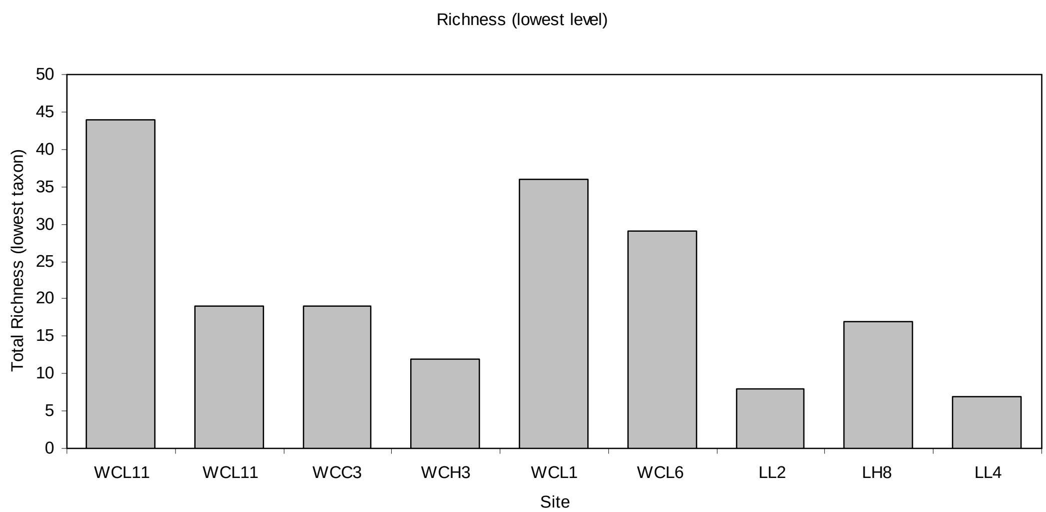
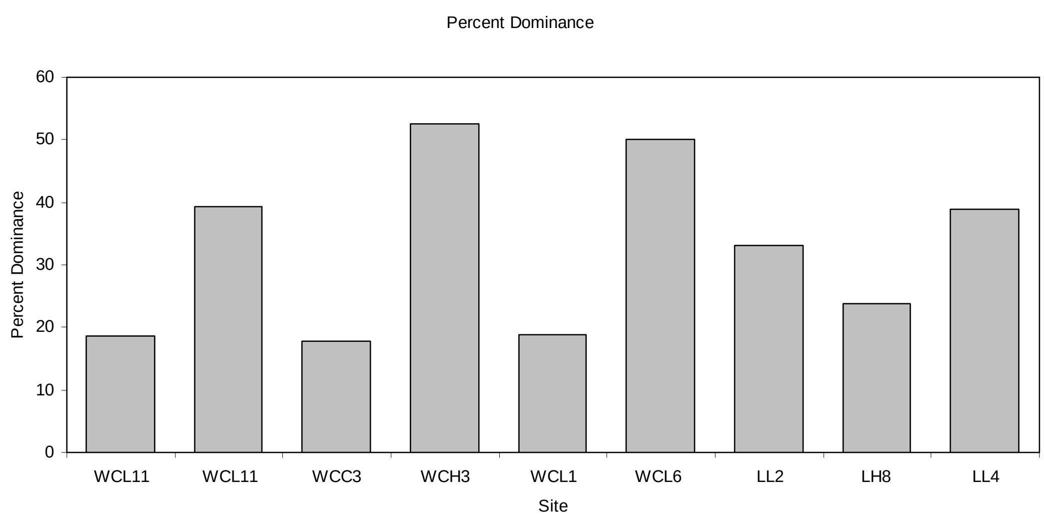






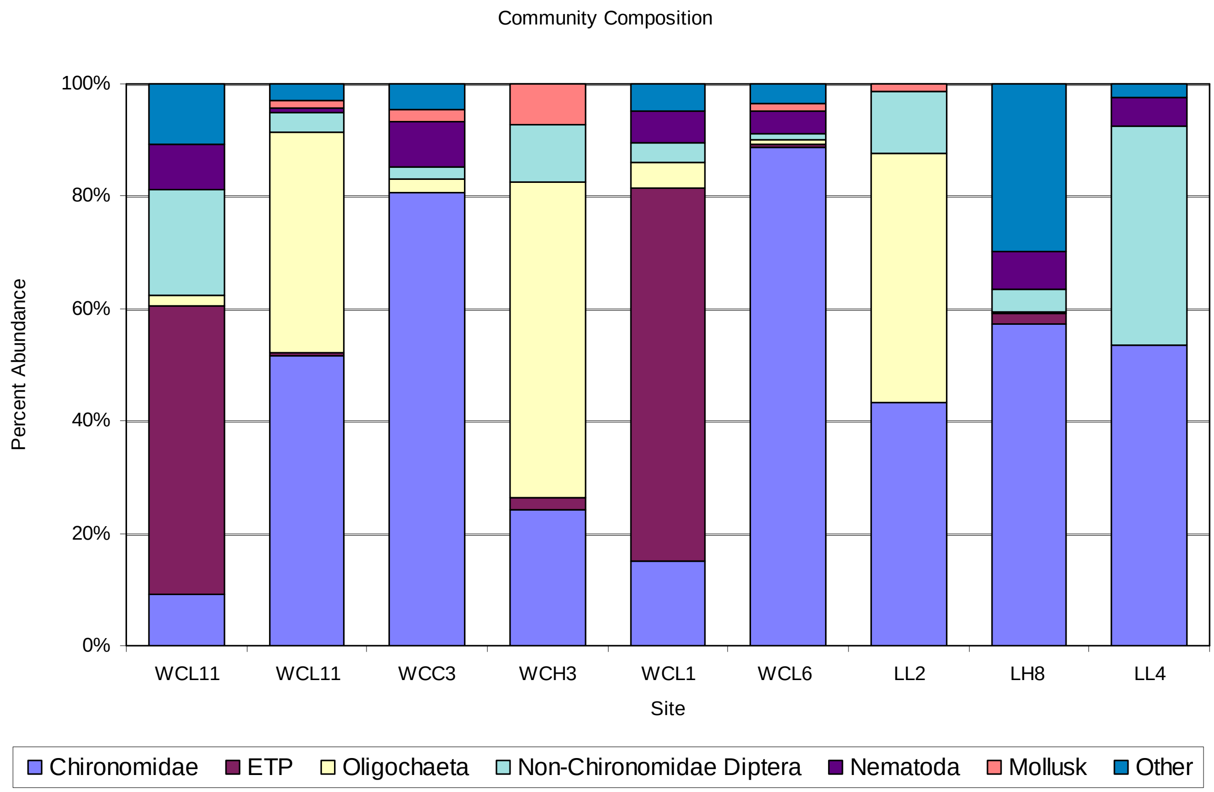
Title:

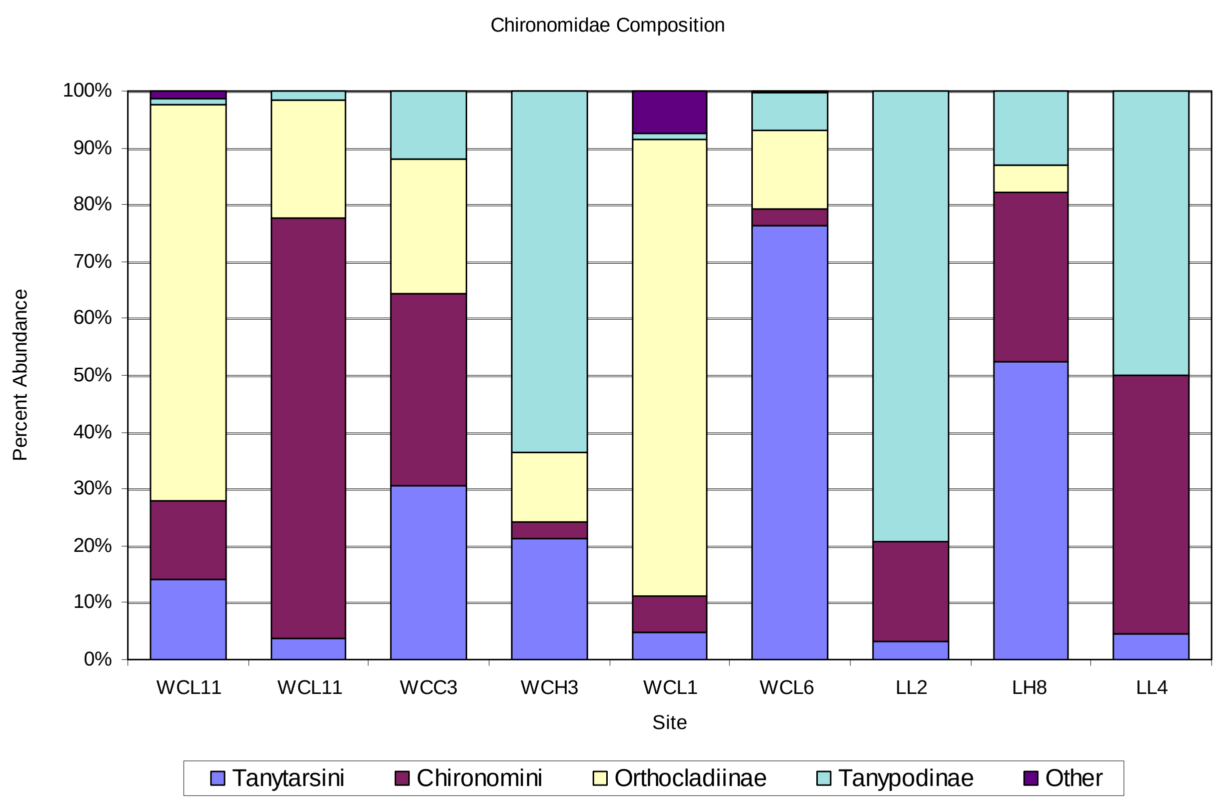
Mean Abundance, Total Richness and Percent Dominance of Benthic Invertebrates at Sampling Locations in the Local Study Area

NORTH AMERICAN OIL SANDS CORPORATION

Approved: **DJ**		Revision Date: **June 4, 2007**
File:		
Drawn by: **JC**	Checked: **LZ**	Fig. No.: **8A-2**

I:\4455-514_NAOSC\NAOSC_Maps\General Maps\June\Figure 8B 2 Mean Abundance, Total Richness and Percent Dominance of Benthic Invertebrates at Sampling Locations in the Local Study Area_20070604.mxd



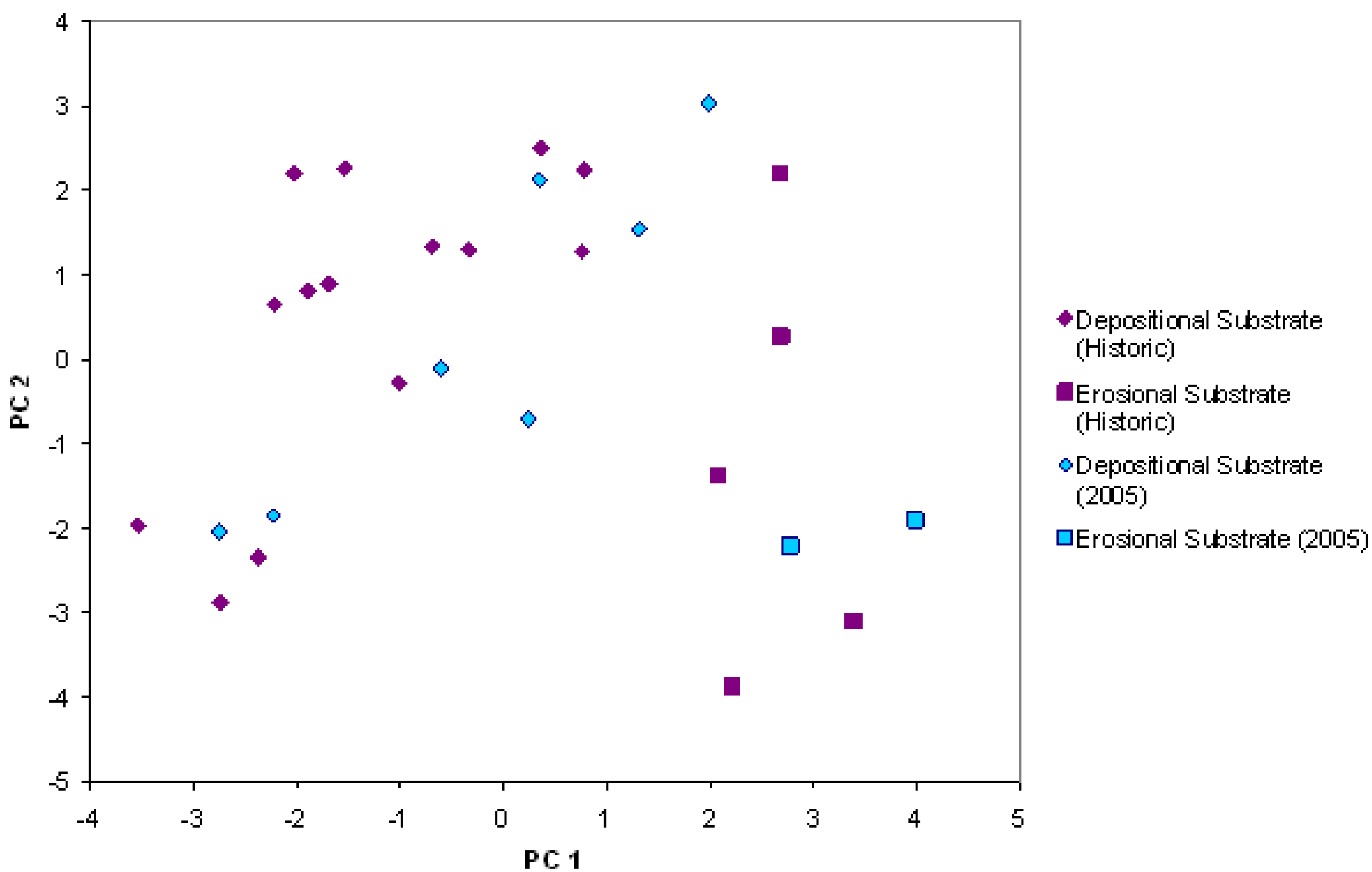


Title:

Benthic Invertebrate Community Composition and Chironomidae Composition at Sampling Sites in the Local Study Area

NORTH AMERICAN OIL SANDS CORPORATION

Approved:	Revision Date:	
DJ	**June 4, 2007**	
File:		
Drawn by: **JC**	Checked: **LZ**	Fig. No.: **8A-3**



Title: **Principal Component Analysis Showing Relationships among Benthic Invertebrate Communities from Depositional and Erosional Sites (includes data from historic samples)**	NORTH AMERICAN OIL SANDS CORPORATION	
	Approved: **DJ**	Revision Date: **June 6, 2007**
	File:	
	Drawn by: **JC**	Checked: **LZ**
	Fig. No.: **8A-4**	

I:\4455-514_NAOSC\NAOSC_Maps\General Maps\March\Figure 8A-4 Principal Component Analysis Showing Relationships among Benthic Invertebrate Communities from Depositional and Erosional Sites (includes data from historical project samples).mxd