AQUATIC ECOLOGY BASELINE REPORT
FOR THE
CANADIAN NATURAL
KIRBY IN SITU OIL SANDS EXPANSION PROJECT

Prepared for:
Canadian Natural Resources Limited

Prepared by:
Golder Associates Ltd.

December 2011 **10-1346-0052**

EXECUTIVE SUMMARY

Canadian Natural Resources Limited (Canadian Natural) is applying for approval of the Kirby In Situ Oil Sands Expansion Project (the Kirby Expansion Project or the Project). The submission contains the following:

- application to the Energy Resources Conservation Board (ERCB) under the *Oil Sands Conservation Act*;
- application to Alberta Environment and Water (AEW) under the *Environmental Protection and Enhancement Act* (EPEA); and
- application to AEW under the *Water Act.*

The above submissions are collectively referred to as the Application.

The Project is located in Townships 73, 74 and 75, Ranges 7, 8 and 9 West of the Fourth Meridian (W4M). The proposed development will include the use of in situ Steam Assisted Gravity Drainage (SAGD) well pairs and expansion phases of the two approved on-site steam generation and oil/water treatment plants.

The baseline conditions for aquatic ecology are characterized in detail in this report, which summarizes historical as well as current information for the watercourses and waterbodies within the aquatics Regional Study Area (RSA) and Local Study Area (LSA).

The RSA contains watercourses and waterbodies that provide high to moderate quality fish habitats, including spawning, nursery, rearing, feeding and overwintering habitats. Key fisheries resources include the Christina River, Winefred River, Sand River, Christina Lake, Winefred Lake and Lac la Biche. These resources support a variety of fish species, including sport, sucker and forage fish species.

The LSA contains Wiau Lake, Glover Lake and Edwards Lake and several small unnamed waterbodies. Watercourses within the LSA include Sunday Creek and Birch Creek and several small unnamed watercourses. These waterbodies and watercourses are located within the Christina River at Chard sub-basin, Winefred River sub-basin and Lac la Biche basin. Most of these watercourses and waterbodies have habitat limitations associated with small size, low flows, shallow depths and barriers to fish movements. Some have negligible fish habitat potential while others provide low to high habitat potential for small-bodied forage fish and low to moderate potential for a few large-bodied fish species, including suckers and northern pike.

A total of 26 fish species have been recorded in the RSA, including 9 sport fish species, 2 sucker species and 15 forage fish species. Most of these fish species occur in the Christina River, Winefred River, Christina Lake and Winefred Lake,

downstream of or adjacent to the LSA, or in Lac la Biche and Sand River located in the southwest and southeast of the RSA, respectively. Within the LSA, the fish communities are dominated by forage fish species, with smaller populations of white sucker also occurring in some of the watercourses and waterbodies. Sport fish occurrence within the LSA are limited to Sunday Creek, Birch Creek, Edwards Lake and Wiau Lake.

Aquatic resources in the LSA that provide exploitable fish populations of importance to sport fisheries are limited. Northern pike and yellow perch have been captured in Wiau Lake, while northern pike and lake whitefish have been captured in Glover Lake and Edwards Lake. Arctic grayling and northern pike have been captured in Sunday and Birch creeks. The potential for these populations to support a fishery is currently unknown.

In the portion of the RSA outside the LSA, key resources with exploitable fish populations include the mainstem of the Christina River, the mainstem of the Winefred River, Sand River, Christina Lake, Winefred Lake, Lac la Biche and their associated inlet and outlet watercourses, and Ipiatik Lake in the winter. Sport fishing lodges or camps operate on Christina and Winefred lakes that target species such as Arctic grayling, northern pike and walleye.

There is no potential for commercial fisheries in the LSA, and the potential for commercial fisheries in the RSA is limited to the larger waterbodies with most fisheries having been shut down in recent years. Lake whitefish, northern pike, white sucker and burbot are commercially caught in Ipiatik Lake in the Sand River sub-basin, which is located in the Cold Lake Air Weapons Range and access is restricted except for a few days of commercial fishing each winter.

In total, 13 potential watercourse crossings associated with the Project were examined to identify the type of watercourse channel present, if any, and to evaluate the fisheries habitat potential.

Benthic invertebrates were collected from watercourses and waterbodies within the LSA in summer 2011. Details of the benthic invertebrate survey will be provided as a supplement at submission, as the results of the survey are not yet available.

Aquatic ecosystem diversity was addressed as part of the baseline study through the assessment of the diversity of the fish communities and fish habitats present in the surveyed waterbodies and watercourses in the LSA. Fish and fish habitat diversity was assessed for the waterbody and watercourse sampling sites that were examined during the Project baseline study. The contribution of each waterbody or watercourse to fish and fish habitat diversity was categorized as very low, low, moderate or high based on the ranking they received in the evaluation of each of the species, habitat and ecosystem indicators. Wiau Lake

and its major tributary have been assessed as having moderate overall diversity. Edwards Lake, Glover Lake, Birch Creek and Sunday Creek have also been assessed as having moderate habitat potential. All remaining sites were assessed as having either low or very low overall diversity.

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Attachment B Habitat Maps for Waterbody and Watercourse Field Sampling Sites
Attachment C Fish Inventory Catch-Per-Unit Effort Results for Waterbody and Watercourse Field Sampling Sites

1 INTRODUCTION

Canadian Natural Resources Limited (Canadian Natural) is applying for approval of the Kirby In Situ Oil Sands Expansion Project (the Kirby Expansion Project or the Project). The applications to the Energy Resources Conservation Board (ERCB) under the Oil Sands Conservation Act, and Alberta Environment and Water (AEW) under Environmental Protection and Enhancement Act (EPEA) and Water Act as well as the Environmental Impact Assessment (EIA) are herein collectively referred to as the Application.

The proposed Project will involve bitumen production from oil sands formations within a Lease Area located in Townships 73, 74 and 75, Ranges 7, 8 and 9, West of the Fourth Meridian (W4M) and within the Regional Municipality of Wood Buffalo (RMWB). Minor portions of the proposed Project facilities will extend beyond the Lease Area boundary. The footprint includes water source and disposal wells and pipelines that extend west of the Lease Area into Lac La Biche County.

The Lease Area consists of 110.75 sections (29,143 ha) of land on which Canadian Natural fully or partially holds the oil sands exploration and development rights. To facilitate description of the expansion plans and facility locations, the Lease Area has been divided into two geographic areas, referred to as the North Expansion Area and the South Expansion Area, which are generally divided by Provincial Highway 881. The Project will be accessed via an all-weather gravel road which intersects with Highway 881, at a location approximately 35 km by road south of Conklin and 110 km by road northeast of Lac La Biche.

Canadian Natural currently has ERCB commercial scheme approvals for the following two projects:

- The Canadian Natural Kirby In Situ Oil Sands Project, hereafter referred to as Kirby South 2010 (or KS1) was approved in 2010 for bitumen production of 45,000 bbl/d (7,150 m^3/d) using Steam Assisted Gravity Drainage (SAGD) technology.

- The Enerplus Resources Fund (Enerplus) Kirby Oil Sands Project Phase 1, hereafter referred to as Kirby North 2010, was approved in 2010 for bitumen production of 10,000 bbl/d (1,590 m^3/d), also using SAGD technology. The Kirby North 2010 oil sands leases and nearby Enerplus oil sands leases were acquired by Canadian Natural in 2010.

The Kirby Expansion Project will occur in three phases, as described below:

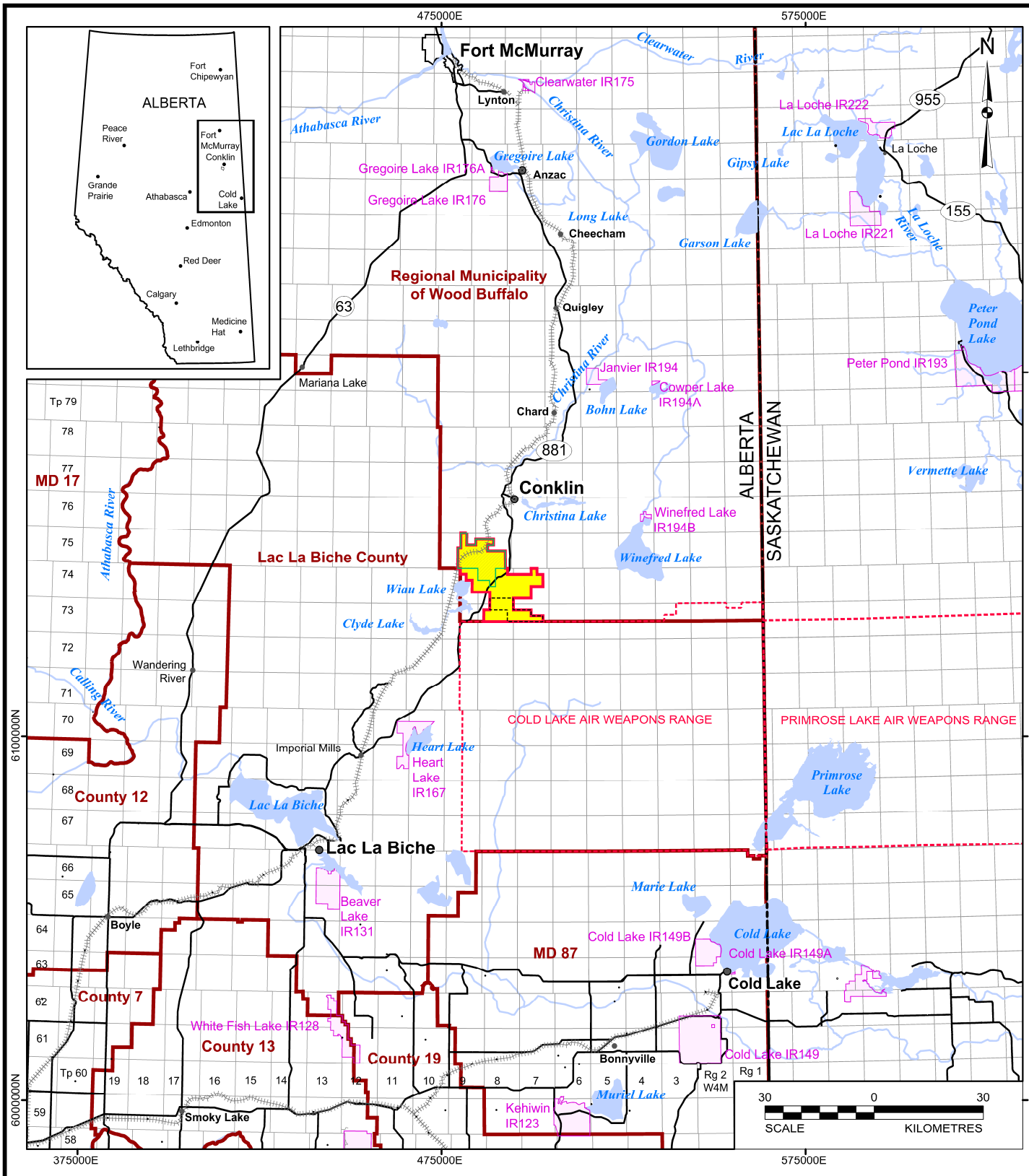
- Kirby North Phase 1 (KN1) will involve the expansion of the approved Kirby North Central Processing Facility (CPF) and development of facilities to increase bitumen production and processing capacity in the North Expansion Area from the approved 10,000 bbl/d (1,590 m^3/d) to 50,000 bbl/d (7,950 m^3/d);
- Kirby North Phase 2 (KN2) will further expand the Kirby North CPF, facilities, and bitumen production and processing capacity within the North Expansion Area from the 50,000 bbl/d (7,950 m^3/d) to 80,000 bbl/d (12,720 m^3/d).; and
- Kirby South Phase 2 (KS2) will involve expansion of the approved Kirby South CPF and development of facilities to allow an increase in South Expansion Area bitumen production and processing capacity by 15,000 bbl/d (2,384 m^3/d) from the approved 45,000 bbl/d (7,150 m^3/d) to a total of 60,000 bbl/d (9,540 m^3/d) bitumen.

As a result of the expansion, the Kirby North CPF will have a design capacity of 80,000 bbl/d (12,720 m^3/d) and the Kirby South CPF will have a design capacity of 60,000 bbl/d (9,540 m^3/d), for to a total bitumen production capacity within the Lease Area of 140,000 bbl/d (22,260 m^3/d). In addition, the Project will increase the combined life of Kirby lease developments from 20 years to approximately 30 years. The layout of surface facilities associated with the Project is shown on Figure 1.

The baseline studies for the two existing permitted areas were based on the available information up to year 2008 for the Approved Kirby North 2010 Project Area, and up to year 2006 for Approved Kirby South 2010 Project Area. New baseline studies within the Lease Area were completed in 2011.

1.1 STUDY OBJECTIVES

The main objectives of this baseline study were to characterize the aquatic ecology, as represented by fish and fish habitat, in waterbodies and watercourses in the Local Study Area (LSA), with emphasis on those in or near the Lease Area, and to provide the data and information necessary to support the assessment of any potential effects of the Project on fish and fish habitat.



LEGEND

- COLD LAKE / PRIMROSE LAKE AIR WEAPONS RANGE BOUNDARY
- RAILWAY
- ROAD
- KIRBY EXPANSION PROJECT LEASE AREA*
- APPROVED KIRBY SOUTH 2010 PROJECT AREA
- APPROVED KIRBY NORTH 2010 PROJECT AREA

Note

*Includes Oil Sands Leases fully and partially held by Canadian Natural

REFERENCE

ALBERTA NTDB DATA SUPPLIED BY GEOMATICS CANADA, AUGUST 2001. NAD 83 ZONE 12. SHEETS 74D, E AND 74L IN NAD 27 ZONE 12. SASKATCHEWAN NTDB DATA SUPPLIED BY ISC, AUG. 2001. NAD 83 ZONE 13. ALL DATA CONVERTED TO NAD 83 UTM ZONE 12.

PROJECT

KIRBY IN SITU OIL SANDS EXPANSION PROJECT

TITLE

PROJECT LOCATION

Canadian Natural

PROJECT	10.1346.0052.8700		FILE No.	10134600528750A001	
DESIGN	BB	17/11/11	SCALE	1:1,500,000	REV. 0
CADD	PSR	05/12/11			
CHECK	TGC	07/12/11			
REVIEW	SM	08/12/11			

FIGURE: 1

L:\2010\1346\10-1346-0052\Baseline\Fig 1_10134600523000A001 Project Location.dwg Dec 08, 2011 - 12:41pm

The characterization of fish and fish habitat included:

- descriptions and maps of habitat conditions in the waterbodies and watercourses in the Lease Area;
- descriptions of critical and sensitive habitat areas (i.e., spawning, rearing, overwintering);
- discussion of the suitability of the habitats in relation to the needs of the various life stages of fish species and benthic invertebrates;
- description of seasonal habitat use by fish populations;
- description of the fish communities, including species composition, distribution, relative abundance, movements and general life-history parameters;
- identification of species that are listed as having special status by a provincial or federal agency;
- description of the benthic invertebrate communities; and
- description of the current and potential use of the fish resources by aboriginal, sport or commercial fisheries.

1.2 APPROACH

As described in the Terms of Reference (AEW 2011), the scope of the aquatic ecology baseline report is focused on fish and fish habitat, describing the fish habitats, fish communities and benthic invertebrate communities in waterbodies and watercourses in or near the Lease Area on a regional and local scale (Table 1.2-1). Benthic invertebrates are included as an aspect of fish habitat as a key food source for fish. The baseline report incorporates relevant historical information obtained from the literature and the results of recent field investigations conducted between 2001 and 2008 to support previous applications within the Lease Area.

Existing fish and fish habitat information for the Project was reviewed and a gap analysis was conducted to determine if additional (or more current) information was needed to characterize fish and fish habitat in the waterbodies and watercourses in or near the Lease Area. Field studies were then conducted to collect data for waterbodies and watercourses potentially affected by the Project for which existing information was not available or was considered incomplete. The information from these sources was then summarized to describe fish and fish habitat in the waterbodies and watercourses in or near the Lease Area.

1.3 STUDY AREAS

Two study areas were established for the Project to evaluate aquatic resources (including fish and fish habitat) on a regional and local scale:

- the aquatics Regional Study Area (RSA); and
- the aquatics Local Study Area (LSA).

The two study areas were used to determine the level of detail of the baseline fish and fish habitat assessment, with literature information evaluated for the RSA, and information collected and evaluated in more detail for waterbodies and watercourses in the LSA.

1.3.1 Aquatics Regional Study Area

The aquatics RSA was established based on potential direct or indirect effects from the Project on flows and water levels in watersheds in which the Project is located, including surface water/groundwater interactions. This RSA also contains other projects and activities that are considered in the Baseline Case and Planned Development Case (PDC).

The aquatics RSA is shown in Figure 2 and includes the following three basins:

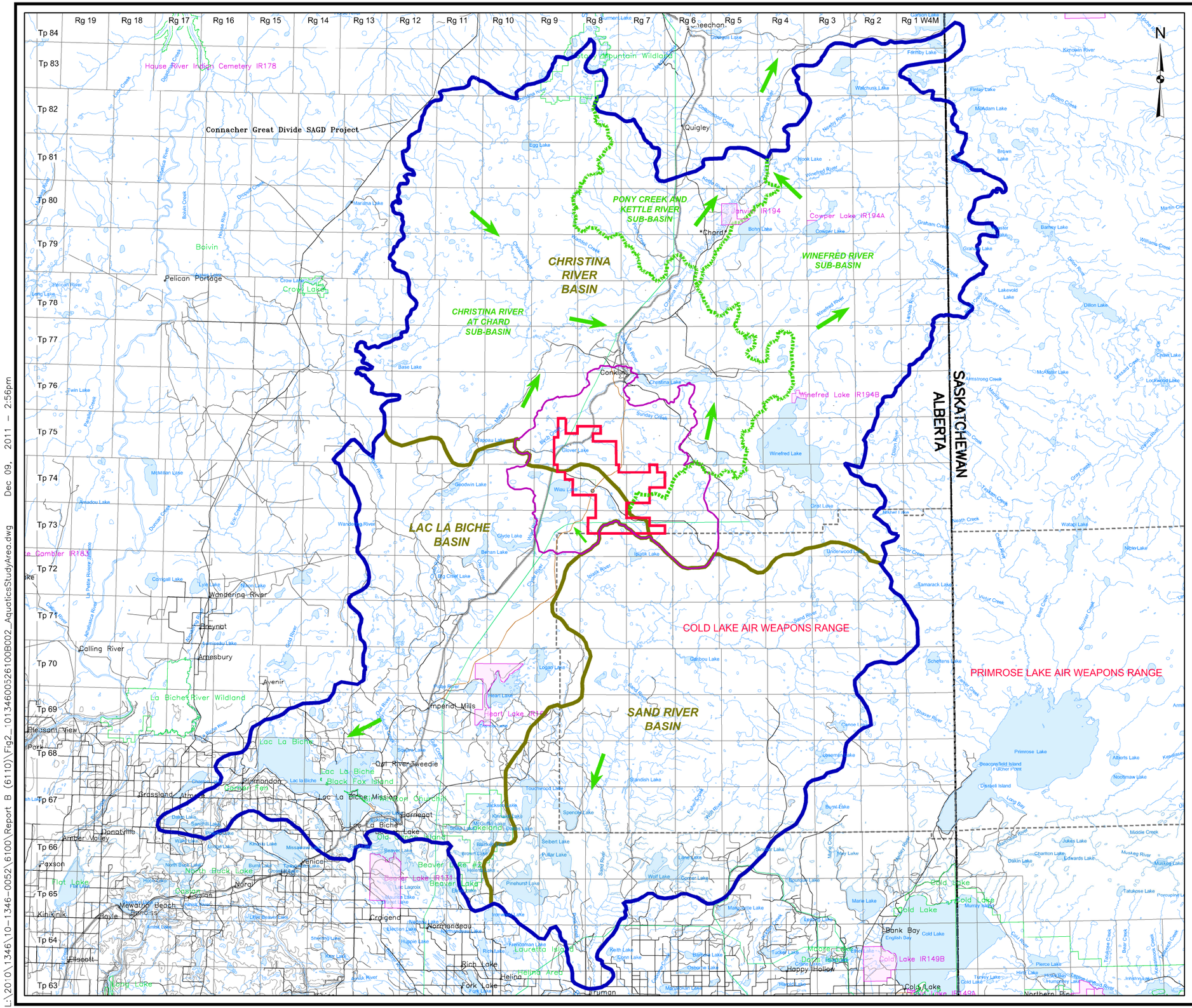
- Christina River basin (drainage area of 9,821 km^2 at the Winefred River confluence): The Christina River basin has been subdivided into three sub-basins:
  - The Christina River at Chard sub-basin with a drainage area of 4,784 km^2. This sub-basin was selected to correspond to the drainage measured at the Water Survey of Canada (WSC) Station 07CE002 such that an assessment of flow characteristics and drainage area can be made. The Christina River flows in a northerly direction to the Christina River at the north end of the RSA.
  - The Pony Creek and Kettle River sub-basin with a drainage area of 782 km^2. This sub-basin was selected to correspond to the drainage at the WSC Pony Creek Station 07CE003 (effective drainage area of 278 km^2 [27,800 ha]) that is representative of a smaller drainage area upstream of the Pony Creek confluence.
  - The Winefred River sub-basin with a drainage area of 4,255 km^2. This sub-basin drains to the north into the Christina River at the north end of the RSA.

- Lac la Biche basin (effective drainage area of 4,476 km^2): Lac la Biche drainage basin is about 17 times the size of the lake and is mostly located to the east and north of the lake. The major inflow is the Owl River and its tributaries: the Logan, Clyde and Piche rivers and Gull Creek. The outflow is the La Biche River, which eventually joins the Athabasca River in a northerly direction.
- Sand River basin (effective drainage area of 4,974 km^2 at the WSC Station 06AB001): Sand River basin consists of Ipiatik River, Caribou Lake, Wolf River and Punk Creek sub-basins.

The total area of the aquatics RSA is approximately 19,271 km^2 [1,927,118 ha]. Most of the RSA lies within Alberta, with 2% extending into Saskatchewan. The portion in Saskatchewan lies within the Winefred River watershed, as shown in Figure 2.

The Lease Area is at a watershed divide between the three basins described above. Portions of the Lease Area and of the disposal and source water pipelines that extend to the west and east respectively drain into the three basins.

The delineation of the RSA boundaries is based on the rationale listed in Table 1.



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LEGEND

- ROAD
- RAILWAY
- RIVER
- OPEN WATER
- AQUATICS REGIONAL STUDY AREA
- AQUATICS LOCAL STUDY AREA
- KIRBY EXPANSION PROJECT LEASE AREA*
- DRAINAGE BASIN AREA
- DRAINAGE SUB-BASIN AREA
- DIRECTION OF SURFACE DRAINAGE

Note

*Includes Oil Sands Leases fully and partially held by Canadian Natural

REFERENCE

ALBERTA DIGITAL DATA OBTAINED FROM ALTALIS LTD. (SEPTEMBER 2004). USED UNDER LICENSE. DATUM: NAD83 PROJECTION: UTM ZONE 12. ALBERTA NTDB DIGITAL DATA OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.

20 0 20

SCALE 1:800,000 KILOMETRES

PROJECT

Canadian Natural

KIRBY IN-SITU OIL SANDS EXPANSION PROJECT

TITLE

AQUATICS REGIONAL STUDY AREA

Golder Associates Calgary, Alberta

PROJECT	10.1346.0052.6600		FILE No.	10134600526600A002	
DESIGN	ERI	10/11/11	SCALE	AS SHOWN	REV. 0
CADD	TRE	08/12/11			
CHECK	ERI	08/12/11			
REVIEW	KC	08/12/11			

FIGURE: 2

Table 1 Regional Study Area Boundaries

Basin Name	Boundary		Rationale
Christina River	*North:*	Upstream of confluence with Cottonwood Creek	The downstream extent of aquatic resources assessment due to existing, approved and planned development that is expected to have a negligible effect (including any development within the Christina Lake and the Winefred River sub-basin).
	South:	Headwaters of Sunday and Birch creeks	Most of the proposed development is located at the Christina River headwaters (this boundary lies within Lease Area).
	East:	Drainage divide of the Christina and Beaver river basins	The full extent of Christina River drainage boundary at the east side.
	West:	Drainage divide of the Christina and Athabasca river basins	The full extent of Christina River drainage boundary at the west side.
Lac la Biche	*North:*	Wiau Lake tributaries, headwaters of the Clyde and Logan rivers	The Lease Area partly lies within headwaters of Wiau Lake.
	South:	Drainage divide of the Lac la Biche and Beaver river basins	The full extent of Lac la Biche drainage boundary at the south side.
	East:	Headwaters of Piche River	The full extent of Lac la Biche drainage boundary at the east side.
	West:	Mouth of La Biche River and outlet of Lac la Biche	Most downstream boundary of Lac la Biche watershed. Potential cumulative effect of the existing, approved and planned development within the entire Lac la Biche drainage basin can be captured within this boundary.
Sand River	*North:*	Headwaters of Ipiatik River	The Project footprint does not fall within the Sand River watershed, but the Ipiatik River has been included to monitor potential effects at its headwaters.
	South:	Downstream of the confluence of Punk Creek	Drainage boundary upstream of the Water Survey Canada Station 06AB001 site.
	East:	Headwaters' of Wolf River	Full extent of Sand River drainage boundary at the east side.
	West:	Sand River along the drainage divide of Lac la Biche basin	Drainage boundary with Lac la Biche watershed.

1.3.2 Local Study Area

In general, the LSA follows the boundaries of the natural watercourses (Birch Creek, Sunday Creek, Wiau River and an unnamed tributary to Winefred Lake) and natural waterbodies (Wiau Lake and Christina Lake), which may have direct or indirect effects due to the Project. The edges of the LSA are generally outside the Project boundaries (including the Lease Area, the disposal pipeline to the west, and the source water pipeline to the east). A small part of the southern end of the Project Lease Area is outside the LSA because there is no development planned in this area and it is in a different drainage sub-basin to Ipiatik Lake to

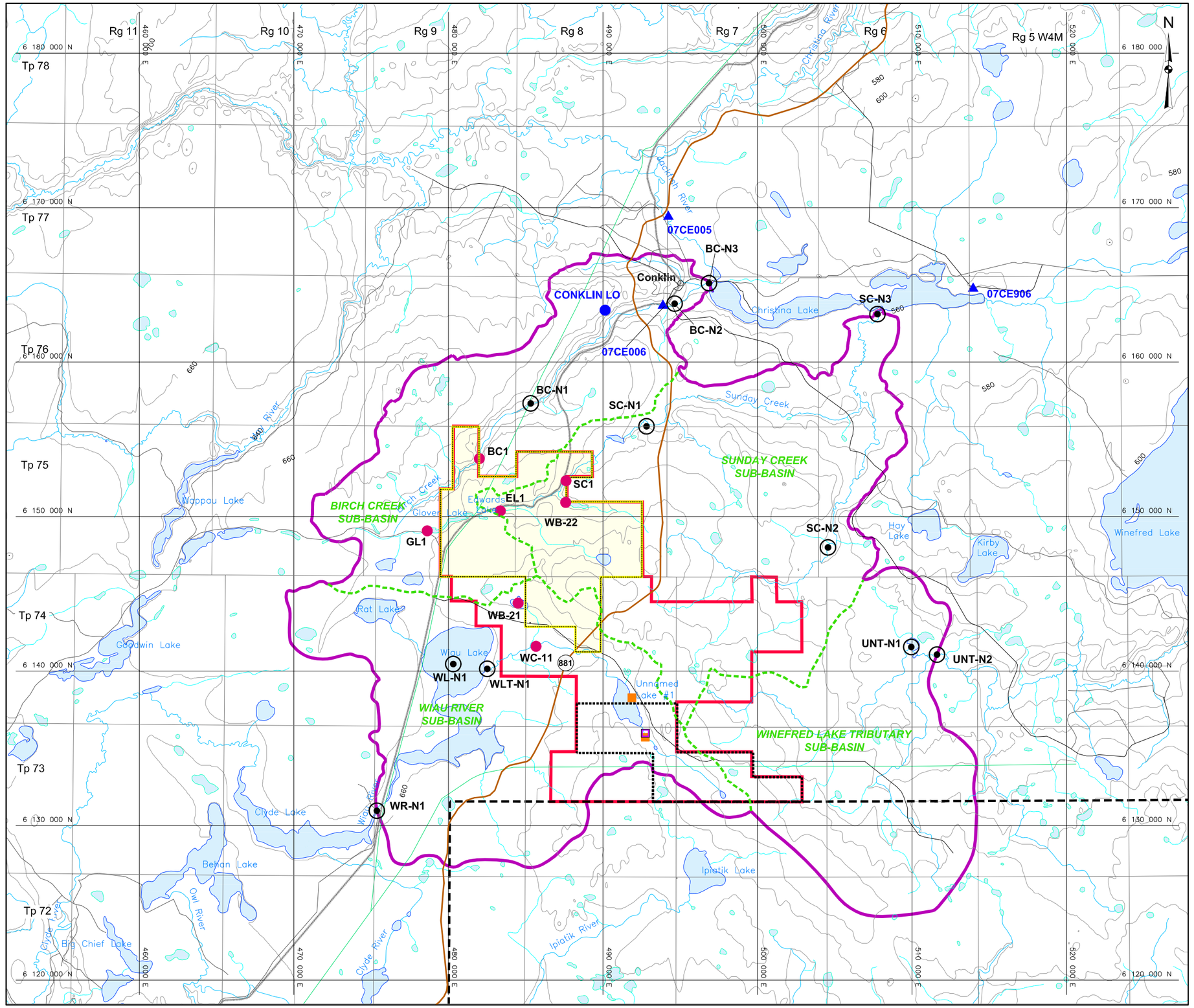
the south. The boundaries of the LSA including aquatic ecology survey locations for the Project are shown in Figure 3.

The delineation of the LSA boundaries is based on the rationale listed in Table 1. The LSA has a total area of 1,212 km^2 [121,193 ha] and consists of three sub-basins as shown in Figure 3.

- Christina River at Chard sub-basin: the main sub-basins located within the LSA are the Sunday Creek sub-basin (drainage area of 384 km^2) and the Birch Creek sub-basin (drainage area of 262 km^2 at the WSC Station site).
- Winefred River sub-basin: an unnamed tributary to Winefred Lake (drainage area of 250 km^2 at the inlet of the unnamed waterbody) is located in the LSA and drains into Winefred Lake. The Winefred River drains from Winefred Lake and drains into the larger Christina River.
- Lac la Biche sub-basin: the Wiau River sub-basin (drainage area of 317 km^2 at the Clyde Lake inlet) is located entirely within the LSA. Wiau River connects Wiau Lake to Clyde Lake that flows into the Clyde River, and eventually drains into the Owl River. The latter contributes flow to the larger Lac la Biche basin.

Sunday Creek, Birch Creek and Winefred Lake tributary sub-basins are located within the Christina River basin while the Wiau River sub-basin is located within the Lac la Biche basin.

The LSA is characterized by fairly undulating topographic relief which ranges in elevation from approximately 560 to 713 masl. The average ground elevation within the LSA is approximately 660 masl. The LSA also has several small unnamed waterbodies and watercourses many, of which are characterized by low flows and are impeded by debris or beaver dams.



LEGEND

- CONTOUR (20 m INTERVAL)
- ROAD
- RAILWAY
- RIVER
- OPEN WATER
- AQUATICS (HYDROLOGY) ASSESSMENT NODE
- LOOKOUT STATION
- TEMPORARY HYDROMETRIC STATION, 2008
- TEMPORARY HYDROMETRIC STATION, 2001, 2006, 2007
- TEMPORARY CLIMATE STATION, 2001, 2006 TO 2007
- WSC STATION
- AQUATICS LOCAL STUDY AREA
- APPROVED KIRBY SOUTH 2010 PROJECT AREA
- APPROVED KIRBY NORTH 2010 PROJECT AREA
- KIRBY EXPANSION PROJECT LEASE AREA*
- SUB-BASIN AREA

Node	Eastings NAD83 Z12	Northing NAD83 Z12
BC-N1	485325	6157330
BC-N2	494640	6163785
BC-N3	496865	6165110
SC-N1	492820	6155845
SC-N2	504565	6148010
SC-N3	507770	6163110
UNT-N1	509955	6141565
UNT-N2	511622	6141071
WLT-N1	482515	6140150
WL-N1	480315	6140460
WR-N1	475370	6130965

Note

*Includes Oil Sands Leases fully and partially held by Canadian Natural

REFERENCE

ALBERTA DIGITAL DATA OBTAINED FROM ALTALIS LTD. (SEPTEMBER 2004). USED UNDER LICENSE. DATUM: NAD83 PROJECTION: UTM ZONE 12. ALBERTA NTDB DIGITAL DATA OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.

5 0 5
SCALE KILOMETRES

PROJECT

Canadian Natural

KIRBY IN SITU OIL SANDS EXPANSION PROJECT

TITLE

AQUATICS LOCAL STUDY AREA

Golder Associates
Calgary, Alberta

PROJECT	10.1346.0052.6600		FILE No.	10134600526600A003
DESIGN	ERI	07/11/11	SCALE 1:250,000	REV. 0
CADD	IPG	24/11/11		
CHECK	ERI	09/12/11		
REVIEW	MZ	09/12/11		

FIGURE: 3

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2 METHODS

2.1 OVERVIEW

The aquatic ecology baseline study included a literature review of the available fish and fish habitat information for waterbodies and watercourses in the RSA and LSA, and field surveys of representative watercourses and waterbodies in and around the LSA where existing information was lacking. After the initial literature review was completed, a gap analysis of the available information for waterbodies and watercourses in the LSA was conducted to determine if the current information was sufficient with respect to spatial and seasonal coverage and to identify areas where additional information gathering was needed to address the requirements of the TOR (AEW 2011) were identified to support the Environmental Impact Assessment for the Project. Field investigations were then conducted in March and August/September 2011, to collect additional data to describe the current baseline conditions of fish habitat, fish communities and benthic invertebrate communities in the waterbodies and watercourses in the LSA that may be directly affected by the Project.

The habitat evaluation consisted of characterizing the habitat conditions in the relevant watercourses and waterbodies, and describing the potential suitability of these aquatic habitats for use by fish. Habitat suitability was evaluated based on the life history needs of the different fish species that are indigenous to aquatic resources in the LSA. The habitat components used to evaluate habitat conditions and their suitability for use by different fish life stages are shown in Table 2. Benthic invertebrates are a food source for fish and were also evaluated.

Table 2 Fish Life History Stages and Habitat Components

Life History Stage	Habitat Component
spawning adult	spawning habitat
fry (young-of-the-year)	nursery habitat
juvenile	rearing habitat
adult	feeding habitat
all stages	overwintering habitat
all stages	migration routes

The potential suitability of the available habitats for use by fish was determined by assessing habitat use potential, which evaluates how well the habitat can provide the physical environment indigenous fish species require throughout their

life history (Nelson and Paetz 1992; Scott and Crossman 1973). The potential suitability of available habitats is ranked as nil, low, moderate and high. These rankings are based on the following criteria:

- Nil:
  - dry and/or undefined channel.
  - no suitable habitat for overwintering (frozen to bottom, anoxic conditions).
  - water quality beyond threshold limits for species in region in all seasons.
  - no suitable habitat for spawning, or rearing.
  - not suitable for use as a migratory corridor.
- Low:
  - deep pools, evidence of groundwater seepage and suitable flows/depths for overwintering is limited.
  - water quality (dissolved oxygen/temperature) routinely at or near tolerance levels for species in the region.
  - size of substrate or macrophytes, flows or water depth suitable for spawning is limited.
  - water depths, flows, size of substrate, and instream or overhead cover suitable for rearing is limited.
  - presence of barriers to upstream movement such as low seasonal flow, beaver dams, waterfalls, and perched culverts present.
- Moderate:
  - deep pools, evidence of groundwater seepage for overwintering present but not abundant. Flow and depths suitable for overwintering.
  - water quality (dissolved oxygen/temperature) infrequently near tolerance levels for species in region under some conditions.
  - substrate or macrophytes suitable for spawning present but not abundant. Flows or water depth suitable for spawning.
  - size of substrate and instream or overhead cover suitable for rearing present, but not abundant. Flow and depths suitable for rearing.
  - flows, water depth, and instream or overhead cover suitable for adult holding or feeding.

  - barriers to upstream movement such as seasonal flow, beaver dams, waterfalls, and perched culverts more than 5 km from the survey location.

- High:
  - deep pools, evidence of groundwater seepage for overwintering abundant. Flow and depths suitable for overwintering.
  - no water quality limitations for species in the region.
  - size of substrate or macrophytes suitable for spawning abundant. Flows or water depth suitable for spawning.
  - size of substrate and instream or overhead cover suitable for rearing abundant. Flows and depths suitable for rearing.
  - flows, water depth, and instream or overhead cover suitable for adult holding or feeding.
  - no barriers to upstream movement such as seasonal flow, beaver dams, waterfalls, and perched culverts.

Habitat use potential is not necessarily based on whether a particular fish species or life stage was found using the habitat during baseline sampling, but on how well that habitat would potentially meet the requirements of the species or life stage. At times, this evaluation is conducted for fish guilds, which are groupings of fish species based on similar characteristics or habitat requirements. This evaluation includes three guilds:

- sport fish – large-bodied fish species targeted by subsistence and sport fisherman;
- non-sport fish – large-bodied sucker species; and
- forage fish – small-bodied species that provide food for larger fish.

2.2 FISH HABITAT AND FISH COMMUNITIES

2.2.1 Literature Review

Available literature information for the RSA and LSA was reviewed to establish and compile existing fish and fish habitat information. The following sources were accessed:

- baseline data collected to support regulatory applications for other industrial applications within the RSA and LSA, including the data from the previous Kirby North 2010 and Kirby South 2010 projects;
- fish catch data reported in the Fisheries and Wildlife Management Information System (FWMIS) database;
- published reports; and
- government resource agency reports, such as Alberta Sustainable Resource Development (ASRD) and Alberta Environment and Water (AEW).

2.2.2 Field Surveys

2.2.2.1 Field Sampling Timing and Locations

Field surveys were conducted to assess habitat conditions and the seasonal use of waterbodies and watercourses by fish species and their various life stages. Data were collected during winter and summer in 2011 from selected sampling sites within and around the LSA (Table 3).

Eleven sampling locations were selected for evaluation, representing the various watercourses and waterbodies located in or near the Lease Area (Figure 3). Historical sampling sites are also shown in Figure 3. Sampling sites were located on Wiau Lake, four unnamed waterbodies and six unnamed watercourses. Universal Transverse Mercator (UTM) grid coordinates and the watershed locations for the field sampling sites are listed in Table 4.

Table 3 Seasonal Surveys and Sampling Dates for Aquatic Ecology Baseline Field Studies

Season	Survey	Dates	Sites Sampled	Field Studies
winter	fish inventory and fish habitat surveys	March 7, 2011	WLT-1, WLT-2	examined potential for waterbodies and watercourses to provide overwintering habitat for fish, and documented fish species presence in waterbodies and watercourses
		March 8 2011	SCT-1, SCT-2, SCT-3, UNT-1	
		March 9, 2011	WL-1, WB-1, WB-2	
summer	fish inventory, fish habitat and benthic invertebrate surveys	August 30, 2011 to September 13 2011	WLT-1, WLT-2, SCT-1, SCT-2, SCT-3, UNT-1, WL-1, WB-1, WB-2,WB-3, WB-4	conducted fish habitat assessment and fish sampling in waterbodies and watercourses to document fish habitat diversity and fish species presence in waterbodies and watercourses

Table 4 Details of Sampling Locations for the Baseline Field Studies

Watercourse or Waterbody	Sampling Site[a]	UTM Coordinates (NAD 83)[b]						Length of Surveyed Section [m]
		Sampling Point[c]		Sampling Section				
		Easting	Northing	Upstream Boundary		Downstream Boundary		
				Easting	Northing	Easting	Northing	
Wiau Lake	WL-1	480783	6140433	-	-	-	-	-
Unnamed waterbody	WB-1	490074	6147002	-	-	-	-	-
Unnamed waterbody	WB-2	499589	6141197	-	-	-	-	-
Unnamed waterbody	WB-3	495713	6140043	-	-	-	-	-
Unnamed waterbody	WB-4	496441	6139203	-	-	-	-	-
Unnamed watercourse	WLT-1	-	-	486240	6136265	486224	6136256	200
Unnamed watercourse	WLT-2	-	-	485306	6134412	485136	6134390	250
Unnamed watercourse	SCT-1	-	-	501735	6145494	501898	6145551	200
Unnamed watercourse	SCT-2	-	-	502527	6142830	502523	6142925	100
Unnamed watercourse	SCT-3	-	-	497349	6141978	497393	6142089	120
Unnamed watercourse	UNT-1	-	-	502891	6136434	502964	6136323	205

[a] Sampling site locations are shown in Figure 3.

[b] Universal Transverse Mercator (UTM) coordinates - North American Datum 1983.

[c] Waterbodies surveyed in their entirety - UTM coordinates for either centre of the waterbody or sampling location.

- = Not applicable.

The waterbodies that were included in the study were examined in their entirety, with the exception of Wiau Lake for which field surveys were restricted to a localized area. Watercourses were examined at selected locations considered to be representative of conditions within the watercourse. Field data from the surveyed sites provided current baseline information on habitat potential and fish community composition. This information was used to infer typical habitat conditions and fish use within each waterbody or watercourse, and to provide an indication of conditions in other similar waterbodies and watercourses in the LSA that were not sampled.

2.2.2.2 Summary of Field Sampling Methods

Various field sampling techniques were used to assess fish and fish habitat for the selected waterbodies and watercourses. The seasonal sampling activities that were conducted at each of the selected field sampling sites are outlined in Table 5.

Table 5 Summary of Baseline Field Sampling Activities

Description	Waterbody or Watercourse Name	Site ID	OW	H	D	WQ	F	BI
Waterbody	Wiau Lake	WL-1	▲	▲	n/a	▲	▲	▲
	Unnamed Waterbody	WB-1	▲	▲	n/a	▲	▲	▲
	Unnamed Waterbody	WB-2	▲	▲	n/a	▲	▲	▲
	Unnamed Waterbody	WB-3	-	▲	n/a	▲	▲	-
	Unnamed Waterbody	WB-4	-	▲	n/a	▲	▲	-
Watercourse	Unnamed Watercourse	WLT-1	▲	▲	▲	▲	▲	▲
	Unnamed Watercourse	WLT-2	▲	▲	▲	▲	▲	▲
	Unnamed Watercourse	SCT-1	▲	▲	▲	▲	▲	▲
	Unnamed Watercourse	SCT-2	▲	▲	▲	▲	▲	▲
	Unnamed Watercourse	SCT-3	▲	▲	▲	▲	▲	▲
	Unnamed Watercourse	UNT-1	▲	▲	▲	▲	▲	▲

n/a = Not applicable.

Notes: Triangle (▲) indicates sampling activity completed. Dash (-) indicates sampling activity not completed.

Field Sampling Activities:

OW - Overwintering Assessment.

H - Habitat Mapping and Channel Dimensions (watercourse) or Bathymetry (waterbody).

D - Discharge Measurement (watercourses only).

WQ - Water Quality Field Parameters: Surface (watercourse) or Profile (waterbody).

F - Fish Inventory.

BI - Benthic Invertebrate Sampling.

In general, the seasonal baseline field assessment of waterbody sites included the following:

- investigation of under-ice habitat and overwintering potential;
- habitat mapping of the waterbody basin and shoreline characteristics (including distribution of aquatic macrophytes);
- determination of maximum water depth;
- description of riparian vegetation;
- examination of inlet and outlet channels to evaluate fish passage potential;
- measurement of water quality field parameters (pH [±0.1], conductivity [±1µS/cm], temperature [±0.1°C] and dissolved oxygen [±0.1 mg/L]) along a vertical profile or series of profiles at various depths;
- fish inventory to determine the fish species present;
- benthic invertebrate community survey at selected waterbodies; and
- photographs documenting available habitat types and general basin morphology.

In general, the seasonal baseline field assessments for watercourses included:

- investigation of under-ice habitat and overwintering potential;
- habitat mapping of all relevant instream and bank habitat characteristics to provide an inventory of available spawning, rearing, feeding and overwintering habitats;
- description of riparian vegetation;
- measurement of average channel dimensions;
- identification of features that may affect fish movements;
- measurement of stream discharge to help evaluate habitat use potential and fish migration potential;
- measurement of water quality field parameters (pH (±0.1), conductivity [±1µS/cm], temperature [±0.1˚C] and dissolved oxygen [±0.1 mg/L]);
- fish inventory to determine the fish species present;
- benthic invertebrate community survey at selected sites; and
- photographs documenting available habitat types and general stream morphology.

Details of the various field sampling activities are provided below for habitat evaluation and fish sampling techniques.

2.2.2.3 Habitat Evaluation

Habitat Mapping

Detailed habitat maps were generated for each waterbody except Wiau Lake. Detailed habitat surveys were completed for watercourses. The habitat evaluation methods used for waterbodies and watercourses are detailed below.

Waterbodies

Waterbodies were mapped during the summer field visit. Maximum depth was determined using sounding equipment (i.e., sounding line or sonar, depending on the size and depth of the waterbody). Habitat maps were developed to show the location and extent of other habitat features such as shoreline characteristics and the distribution of aquatic vegetation.

The recorded physical characteristics of each waterbody included:

- water depths;
- distribution of aquatic macrophytes (submergent, emergent and floating-leaved vegetation);
- substrate composition;
- shoreline slope and stability; and
- riparian vegetation.

Waterbody habitat maps were completed for the four unnamed waterbodies that are located in the LSA. Bathymetry surveys were completed at each of the waterbodies.

The habitat use potential for the waterbodies was evaluated, in part, based on the characteristics of the available habitats. The proportions of the available habitat types and depths (e.g., littoral and pelagic zones), combined with information on water quality parameters, substrate material, vegetation distribution and shoreline development, provides an indication of the potential suitability of the habitats for use by fish in the waterbody relative to the habitat requirements of different fish species and life stages.

Watercourses

Watercourse sites were surveyed during the summer field program by measuring habitat parameters and taking photographs to document representative habitats found at each site. Habitat parameters including the extent of all instream habitat types and bank characteristics of the watercourse were identified to provide an inventory of available habitats. The length of the watercourse at each site was divided into a continuous series of habitat types, termed channel units. A channel unit is a distinct section of the channel with specific characteristics of water depth, velocity and cover for fish. Typical channel units include riffle, pool, run and flat habitats. Pool and run channel units were further classified as Class 1, 2 or 3 habitats, depending on their depth and available cover for fish, with Class 1 habitats being the deepest (i.e., more than 1.0 m), Class 2 being moderately deep (i.e., 0.75 to 1.0 m), and Class 3 being shallow (i.e., less than 0.75 m).

The recorded physical characteristics of each channel unit included:

- channel unit type and class;
- maximum water depth;
- channel dimensions, including mean channel width and wetted width;
- dominant substrate particle size or sizes (visually estimated according to the size criteria presented in Attachment A);
- aquatic vegetation;
- debris piles (small and large woody debris);
- cover for fish, including both instream (velocity shelter) and overhead (visual isolation) cover;
- beaver dams and other features that might impede fish movements;
- bank and shoreline 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 and channel characteristics.

The habitat use potential for the sampling sites was evaluated relative to the habitat requirements of the different fish species and life stages (i.e., spawning, nursery, rearing, feeding, overwintering) based on the types and proportions of

the available channel units, combined with general water depths and information on substrate material.

Discharge Measurements

Stream discharge was measured at watercourse sampling sites during seasonal sampling activities. A calibrated tagline was used to determine horizontal stations, and a water velocity meter and top setting-wading rod were used to measure water depth and velocity. The station distance, depth and velocity data were used to calculate the total stream discharge.

Water Quality Field Parameters

Basic water quality field parameters (i.e., water temperature, dissolved oxygen, pH and conductivity) were measured at sampling sites during seasonal sampling activities. In waterbodies, water quality parameters were measured at one or more locations along vertical profiles, including one at the point of maximum depth. Profiles were measured using a field-calibrated water quality multi-parameter meter (e.g., YSI Model 556 multi-meter equipped with a 30-m cable).

In watercourses, water quality parameters were measured mid-stream at approximately 0.2 m below the surface using a field-calibrated water quality multi-parameter meter.

Overwintering Assessment

The overwintering assessment evaluated the potential for waterbodies and watercourses to provide habitat for fish throughout the winter season. The assessment was done during the late-winter period (i.e., March) to represent the most severe conditions to determine if fish could survive the entire winter in these habitats. The evaluation of overwintering potential was largely based on late-winter conditions for available under-ice water depth and dissolved oxygen level.

The winter field assessment of waterbody sampling sites included the following:

- measurement of snow thickness, ice thickness and under-ice water depth;
- measurement of water quality field parameter profiles (water temperature, dissolved oxygen, pH and conductivity);

- fish inventory to determine fish presence (Section 2.2.2.4); and
- underwater video documenting habitat conditions and fish presence (Section 2.2.2.4).

The winter field assessment of watercourse sampling sites included the following:

- type and class of channel unit present at the sampling site;
- measurement of snow thickness, 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 at selected sites;
- measurement of water quality field parameters (water temperature, dissolved oxygen, pH and conductivity);
- fish inventory to determine fish presence (Section 2.2.2.4); and
- underwater video documenting habitat conditions and fish presence (Section 2.2.2.4).

The winter fish inventory was conducted at selected sites using minnow trapping and underwater video (Section 2.2.2.4). In waterbodies, several holes were drilled through the ice to determine general under-ice water depths and to locate the area of greatest depth. In watercourses, several holes were drilled in channel units that appeared to be pools, deep runs, or impoundments to locate deep water areas.

Watercourse Crossing Assessment

Watercourse crossing assessments were conducted at 13 sites where proposed rights-of-way (ROW) intersected watercourses. These crossings include proposed ROW roads, above-ground pipelines, below-ground pipelines and power lines. At each crossing location, physical stream characteristics and biological habitat conditions were measured to support the data requirements necessary for required regulatory submissions. The results of this work are presented in the Watercourse Crossing Assessment Summary provided on CD with this Application.

2.2.2.4 Fish Inventory

Fish Sampling

Fish sampling was conducted at each waterbody and watercourse sampling site to determine the fish species present. A variety of sampling techniques was used to determine the species and their various life stages present at each site dependant on the habitat conditions present at the time of the survey.

Fish sampling techniques employed during field investigations included:

- backpack electrofishing in wadeable areas;
- baited minnow traps;
- gill-netting; and
- underwater video.

Winter

Winter fish sampling was conducted at waterbody and watercourse sites as conditions permitted using underwater video and minnow trapping. Standard Gee minnow traps (baited) were set at selected sites with sufficient water depths (generally 0.4 m or more). Where visibility and conditions permitted, an underwater camera was also used at some sampling sites to look for the presence of fish. The video was obtained using an underwater video camera equipped with infra-red lighting. The winter fish sampling effort is summarized in Table 6.

Table 6 Summary of Baseline Winter Sampling Methods and Effort

Site ID	Minnow Trapping			Underwater Video [minutes]	Comments
	Number of Traps	Duration of Trap Set [hr]	Total Effort [trap-hr]		
WL-1	3	22.06	66.18	35	-
WB-1	3	21.11	63.33	70	-
WB-2	3	18.42	55.25	30	-
WB-3	-	-	-	-	not sampled
WB-4	-	-	-	-	not sampled
WLT-1	n/a	n/a	n/a	n/a	frozen to bottom
WLT-2	-	-	-	-	insufficient depth for minnow traps
SCT-1	-	-	-	-	insufficient depth for minnow traps
SCT-2	-	-	-	-	insufficient depth for minnow traps
SCT-3	2	19.45	38.9	-	-
UNT-1	-	-	-	-	insufficient depth for minnow traps

n/a = Indicates sampling could not be conducted because watercourse was completely frozen.

- = Indicates no sampling conducted.

Open-Water Seasons

Waterbodies were sampled using large multi-panel gill nets, with the exception of unnamed waterbody 1 (WB-1) where abundant aquatic macrophyte growth precluded a gill net to be effectively set. The number and dimensions of gill nets used during sampling are provided in Table 7. Minnow trapping was used at all waterbody and watercourse sites (Table 8).

Electrofishing was conducted for the seasonal surveys during the open-water period (Table 8). Backpack electrofishing was conducted at watercourse sampling sites using a Smith-Root LR-24 backpack unit.

Table 7 Seasonal Open-Water Gill-Netting Effort for Waterbodies, 2011

Site ID	Season	Number of Gill Nets	Duration of Gill Net Set [hr]	Number of Panels	Panel Size [m]	Mesh Size per Panel [cm - stretch measure]	Total Gill Net Effort [panel-hr]
WL-1	summer	1	1.33	8	7.6 x 1.8	2.5, 3.8, 5.1, 6.4, 7.6, 10.2, 12.7, 15.2	10.67
WB-1	summer	-	-	-	-	-	-
WB-2	summer	1	4.33	8	7.6 x 1.8	2.5, 3.8, 5.1, 6.4, 7.6, 10.2, 12.7, 15.2	34.67
WB-3	summer	1	3.08	8	7.6 x 1.8	2.5, 3.8, 5.1, 6.4, 7.6, 10.2, 12.7, 15.2	24.67
WB-4	summer	1	3.08	8	7.6 x 1.8	2.5, 3.8, 5.1, 6.4, 7.6, 10.2, 12.7, 15.2	24.67

- = Indicates no sampling conducted.

Table 8 Seasonal Open-Water Minnow Trapping and Electrofishing Effort for Waterbodies and Watercourses, 2011

Site ID	Season	Minnow Trapping			Electrofishing
		Number of Traps	Duration of Trap Set [hr]	Total Effort [trap-hr]	Backpack Effort [s]
WL-1	summer	4	167.5	670	-
WB-1	summer	4	9.55	38.2	-
WB-2	summer	4	13.75	55	-
WB-3	summer	4	9	36	-
WB-4	summer	4	10.83	43.33	-
WLT-1	summer	4	16.62	62.47	-
WLT-2	summer	4	37.17	148.67	1,221
SCT-1	summer	4	6.25	25	411
SCT-2	summer	4	33.42	133.67	562
SCT-3	summer	4	51.58	206.33	505
UNT-1	summer	4	9.42	37.67	696

- = Indicates no sampling conducted.

Note: Some numbers are rounded for presentation purposes.

Captured fish were identified and enumerated by species. Large-bodied fish were also identified to life stage (i.e., fry, juvenile or adult). Fork length (mm) and body weight (g) were measured for all large-bodied species and for a

representative subsample of individuals for forage fish species. If discernable from external examination, sex and state-of-maturity of captured fish were also recorded.

Spawning Surveys

Spawning surveys were not conducted in the LSA as existing information from other streams and waterbodies in the LSA was deemed sufficient to characterize spawning habitats.

2.2.2.5 Data Analysis

Fish habitat and fish community data collected during baseline sampling were entered into a Microsoft Access database. Data files were checked and verified against original field data to confirm the accuracy of data entry.

Catch-Per-Unit-Effort

The relative abundance of fish species at each sampling site was determined by calculating catch-per-unit-effort (CPUE) for each species and for each of the sampling techniques used in the field investigations.

Sampling effort for electrofishing was recorded as duration (seconds) of active electrofishing. All electrofishers were equipped with timers that recorded the number of seconds during which electrical current was applied to the water. The CPUE for electrofishing was calculated as the number of fish captured per 100 seconds of effort. Effort for minnow trapping and gill netting was recorded as number of standard-sized traps or panels set multiplied by the duration (hours) of set, and the CPUE was calculated as the number of fish captured per panel-hour or per trap-hour.

2.3 BENTHIC INVERTEBRATE COMMUNITIES

2.3.1 Literature Review

Historical information for the RSA and LSA was reviewed to compile existing benthic invertebrate community information. The following data sources were used:

- government resource agencies such as ASRD and AEW;

- environmental departments of various private industries such as oil and gas development in the area;
- environmental research conducted by multi-stakeholder groups created to study or monitor environmental conditions in the Oil Sands Region, such as the Regional Aquatics Monitoring Program (RAMP) and the Cumulative Environmental Management Association (CEMA); and
- published and unpublished environmental research conducted by consultants working for industry.

2.3.2 Field Surveys

A baseline field program was completed to characterize the benthic invertebrate community in waterbodies and watercourses within the LSA. Benthic invertebrates were sampled at nine sites in September 2011 (Table 5).

Five samples were collected at waterbody sites and depositional watercourse sites with an Ekman grab. Samples were screened in the field using a 250 µm mesh sieve and preserved immediately in 10% buffered formalin.

The following supporting information was collected at each site:

- exact site location (using a global positioning system unit);
- field water quality parameters, including pH, conductivity, dissolved oxygen, water temperature and turbidity (field-calibrated water quality meter);
- aquatic macrophyte and algal cover (visual assessment);
- water depth (m); and
- current velocity (velocity meter, in watercourses only).

2.3.3 Laboratory Analysis

Benthic invertebrate samples were shipped to J. Zloty, Ph.D., of Summerland, British Columbia (independent consultant) for sorting and taxonomic identification. Samples of benthic invertebrates were sorted and identified following standard methods based on recommendations of AEW (AENV 1990), Gibbons et al. (1993) and Environment Canada (2002).

Samples were initially elutriated to remove sand and gravel. All organisms were removed from the inorganic material, which was then discarded. The remaining

organic material was separated into coarse and fine size fractions using nested 1 mm and 250 µm mesh sieves. Invertebrates were removed from the detritus under a dissecting microscope at 6 to 10X magnification. The entire coarse fractions were sorted. Fine fractions of large samples were subsampled using the device described by Wrona et al. (1982). All remaining material was preserved for random checks of sorting efficiency. Quality control procedures included re-sorting two randomly selected samples to evaluate sorting efficiency.

Invertebrates were identified to the levels recommended by Environment Canada (1998), typically genus for most invertebrates. Exceptions included Oligochaeta, which were identified to family, and Nematoda, zooplankton and ostracods, harpacticoid copepods and Hydracarina, which were identified to major taxon. Damaged organisms and early instar insects were identified to the lowest level possible, generally to family. Identifications were made using recognized keys (Brinkhurst 1986; Clifford 1991; Epler 2001; Merritt and Cummins 1996; Pennak 1989; Stewart and Stark 1988; Wiederholm 1983).

2.3.4 Data Analysis

Benthic invertebrate taxa and abundances were tabulated for all samples and sites. Terrestrial and non-benthic invertebrates were excluded from the data summary. Counts of individuals (numbers per sample) were converted to density (numbers per square metre, or no/m^2) using the sampling area of the respective sampling devices. Benthic community summary variables were calculated for each site, including mean total density (no/m²), richness (total and mean number of taxa per site), Simpson's diversity index, evenness index and dominance (percentage of dominant taxon). Community composition was summarized as relative density (percent of total density) at the level of major taxon.

For interpretation purposes, taxa were considered dominant if they accounted for 5% or more of total invertebrate density, common taxa were identified as those accounting for 1% or more of total invertebrate density, and benthic invertebrate densities and richness values were categorized as follows:

- Low: density less than 5,000 organisms/m², richness less than 10 taxa/site;
- Moderate: density ranging from 5,000 to 50,000 organisms/m², richness ranging from 10 to 40 taxa/site; and
- High: density greater than 50,000 organisms/m², richness greater than 40 taxa/site.

2.4 DIVERSITY OF FISH AND FISH HABITAT

Aquatic ecosystem diversity was addressed as part of the baseline study through the diversity of the fish communities and fish habitats present in the surveyed waterbodies and watercourses in the LSA. Fish and fish habitat diversity was assessed through an examination of:

- fish species diversity;
- fish habitat diversity; and
- ecosystem diversity, as represented by trophic level complexity.

These three aspects of the aquatic ecosystem were selected as being suitable representatives of diversity based on Hurlbert (1971) and Pielou (1975), as described by Legendre and Legendre (1998). Fish species diversity and fish habitat diversity were examined at the waterbody or watercourse level, and at the watershed ecosystem level. Specific characteristics of fish communities and fish habitats were selected as indicators of diversity. A ranking system was developed to summarize the available information for the selected diversity indicators and to categorize the diversity of fish and fish habitat. The temporal boundary for the analysis was defined as the period of record for each watercourse or waterbody and includes all historical, current and baseline data.

Fish and fish habitat diversity was assessed for waterbodies and watercourses within the LSA examined during the Project baseline study. The assessment was conducted for sampling sites at which habitat mapping was conducted so that appropriate, quantifiable habitat data were available. The assessment of fish species diversity for each of these sampling sites was based on all available species distribution data for the RSA and LSA, including literature review and field sampling results.

2.4.1 Fish Species Diversity

Three indicators were selected to assess fish species diversity:

- species richness;
- species overlap; and
- presence or absence of listed species (i.e., species listed by federal or provincial agencies at some level of risk).

Species richness indices are measures of the number of species present (Magurran 1988). Species richness was selected as an indicator because the number of species present is typically proportional to the number of available ecological niches (Hutchinson 1957, 1965) and provides a link between species diversity and environmental diversity (Legendre and Legendre 1998). Species richness is typically greater in larger waterbodies and higher order streams and in regions where species pools are large; therefore, these factors were included in the assessment. Species richness was determined for each waterbody and watercourse by comparing the number of species documented to occur in the waterbody or watercourse to the total number of species known for the entire study area (i.e., RSA) in which the waterbody or watercourse occurs.

The following formula was used to determine species richness for each waterbody and watercourse:

$$\text{Species Richness (\%)} = \frac{\text{Number of species in the waterbody or watercourse}}{\text{Number of species in the RSA}} \times 100$$

For example, species richness in Unnamed Waterbody 1 (WB-1) was calculated by comparing the number of species at WB-1 to the total number of species documented in the RSA.

Species overlap refers to the proportion of species present in an ecosystem (or other defined habitat area) that are also found in other ecosystems. Species overlap thus provides a measure of the specificity of the environmental conditions (both biotic and abiotic) in that particular ecosystem. An ecosystem that contains unique species (i.e., contains species that are not found in other ecosystems), would score higher than one that contains species found in other ecosystems. Species overlap was assessed for each waterbody and watercourse by comparing the number of unique species present in the waterbody or watercourse to the total number of species in the waterbody or watercourse.

The following formula was used to determine species overlap for each waterbody and watercourse:

$$\text{Species Overlap (\%)} = \frac{\text{Total number of species} - \text{Number of unique species}}{\text{Total number of species}} \times 100$$

For example, species overlap for Unnamed Waterbody 1 (WB-1) was calculated by comparing the number of species present in WB-1 that are not present elsewhere in the RSA (i.e., are unique) to the total number of species in the waterbody.

Listed species refers to fish species for which there is some level of concern regarding the viability of their populations such that they have been designated as having a special status by either a provincial or federal agency (i.e., General Status of Alberta Wild Species [ASRD 2010,]; *Species at Risk Act* [Government of Canada 2003]; the Committee on the Status of Endangered Wildlife [COSEWIC] 2011). The presence of listed species may have important ecological, social and regulatory implications. Certain species may be rare in the RSA due to low reproductive rates, limited dispersal capabilities, specialized habitat requirements, or because the RSA occurs at the limit of their distribution range. These conditions may make these species more vulnerable to disturbance and emphasize their need for special consideration. Therefore, an important aspect of preserving diversity is the identification and possible maintenance of sustainable populations of rare or otherwise listed species. Other vulnerable species may also appear to be rare because they are difficult to capture using standard fisheries techniques.

A ranking system was developed to summarize the available information for the selected indicators and categorize the fish species diversity for the selected waterbodies and watercourses. A scale of 1 to 4 was devised for each of the three species diversity indicators. Species richness and overlap were ranked using quartiles (i.e., 25% intervals), and the presence of listed species was ranked in accordance with ASRD's four main definitions of general status categories for the identification of species at risk (ASRD 2005), based on the absence of any federally listed species. The indicators and the rankings used to categorize fish species diversity are summarized in Table 9.

Table 9 Indicators and Ranking Categories for Fish Species Diversity

Indicator	Ranking	Ranking Description
Species Richness	1	very low – less than 25% of total potential species present
	2	low – 25% to 49% of total potential species present
	3	moderate – 50% to 75% of total potential species present
	4	high – more than 75% of total potential species present
Species Overlap	1	very low – more than 75% of species present are shared with one or more other resource, or no fish detected
	2	low – 50% to 75% of species present are shared with one or more other resource
	3	moderate – 25% to 49% of species present are shared with one or more other resource
	4	high – less than 25% of species present are shared with one or more other resource
Presence of Listed Species	1	secure – there are no “At Risk”, “May be at Risk”, or “Sensitive” species present or the status of the species present is not determined
	2	sensitive – at least one species present that is not at risk of extinction or extirpation, but may require special attention or protection to prevent it from becoming at risk
	3	may be at risk – at least one species may be at risk of extinction or extirpation, and is therefore a candidate for detailed risk assessment
	4	at risk – at least one species known to be “At Risk” after a formal detailed status assessment and designation as “Endangered” or “Threatened” in Alberta

A general ranking of species diversity was then derived by multiplying the individual ranks for each of the three indicators. The general ranking of the watercourses and waterbodies has a minimum value (score) of one, indicating low contribution to the local fish species diversity, and a maximum of 64, which denotes a high contribution. The general ranking system used for categorizing the selected watercourses and waterbodies according to their diversity at the fish species level is summarized in Table 10.

Table 10 General Ranking for Fish Species-Level Indicators of Diversity

Indicator	Ranking	Ranking Description
Fish Species Diversity Ranking	1	very low – total score 1 to 3
	2	low – total score 4 to 8
	3	moderate – total score 9 to 27
	4	high – total score 28 to 64

2.4.2 Fish Habitat Diversity

Five indicators were used in the assessment of fish habitat diversity:

- waterbody habitat diversity index;
- watercourse habitat unit diversity index;

- waterbody area;
- waterbody maximum depth; and
- stream order.

Three of these indicators were applicable to the waterbodies that were included in the assessment and two were applicable to the watercourses. Waterbody area was calculated from digitized aerial photographs using AutoCAD.

The Waterbody Habitat Diversity Index assesses habitat diversity through the examination of habitat variation and habitat composition. Habitat variation refers to the number of habitats present per area of waterbody and habitat composition refers to the number of different habitat types present in the waterbody. This assessment was based on the habitat maps prepared for the waterbodies that show the location and extent of all habitat types. The total number of possible waterbody habitat types is 20 (e.g., littoral, pelagic, submergent vegetation and emergent vegetation).

The following formula was used to calculate the Waterbody Habitat Diversity Index:

$$\text{Habitat Diversity} = \frac{\text{Number of Discrete Habitats/100 m}^2 \text{ x Number of Habitat Types}}{\text{Number of Possible Habitat Types}}$$

Similarly, the Watercourse Habitat Unit Diversity Index also assesses habitat diversity through the examination of habitat variation and habitat composition, as represented by the types and distribution of channel units. In a given length of watercourse, habitat variation refers to the number of discrete channel units present and habitat composition refers to the number of different channel unit types present. The assumption for this indicator is that a higher number of different types of habitat units can accommodate a higher number of species and a wider range of life stages, and therefore promotes species diversity.

The habitat assessment for watercourses was based on the habitat surveys completed for each sampling site. At each site, the length of channel examined was divided into a series of discrete channel units and each unit was assigned a channel unit type. A total of 17 possible channel unit types are defined for watercourses (principal examples of channel unit types include riffle, class 1, 2 or 3 run, and class 1, 2 or 3 pool).

The following formula was used to calculate the Watercourse Habitat Unit Diversity Index:

$$\text{Habitat Unit Diversity} = \frac{\text{Number of Discrete Channel Units/ 100 m of stream x Number of Channel Unit Types}}{\text{Number of Possible Channel Unit Types}}$$

Other habitat indicators (i.e., waterbody area, waterbody depth and stream order) were selected based on the premise that, to a certain extent, larger watercourses and waterbodies are capable of supporting a higher level of diversity (Chase and Leibold 2002; Post et al. 2000; Vannote et al. 1980). Watercourse size was represented by stream order. Waterbody size was represented by a combination of waterbody area and maximum depth, where scores were calculated separately and averaged. If the average was not a whole number, the score was rounded down.

All waterbodies and watercourses were evaluated on a scale of 1 to 4 for each relevant habitat indicator. The indicators and the ranking categories used to assess the diversity of habitats in waterbodies and watercourses, and their potential to support a diversity of fish are summarized in Table 11.

Table 11 Indicators and Ranking Categories for Habitat Diversity

Indicator	Ranking	Ranking Description
Waterbody Habitat Diversity Index	1	very low – less than 0.25
	2	low – 0.25 to 0.44
	3	moderate – 0.45 to 1.4
	4	high – more than 1.4
Watercourse Habitat Unit Diversity Index	1	very low – less than 0.25
	2	low – 0.25 to 0.44
	3	moderate – 0.45 to 1.4
	4	high – more than 1.4
Waterbody Size (average score)	**Waterbody Area**	
	1	very low potential – less than 1 ha
	2	low potential – 1 to 10.4 ha
	3	moderate potential – 10.5 to 1,000 ha
	4	high potential – more than 1,000 ha
	Maximum Depth	
	1	very low potential – less than 2 m
	2	low potential – 2 to 6.4 m
	3	moderate potential – 6.5 to 40 m
	4	high potential – more than 40 m
Stream Order at Mouth	1	very low potential – first order
	2	low potential – second order
	3	moderate potential – third order
	4	high potential – fourth and higher order

A general ranking of habitat diversity was then derived by multiplying the individual ranks for each of the two habitat diversity indicators relevant to a watercourse or waterbody. The general habitat diversity ranking has a minimum value (score) of one and a maximum of 16. The general ranking system used for categorizing the selected waterbodies and watercourses according to their diversity at the fish habitat level is summarized in Table 12.

Table 12 General Ranking for Fish Habitat-Level Indicators of Diversity

Indicator	Ranking	Ranking Description
Fish Habitat Diversity Ranking	1	very low – total score 1 to 2
	2	low – total score 3 to 4
	3	moderate – total score 5 to 9
	4	high – total score 10 to 16

2.4.3 Ecosystem-Level Indicators of Diversity

Diversity may be assessed at higher levels of system organization, such as at the ecosystem, community or guild level. A guild is described as a group of species that exploit the same class of environmental resources in the same manner (Begon et al. 1990). The ratio of predatory fish species to trophic generalists/prey species was used in this assessment as a method of assessing diversity at the community and guild level, and is an indication of the diversity potential and the functioning of an ecosystem.

To maintain a sustainable population, large-bodied top predators require a higher degree of habitat diversity, including the presence of deep-water habitat to provide large pelagic prey and refuge. Due to these stricter trophic and habitat requirements, predators are usually more sensitive to changes in the ecosystem than most generalist species (Rieman and McIntyre 1993). The ranking system devised to assess the status of predator/prey ratios is shown in Table 13.

Table 13 Ranking Categories for Predator to Prey Species Ratios

Indicator	Ranking	Ranking Description
Predator to Prey/ Forage Guild Ratio	1	very low (no relationship) – no predator species, or no fish species detected
	2	low – one predator species, one prey/forage guild species
	3	moderate – one predator species, two or more prey/forage guild species
	4	high – two or more predator species, two or more prey/forage guild species

For the purpose of this study, predators have been defined as those fish species that have a predominantly piscivorous diet at the adult stage of their life cycle (i.e., feed on fish). Within the RSA, these species include lake trout, northern pike, walleye and burbot. Prey species were considered to be the forage fish guild.

2.4.4 Overall Diversity Ranking

The overall diversity ranking for fish and fish habitat was derived by multiplying the ranks for each of the three individual assessments (i.e., species diversity, habitat diversity and ecosystem diversity) together for each watercourse or waterbody. The overall diversity ranking has a minimum value (score) of one and a maximum of 64. The ranking system used for categorizing the waterbodies and watercourses according to their overall diversity is shown in Table 14.

Table 14 Ranking for Overall Diversity

Total Score	Ranking Description
1 to 3	very low diversity
4 to 9	low diversity
10 to 27	moderate diversity
28 to 64	high diversity

3 RESULTS

3.1 FISH HABITAT AND FISH COMMUNITIES

3.1.1 Literature Review

3.1.1.1 Regional Study Area

A number of documents were examined that detailed investigations conducted within the RSA to assess fish habitat or fish communities. The available data extended from surveys completed in 1967 through to 2010. The fish distribution and fish habitat information obtained from the literature review is summarized below in general terms for aquatic resources in the RSA, and in more detail for watercourse segments and waterbodies located within the LSA.

Nine sport fish and two sucker species are known to occur in the RSA (Table 15), including: Arctic grayling, burbot, cisco, goldeye, lake trout, lake whitefish, northern pike, walleye, yellow perch, longnose sucker and white sucker (ASRD 2011a; Bradley n.d.; Canadian Natural 2007; Devon 2004, 2006; EnCana 2008; Enermark 2008; FRM 1994, 1995a,b, 1996, 1998; Golder 1997, 1998; Herdman 1984; Lowe and Moller 1975; McDonald 1967; MEG 2008; Mills 1987; Mitchell and Prepas 1990; Rhude 1976). Forage fish species known to occur within the RSA (Table 15), include brook stickleback, fathead minnow, finescale dace, Iowa darter, lake chub, logperch, longnose dace, ninespine stickleback, northern redbelly dace, pearl dace, river shiner, slimy sculpin, spoonhead sculpin, spottail shiner and trout-perch (Bradley n.d.; Canadian Natural 2007; Devon 2004, 2006; EnCana 2008; Enermark 2008; FRM 1994, 1995a,b, 1996, 1998; Golder 1997; Gulf 2001; Lowe and Moller 1975; McDonald 1967; Mills 1987; Rhude 1976).

Existing fish and fish habitat information is available for Christina, Winefred, Bohn, Cowper, Glover, Grist, Jumbo, Watchusk, Ipiatik, Lac la Biche, Spencer, Seibert, Wolf, Touchwood and Pinehurst lakes, as well as several unnamed waterbodies within the RSA. Existing fish and fish habitat information was also available for Wiau Lake and several unnamed waterbodies within the LSA. In addition, information was available for Christina River (the portion within the RSA), Winefred River, Birch Creek, May River, Jackfish River, Sunday Creek, Landels River, Sand River, Grist River, Kettle River, Pony Creek, Waddell Creek, Goose River, Owl River, Wolf River, Wiau River and Sand River as well as for several unnamed watercourses within the RSA and the LSA.

Traditional Land Use (TLU) information indicates traditional fishing activities throughout the RSA for species including lake whitefish, northern pike, walleye, burbot, lake trout and sucker species.

Table 15 Fish Species Within the Regional Study Area

Category	Species	
	Common Name	**Scientific Name**
Sport fish	Arctic grayling[(a)]	*Thymallus arcticus*
	burbot[(a)]	*Lota lota*
	cisco[(a)]	*Coregonus artedi*
	goldeye	*Hiodon alosoides*
	lake trout	*Salvelinus namaycush*
	lake whitefish[(a)]	*Coregonus clupeaformis*
	northern pike[(a)]	*Esox lucius*
	walleye[(a)]	*Sander vitreus*
	yellow perch[(a)]	*Perca flavescens*
Suckers	longnose sucker	*Catostomus catostomus*
	white sucker[(a)]	*Catostomus commersoni*
Forage fish	brook stickleback[(a)]	*Culaea inconstans*
	fathead minnow[(b)]	*Pimephales promelas*
	finescale dace	*Phoxinus neogaeus*
	Iowa darter[(a)]	*Etheostoma exile*
	lake chub[(a)]	*Couesius plumbeus*
	logperch	*Percina caprodes*
	longnose dace[(b)]	*Rhinichthys cataractae*
	ninespine stickleback[(a)]	*Pungitius pungitius*
	northern redbelly dace	*Phoxinus eos*
	pearl dace[(a)]	*Semotilus margarita*
	river shiner	*Notropis blennius*
	slimy sculpin	*Cottus cognatus*
	spoonhead sculpin[(a)]	*Cottus ricei*
	spottail shiner[(a)]	*Notropis hudsonius*
	trout-perch	*Percopsis omiscomaycus*

(a) Documented within the LSA.

(b) Documented in lower reaches of the Christina River mainstem, but assumed possible in the upper reaches as well within the RSA.

Christina River at Chard Sub-Basin

Waterbodies

Christina Lake

Christina Lake drains north through the Jackfish River, which then drains to the Christina River. The Christina River then discharges into the Clearwater River, which is a major tributary to the Athabasca River. Christina Lake is a long, narrow waterbody with three distinct, deep basins that reach maximum depths of 33 m, 26 m and 24 m. The lake has a surface area of 21.3 km^2 and mean and maximum depths of 17 m and 33 m, respectively (Mitchell and Prepas 1990). The lake has a large upstream drainage area of 1,467 km^2 (Mills 1987). The shoreline drops off quickly around most of the lake, except for the two shallow northern bays at the east end of the lake. Areas of sand and gravel are present along the perimeter.

An aquatic vegetation map of Christina Lake from July 1985 (Mills 1987) indicated emergent vegetation including bulrushes, cattail, reeds and sedges present around the perimeter of the lake. Submergent and floating-leaved vegetation also occurred in a narrow band along the shoreline, consisting of water milfoil, pondweed, pond lily, smartweed and horse tail. The percentages of aquatic vegetation were estimated at 15% emergent, 50% submergent and 35% floating-leaved (Mills 1987). However, the presence of aquatic vegetation in Christina Lake was limited by the steep shoreline drop off around most of the lake except for in shallow bays (Mills 1987). The low hills surrounding the lake are covered with a mixed forest of birch, balsam poplar and white spruce, while willows and wet areas are present around the shoreline (Mitchell and Prepas 1990).

Past studies have determined that fish production in Christina Lake is constrained by the limited littoral area and apparent lack of spawning habitat (Bradley n.d.; Mills 1987). Walleye spawning is known to occur in the small bay at the north shore of Christina Lake (“Sawbones Bay”) in the spring. In the past, walleye were caught in this bay in great numbers during the spring spawning season (Herdman 1984).

Because of its depth, the lake becomes stratified during summer (Mitchell and Prepas 1990). Water quality profiles conducted in the main basin of Christina Lake during summer 1985 and 2004 indicated a distinct thermocline and oxygen gradient at a depth of 8 m.

Arctic grayling, walleye, northern pike, yellow perch, lake whitefish, cisco, burbot and white sucker have been reported to be captured from 1996 to 2009 in Christina Lake (ASRD 2011a; Mitchell and Prepas 1990). Forage fish species, including Iowa darter, ninespine stickleback, trout-perch and spottail shiner, have been also been documented within the lake (ASRD 2011a; Mills 1987). Traditional Land Use information indicates traditional fishing for lake whitefish, burbot, walleye, northern pike and suckers.

In the past, Christina Lake supported a commercial fishery that included lake whitefish, cisco, northern pike and walleye (Bradley n.d.; PanCanadian 1998; Westworth 2002). Commercial fishing records indicate that the lake was fished heavily in the 1940s to late 1960s (Bradley n.d.). Commercial fishing for whitefish occurred up to 1982, and resumed between 1987 and 1989 (Christina Lake Management Plan 1991).

Christina Lake has historically been a high-quality sport fishing destination (Christina Lake Management Plan 1991). The target species for sport fishing in Christina Lake has historically been walleye and pike (Herdman 1984). A creel census in 1983 identified northern pike up to 21 lbs (9.5 kg) and walleye up to 8 lbs 7 oz (3.8 kg). The shoreline habitat is considered important for spawning, nursery and feeding habitat for sport, suckers and forage fish (Christina Lake Management Plan 1991; PanCanadian 1998). In the 1970s, sport fish capability in the area was rated fair to good, particularly on the Christina River system; Christina Lake was identified as a Class 2 lake (few or minor limitations on sport fish production) (AENV 1976-7).

In the past, Christina Lake also supported a sustenance fishery for walleye. The walleye fishery was recently deemed collapsed but Christina Lake still supports a large population of lake whitefish (Westworth 2002). The *2011 Alberta Guide to Sport Fishing Regulations* outlines specific restrictions for walleye, northern pike, lake whitefish, yellow perch, Arctic grayling and burbot in this waterbody, and includes a fish consumption advisory (mercury) for walleye and northern pike in Edwards Lake (ASRD 2011b).

Kirby Lake

Kirby Lake is located west of Winefred Lake and drains into Hay Lake and then to an unnamed tributary of Christina Lake. Existing information for this waterbody is limited. The FWMIS database indicates northern pike and lake whitefish were captured between 1999 and 2001 (ASRD 2011a). The *2011 Alberta Guide to Sport Fishing Regulations* outlines specific restrictions for northern pike, yellow perch, and lake whitefish in this waterbody (ASRD 2011b).

TLU information indicates traditional fishing for lake whitefish, northern pike, burbot and suckers.

Unnamed Waterbody (Hay Lake)

An unnamed waterbody, locally known as Hay Lake, drains into an unnamed tributary to Christina Lake. The maximum depth recorded for Hay Lake in March 2003 was about 4.7 m (including ice cover), with a dissolved oxygen concentration of 9.0 mg/L (Devon 2004).

Fish species known to occur in Hay Lake include northern pike and lake whitefish (Devon 2004). Interviews conducted with elders and the local community indicated that the lake supported a limited domestic or subsistence fishery for lake whitefish in the past; however, low water levels and beaver dams have been reported to have adversely affected the fish populations in Hay Lake (Devon 2004).

Watercourses

Unnamed Tributary to Christina Lake

This tributary to Christina Lake flows west from a moderately sized unnamed waterbody into the east shore of the lake. The lower portion of this watercourse lies within the LSA and is discussed in Section 3.1.1.2. The remaining portion of this watercourse, however, is within the RSA.

Within the RSA, this watercourse was comprised primarily of run habitat with defined banks and silt substrate (MEG 2008). However, where beaver activity was present, there was ponding and sections with poorly defined banks. Brook stickleback was the only fish species captured in this watercourse at sampling sites outside of the LSA.

Unnamed Tributary to Christina Lake (Sawbones Creek)

This tributary to the north shore of Christina Lake is locally known as “Sawbones Creek”. The lower reach near the confluence with Christina Lake is wide, run habitat with a well-defined channel (MEG 2008). The lower reach of “Sawbones Creek” was considered to contain critical or sensitive habitats, including spawning sites for walleye and northern pike. Habitat limitations were present in the middle and upper reaches, including poor habitat diversity, limited fish passage due to beaver dams and sections of undefined channel, and poor water quality (MEG 2008).

Walleye were captured near the confluence of “Sawbones Creek” and Christina Lake, with northern pike and white sucker also being observed during sampling (MEG 2008).

Unnamed Tributary to Sunday Creek

An unnamed tributary to Sunday Creek flows into Sunday Creek at the southern edge of the Lease Area boundary. Surveys were conducted in the unnamed tributary by Devon Canada Corporation (Devon 2004, 2006). Sample sites were located near the confluence with Sunday Creek, as well as in the upper end of the watercourse, near the headwaters.

Near the confluence, this unnamed tributary to Sunday Creek was characterized by low-quality run habitat, with some low-quality pool and impoundment habitat as well as sparse riffle habitat (Devon 2004, 2006). Near its headwaters, this tributary was dominated by deep pool habitat formed by beaver dams as well as some low-quality run habitat and moderate-quality pool habitat (Devon 2006). Substrate was comprised primarily of fines overlying cobble near the headwaters, and a combination of fines, gravel and cobble near its confluence with Sunday Creek (Devon 2006). Channel widths ranged from 4 to 16 m throughout the surveyed sections of the watercourse (Devon 2004, 2006). Average water depths ranged from 0.2 to 0.6 m in run habitat, with depths in pool habitat rarely exceeding 1.5 m (Devon 2004, 2006). Winter field water quality measurements indicated that the unnamed creek had low dissolved oxygen levels (1.3 to 1.8 mg/L) under the ice in 2002 (Devon 2004) and moderate dissolved oxygen levels (6.4 to 13.2 mg/L) under the ice in 2005 (Devon 2006).

The presence of barriers to fish movement and the low dissolved oxygen levels in the winter were considered to limit the suitability of the surveyed section of the stream for overwintering, spawning, feeding and rearing (Devon 2004, 2006).

Although no fish were captured in the unnamed creek during May 2002, brook stickleback were captured in May 2005 (Devon 2004, 2006). Historical information on fish species composition or abundance was not available.

Christina River

A habitat survey was conducted by FRM Environmental Consulting Ltd. (FRM 1994) on a section of the Christina River within the RSA, near Waddell and Pony creeks in 1993 (Figure 2). The area surveyed was entirely run habitat, with a maximum width of 32.5 m. Near the banks, substrate was mostly silt, but gravel and larger substrate were present farther out in the channel. Water depth was not measured during the survey.

Electrofishing and angling captured Arctic grayling, northern pike, walleye, white sucker, longnose sucker, goldeye, burbot and lake chub in Christina River (FRM 1994, 1995a,b, 1996, 1998).

Unnamed Tributaries to the Christina River

Two unnamed tributaries to the Christina River were also surveyed in 2004 for the MEG energy Christina Lake Regional Project. No fish were captured in the unnamed tributaries to the Christina River during that survey (MEG 2008).

Jackfish River

Jackfish River flows out of the west end of Christina Lake into the Christina River. FRM Environmental Consulting Ltd. (FRM 1995b) conducted a habitat survey on Jackfish River, about 5 km downstream of Christina Lake in 1995. The area surveyed was primarily run habitat, with some pool and riffle habitat present. Channel width was measured to be between 20 m and 30 m, with maximum water depths ranging from 0.6 to 1.1 m. The substrate in the surveyed section consisted of rubble, boulder and gravel. Electrofishing, angling and seining captured burbot, goldeye, northern pike, walleye and longnose sucker in the Jackfish River (FRM 1995b, 1996). Although not captured during the survey, FRM (1995b) report that Arctic grayling have historically been captured in Jackfish River. TLU information indicates historical fishing for Arctic grayling, northern pike, walleye, lake trout, lake whitefish and sucker.

Waddell Creek

Waddell Creek is a tributary to Christina River upstream of Chard River (Figure 2). Surveys by FRM (1994, 1995a, 1996) indicate this watercourse is dominated by pool and run habitat with occasional riffles. The substrate within Waddell Creek is diverse, dominated by fines and sand, with gravel, rubble and boulders occasionally recorded throughout (FRM 1994, 1995a, 1996).

Fish species captured in Waddell Creek by FRM (1994, 1995a, 1996) include goldeye, longnose sucker, white sucker, brook stickleback, lake chub, pearl dace and slimy sculpin.

Unnamed Tributary to Waddell Creek

One unnamed tributary to Waddell Creek was surveyed by FRM (1995a). At the selected sampling site, this unnamed watercourse was dominated by pool habitat and fine substrate (FRM 1995a). Only one fish species, brook stickleback, was captured (FRM 1995a).

May River

May River is located to the west of Birch Creek and flows into the Christina River. FRM (1994) conducted a habitat survey on the lower portion of May Creek, near where it enters Christina River in 1993. The area surveyed was primarily riffle and run habitat. Channel width was measured to be between 11.8 m and 22.1 m, with maximum water depths ranging from 0.5 to 1.0 m. The substrate in the surveyed section consisted of rubble, gravel and fines. Seining, gill netting, angling and electrofishing captured Arctic grayling, northern pike, longnose sucker, white sucker, brook stickleback, lake chub, pearl dace, spottail shiner, trout perch and slimy sculpin in the May River (FRM 1994, 1995a,b, 1996, 1998).

Goose River

The Goose River is a tributary to the Christina River and is located upstream from the May River confluence. Habitat surveys by FRM (1995b, 1998) indicate habitat was dominated by riffles, with some pool and run habitat. Substrate was composed of fines, sand, gravel, rubble and boulders (FRM 1998). Arctic grayling and northern pike are the only fish species recorded in Goose River (ASRD 2011a; FRM 1995b, 1998). The *2011 Alberta Guide to Sport Fishing Regulations* outlines specific restrictions for walleye, northern pike and Arctic grayling in this river (ASRD 2011b).

Unnamed Tributary to Goose River

Fisheries Management Information System data indicates brook stickleback were captured in one unnamed tributary to Goose River in May 2008.

Pony Creek and Kettle River Sub-Basin

Waterbodies

Unnamed Waterbodies

A few small, unnamed waterbodies occur in the Pony Creek and Kettle River sub-basin, but none have been previously examined and there is no fish and fish habitat information available.

Watercourses

Unnamed Tributaries to the Christina River

Two unnamed tributaries to the Christina River were also surveyed in 2004 for the MEG Christina Lake Regional Project. No fish were captured in the unnamed tributaries to the Christina River during that survey (MEG 2008).

Kettle River

The Kettle River is a significant tributary to the Christina River downstream of Chard River and has been previously studied by Gulf (1979, 2001), FRM (1994, 1995b, 1996) and Golder (1997). The Kettle River has been described as a shallow to deep, low gradient, meandering watercourse (Golder 1997f; Gulf 2001). The substrate was dominated by silt and sand, and beaver activity was observed throughout the watercourse (FRM 1996; Golder 1997f; Gulf 2001). Gulf (2001) estimated 1.5 beaver dams per km of stream in the lower 23 km of the Kettle River.

Nine fish species have been documented in the Kettle River. Sport fish captured include Arctic grayling and burbot (FRM 1995b, 1996, 1998; Gulf 1979, 2001). Non-sport fish captured include both longnose sucker and white sucker (FRM 1994; Gulf 1979, 2001). Five forage fish have been documented in the Kettle River, including brook stickleback, lake chub, pearl dace, slimy sculpin and trout-perch (FRM 1994, 1996, 1998; Gulf 2001).

Tributary to the Kettle River

Locally known as “South Kettle River”, this tributary to the Kettle River generally flows east. This watercourse is located about 14 km upstream of from the confluence of the Christina River and the Kettle River and has been investigated by Gulf (1979) and FRM (1995b). At the sampling site established by FRM (1995b), the habitat was primarily run with occasional riffles. Substrate was dominated by sand with small amounts of fines and gravel (FRM 1995b). Gulf (1979) considered the “South Kettle River” to have moderate sport fishery potential.

One sport fish species (Arctic grayling) and three forage fish species (brook stickleback, spoonhead sculpin and slimy sculpin) have been documented in the “South Kettle River” (FRM 1995b; Gulf 1979).

Pony Creek

Pony Creek is a tributary of the Christina River downstream of Chard River. FRM (1994) describes the habitat as mainly dominated by pools, with riffle and run sections throughout. Some sites were dominated by, or were exclusively composed of, run habitat (FRM 1996, 1998). The substrate at select sampling sites was composed primarily of fines and sand, with some gravel and rubble and occasional boulders (FRM 1994, 1996, 1998).

Fish sampling of Pony Creek resulted in the capture of the following non-sport and forage fish species: longnose sucker, white sucker, brook stickleback, lake

chub, pearl dace, finescale dace, northern redbelly dace and slimy sculpin (FRM 1994, 1995b, 1996, 1998). No sport fish have been captured in Pony Creek.

Winefred River Sub-Basin

Waterbodies

Bohn Lake

Bohn Lake is located in the lower portion of the Winefred River sub-basin and drains into an unnamed tributary of Winefred River. Existing information for this waterbody is limited. Historically, northern pike, white sucker and brook stickleback have been recorded in Bohn Lake (ASRD 2011a; Rhude 1976).

Cowper Lake

Cowper Lake is located in the lower portion of the Winefred River sub-basin. Cowper Lake drains into an unnamed waterbody, which then flows into Cowper River, a tributary to Winefred River. Rhude (1976) described this lake as well oxygenated, with a maximum depth of 5.3 m. The shoreline substrate was primarily composed of silt and organic debris, interspersed with boulders (Rhude 1976).

Two sport fish (northern pike and yellow perch) and one non-sport fish (white sucker) have been recorded in Cowper Lake. Rhude (1976) captured all three of the above species, while ASRD (2011a) recorded the capture of northern pike and yellow perch in 1985 and 1996. The *2011 Alberta Guide to Sport Fishing Regulations* outlines specific restrictions for northern pike and yellow perch in this waterbody (ASRD 2011b).

Grist Lake

Grist Lake drains into Grist River, which then flows into Winefred Lake, within the Winefred River sub-basin. Tributary streams of this waterbody include Jumbo Creek, Cameron Creek and York Creek. Grist Lake has been described by Bradley (n.d.) and Rhude (1976) as a deep lake with limited emergent and submergent vegetation. The maximum depth has been recorded at 42.7 m (Bradley n.d.; Rhude 1976). The shoreline substrate was dominated by sand, with some gravel along the east shore (Rhude 1976).

Six sport fish, one non-sport and four forage fish species have been recorded in Grist Lake. Species captured include Arctic grayling, burbot, cisco, lake trout, lake whitefish, northern pike, white sucker, finescale dace, northern redbelly dace, ninespine stickleback and spottail shiner (ASRD 2011a; Bradley n.d.;

Rhude 1976). The *2011 Alberta Guide to Sport Fishing Regulations* outlines specific restrictions for lake trout, northern pike and lake whitefish in this waterbody (ASRD 2011b). TLU information indicates fishing for northern pike, lake trout, walleye and lake whitefish.

Jumbo Lake

Jumbo Lake is a small waterbody adjacent to the south side of Winefred Lake within the Winefred River sub-basin. Historical fisheries information indicates that Jumbo Lake contains lake whitefish (ASRD 2011a). The *2011 Alberta Guide to Sport Fishing Regulations* outlines specific restrictions for northern pike, lake whitefish and yellow perch in this waterbody (ASRD 2011b).

Watchusk Lake

Located within the Winefred River sub-basin, Watchusk Lake drains into an unnamed tributary of Newby River, which then flows into the Winefred River. Existing information for this waterbody is limited. Historically, northern pike and white sucker have been recorded in 1976 from Watchusk Lake (ASRD 2011a). The *2011 Alberta Guide to Sport Fishing Regulations* outlines specific restrictions for northern pike and yellow perch in this waterbody (ASRD 2011b).

Winefred Lake

Winefred Lake is located in the southeast corner of the RSA within the Winefred River sub-basin. Winefred Lake drains into Winefred River, which then flows into the Christina River. The maximum depth recorded for Winefred Lake in 1976 was 13 m (Rhude 1976). At the time of the 1976 lake survey, most of the lake bottom, to a depth of 6 m, was covered by sand with various amounts of gravel, mud and organic debris. At depths greater than 6 m, the lake bottom was generally covered by organic debris.

Fish species reported to occur in Winefred Lake include walleye, lake whitefish, northern pike, yellow perch, cisco, white sucker, burbot, brook stickleback, ninespine stickleback, river shiner, spottail shiner, slimy sculpin and trout-perch (ASRD 2011a; Lowe and Moller 1975; McDonald 1967; Rhude 1976). In the past, Winefred Lake supported a commercial fishery for walleye, northern pike and whitefish (Rhude 1976). Winefred Lake is classified as a trophy lake and the *2011 Alberta Guide to Sport Fishing Regulations* outlines specific restrictions for walleye, northern pike, yellow perch, lake whitefish and burbot in this waterbody (ASRD 2011b). TLU information indicates fishing for lake whitefish, burbot, walleye, northern pike, lake trout and suckers.

Unnamed Waterbodies Within the Winefred River Sub-Basin

One unnamed waterbody in the Winefred River sub-basin was surveyed by Rhude (1976). This waterbody is connected to Cowper Lake at its south inlet, and flows north at the outlet in Cowper River. A maximum depth of 5.8 m was recorded and the shoreline substrate was primarily composed of silt and organic debris, interspersed with boulders (Rhude 1976). Fisheries information for this unnamed waterbody is limited. Fish sampling by Rhude (1976) captured northern pike and yellow perch.

Two unnamed waterbodies (referred to as Unnamed Waterbodies 1 and 2) within the Winefred River sub-basin were surveyed as part of the Christina Lake Regional Project (MEG 2008). Unnamed Waterbody 1 had a surface area of 250 ha and a maximum depth of 3.2 m measured during the spring of 2007. Unnamed Waterbody 2 had a surface area of 175 ha and a maximum depth of 1.2 m measured during the spring of 2007. Both waterbodies contained emergent vegetation and silt substrate. Neither waterbody provided suitable overwintering habitat, but open-water conditions were suitable for sport and non-sport fish species. Brook stickleback was the only fish species captured in Unnamed Waterbody 1; no fish were captured in Unnamed Waterbody 2 (MEG 2008).

Watercourses

Winefred River

The Winefred River originates from Winefred Lake and flows into the Christina River. At the outlet of Winefred Lake, Winefred River is about 15 m wide with a mean depth of about 1 m (Rhude 1976). In riffle sections, the substrate consists of boulders and gravel, while the substrate in pool habitat is silt, sand and boulders. Fish species reported in the Winefred River include Arctic grayling, white sucker, walleye, yellow perch, longnose sucker and lake chub (Rhude 1976). The ASRD FWHMIS database indicates burbot, longnose sucker, northern redbelly dace, finescale dace and longnose dace were sampled in 2009 (ASRD 2011b). TLU information indicates fishing for Arctic grayling, northern pike, walleye, lake whitefish and suckers.

Landels River

Landels River is a tributary to Winefred River, within the Winefred River sub-basin. Existing information for this watercourse is limited. Rhude (1976) describes Landels River as a slow flowing, meandering watercourse with a large floodplain.

According to the FWMIS database, (ASRD 2011a), the only recorded sampling in Landels River occurred in August 1997; two fish species were captured including northern pike and lake chub.

Grist River

The Grist River connects the outlet of Grist Lake to Winefred Lake, within the Winefred River sub-basin. Extensive beaver activity has historically been observed in this watercourse (Rhude 1976), which has been described as slow flowing, braided and stabilized by vegetation, such as willow and grass species (Rhude 1976). Pool habitats surveyed in the Grist River contained mud and sand substrate (Rhude 1976).

Historically, the Grist River contained northern pike, finescale dace and northern redbelly dace (Rhude 1976). Sampling in July 1996 resulted in the capture of northern pike and spottail shiner (ASRD 2011a).

Unnamed Watercourses Within the Winefred River Sub-Basin

Sport, non-sport and forage fish species have been captured in 13 unnamed watercourses sampled within the Winefred River sub-basin. Species captured include northern pike, longnose sucker, white sucker, brook stickleback, finescale dace, lake chub, northern redbelly dace, pearl dace and spottail shiner (ASRD 2011a; FRM 1994, 1996; MEG 2008).

Sand River Sub-Basin

Waterbodies

Ipiatik Lake

Ipiatik Lake is a moderately sized lake (4.7 km^2), with mean and maximum depths of 3.7 m and 7.0 m, respectively. Inflow to the lake is via two intermittent streams draining the muskeg areas to the north and east of the lake. The outlet stream drains southward into the Ipiatik River (Rhude 1976).

The shoreline of Ipiatik Lake is fairly uniform, with a total length of 9.9 km, and shoreline substrate consisting primarily of silt and detritus. Aquatic vegetation consists primarily of rushes and pondweed. A mixed forest of poplar and black spruce surrounds the lake (Rhude 1976).

Ipiatik Lake is relatively isolated and can only be accessed by floatplane or helicopter during the summer or by snowmobile during the winter. Access is also restricted, as it is located within the Cold Lake Air Weapons Range.

Ipiatik Lake has a winter commercial fishery, with lake whitefish, northern pike, white sucker and burbot being harvested by commercial fishers. The Ipiatik Lake commercial fishery, although not as large as some fisheries in the area, remains important because it is on the Cold Lake and the limited access contributes to a fishery without sport fishing conflict. As a result, commercial fishers can harvest some northern pike along with the lake whitefish, providing added value to the fishery. Many of the commercially fished lakes located outside the range are also heavily fished by sport anglers and the very low tolerances for northern pike can interfere with commercial harvests.

Seibert Lake

Seibert Lake is located in the southeast portion of the RSA and drains into the Punk Creek which discharges into the Sand River. Seibert Lake has a surface area of 37.4 km^2 and mean and maximum depths of 6.9 m and 11 m, respectively (Mitchell and Prepas 1990). The lake has a small upstream drainage area of 67.6 km^2 (Mitchell and Prepas 1990).

The fish species found in Seibert Lake are northern pike, walleye, yellow perch, lake whitefish, burbot, white sucker, Iowa darter, spottail shiner and brook stickleback (ASRD 2011a; Mitchell and Prepas 1990). Seibert Lake supported a small, intermittent commercial fishery from the early 1900s that was discontinued after 1957, largely because the lake whitefish were heavily infested with cysts of the tapeworm *Triaenophorus crassus* (Mitchell and Prepas 1990).

Seibert Lake was designated a trophy lake in 1970 (Mitchell and Prepas 1990). The *2011 Alberta Guide to Sport Fishing Regulations* outlines specific restrictions for walleye, northern pike, yellow perch, lake whitefish and burbot in this waterbody (ASRD 2011b).

Pinehurst Lake

Pinehurst Lake drains into the Punk Creek which discharges into the Sand River. Pinehurst Lake has a drainage area of 285 km^2, surface area of 40.7 km^2 and mean and maximum depths of 12.2 m and 21.3 m, respectively (Mitchell and Prepas 1990). The density of aquatic vegetation is generally low to moderate except in several bays and around the islands, where density is high (Mitchell and Prepas 1990).

The fish species known to occur in Pinehurst Lake include walleye, northern pike, lake whitefish, cisco, yellow perch, burbot, white sucker and spottail shiner (ASRD 2011a; Mitchell and Prepas 1990). The *2011 Alberta Guide to Sport Fishing Regulations* outlines specific restrictions for northern pike, yellow perch, lake whitefish and burbot in this waterbody (ASRD 2011b).

A commercial net fishery was operated on Pinehurst Lake until 1976/77; however, the lake whitefish and cisco in the lake are heavily infested with cysts of the tapeworm *Triaenophorus crassus,* limited its commercial viability as a fishery (Mitchell and Prepas 1990). Test nettings to assess the potential for a whitefish roe fishery in 1981 and 1985 indicated too many sport fish would be caught if the commercial net fishery resumed (Mills 1987).

Wolf Lake

Wolf Lake drains into the Sand River and has a drainage area of 693 km^2, surface area of 31.5 km^2, and mean and maximum depths of 9.2 m and 38.3 m, respectively (Mitchell and Prepas 1990). The average concentrations of algae in Wolf Lake are quite low, but large areas of dense aquatic vegetation are present in some parts of the lake, whereas other areas support a low density of plants (Mitchell and Prepas 1990).

Twelve species of fish have been identified in Wolf Lake including northern pike, walleye, lake whitefish, cisco, burbot, yellow perch, white sucker, longnose sucker, Iowa darter, spottail shiner, brook stickleback and ninespine stickleback (ASRD 2011a; Mitchell and Prepas 1990). The *2011 Alberta Guide to Sport Fishing Regulations* outlines specific restrictions for northern pike, yellow perch, lake whitefish and burbot in this waterbody (ASRD 2011b).

Touchwood Lake

Touchwood Lake has a drainage area of 111 km^2, surface area of 29 km^2, and mean and maximum depths of 14.8 m and 40 m, respectively (Mitchell and Prepas 1990). Concentrations of algae in the lake are low during the open-water period, so the water is generally transparent and the density of aquatic vegetation is sparse to moderate (Mitchell and Prepas 1990).

Ten species of fish have been identified in Touchwood Lake including northern pike, walleye, lake whitefish, cisco, burbot, yellow perch, white sucker, Iowa darter, spottail shiner and brook stickleback (ASRD 2011a; Mitchell and Prepas 1990). The *2011 Alberta Guide to Sport Fishing Regulations* outlines specific restrictions for northern pike, yellow perch, lake whitefish and burbot in this waterbody (ASRD 2011b).

Unnamed Waterbodies Within the Sand River Sub-Basin

An unnamed waterbody (referred to as Unnamed Lake 5 (UL-5) in Canadian Natural 2007) is a small, shallow lake located to the northwest of Ipiatik Lake. Overwintering potential for fish populations in this lake is considered low.

UL-5 is located in large sedge wetlands. Yellow pond-lily is sparsely distributed over most of the lake surface during summer. Water depth is fairly uniform throughout the lake, with a maximum measured depth of 2.3 m. Substrate is composed primarily of fine sediments and detritus, with extensive submergent macrophyte growth. Habitat for rearing, spawning and feeding by resident minnow species is considered moderate. Beaver lodges have been recorded to be present on the lake.

Drainage from UL-5 is to the south to Ipiatik Lake. However, no defined outlet channel is present at the lake. The inlet stream at the northwest shore of the lake has approximately 100 m of defined channel, providing habitat for lake resident fish. Further upstream from this point, the stream is ponded with extensive beaver dams.

Northern pike, lake chub and brook stickleback have been captured in UL-5. Due to the shallow nature of the lake, it is likely subject to periodic winter kills.

Watercourses

Sand River

Sand River is a tributary to Winefred Lake. Existing information for this watercourse is limited. Sampling in July 1996 by seining and angling resulted in the capture of one forage fish species, brook stickleback (ASRD 2011a). However, angling in both May 2000 and May 2001 captured two sport fish species, northern pike and walleye (ASRD 2011a). Electrofishing in June 2004 did not result in any fish capture (ASRD 2011a). The ASRD FWMIS database also indicates yellow perch, lake whitefish, cisco, white sucker, longnose sucker, Iowa darter, northern redbelly dace, lake chub, logperch, fathead minnow, longnose dace and finescale dace are present in the river.

Wolf River

The Wolf River is a tributary to Wolf Lake, within the Sand River sub-basin. Existing information on this watercourse is limited. Fish species identified in the river include: northern pike, white sucker, brook stickleback, pearl dace and spottail shiner (AEL 1983; Canadian Natural 2000; EMA 1985). The ASRD

FWMIS database also indicates walleye, yellow perch and longnose sucker also are present in the river (ASRD 2011a).

Unnamed Watercourses Within the Sand River Sub-Basin

The ASRD FWHMIS database indicates non-sport and forage fish species have been captured in numerous unnamed watercourses sampled within the Sand River sub-basin. Species captured include longnose sucker, white sucker, brook stickleback, pearl dace, lake chub, Iowa darter, fathead minnow (ASRD 2011a).

Lac la Biche Sub-Basin

Waterbodies

Lac la Biche

Lac la Biche is a large lake located in the far southwest portion of the RSA. Lac la Biche drains west into the Athabasca River. The lake is composed of two basins with a surface area of 234 km^2 and mean and maximum depths of 8.4 m and 21.3 m, respectively (Mitchell and Prepas 1990). The lake has a large upstream drainage area of 4,040 km^2 (Mitchell and Prepas 1990).

The fish species in Lac la Biche include walleye, northern pike, lake whitefish, cisco, yellow perch, burbot, white sucker, longnose sucker, spottail shiner, brook stickleback and Iowa darter (ASRD 2011a; Mitchell and Prepas 1990). The lake supports a commercial fishery for cisco, lake whitefish and northern pike, and a domestic fishery for lake whitefish. The *2011 Alberta Guide to Sport Fishing Regulations* outlines specific restrictions for walleye, northern pike, yellow perch, lake whitefish and burbot in this waterbody (ASRD 2011b).

Heart Lake

Heart Lake is a headwater lake within the Piche River drainage which is a tributary of the Owl River. Habitat information on Heart Lake is limited but the ASRD FWMIS database indicates the species present include lake whitefish, northern pike, cisco, walleye, yellow perch, white sucker, brook stickleback, Iowa darter, ninespine stickleback and spottail shiner (ASRD 2011a). The *2011 Alberta Guide to Sport Fishing Regulations* outlines specific restrictions for walleye, northern pike, yellow perch, lake whitefish and burbot in this waterbody (ASRD 2011b).

Watercourses

Owl River

Owl River is tributary to Lac la Biche, within the Lac la Biche sub-basin. Existing information for this watercourse is limited. The ASRD FWMIS database indicates fish species captured within the river include walleye, northern pike, cisco, white sucker, pearl dace and brook stickleback (ASRD 2011a). The Owl River from Lac la Biche upstream to Piche River is closed to recreational fishing (ASRD 2011b).

3.1.1.2 Local Study Area

Baseline field programs have been completed at numerous locations throughout the LSA to support KS1 (Canadian Natural 2007) and the Kirby North 2010 (Enermark 2008). Site locations and unnamed waterbody and watercourse site labels are shown in Figures 4 and 5 for North Expansion Area and South Expansion Area, respectively.

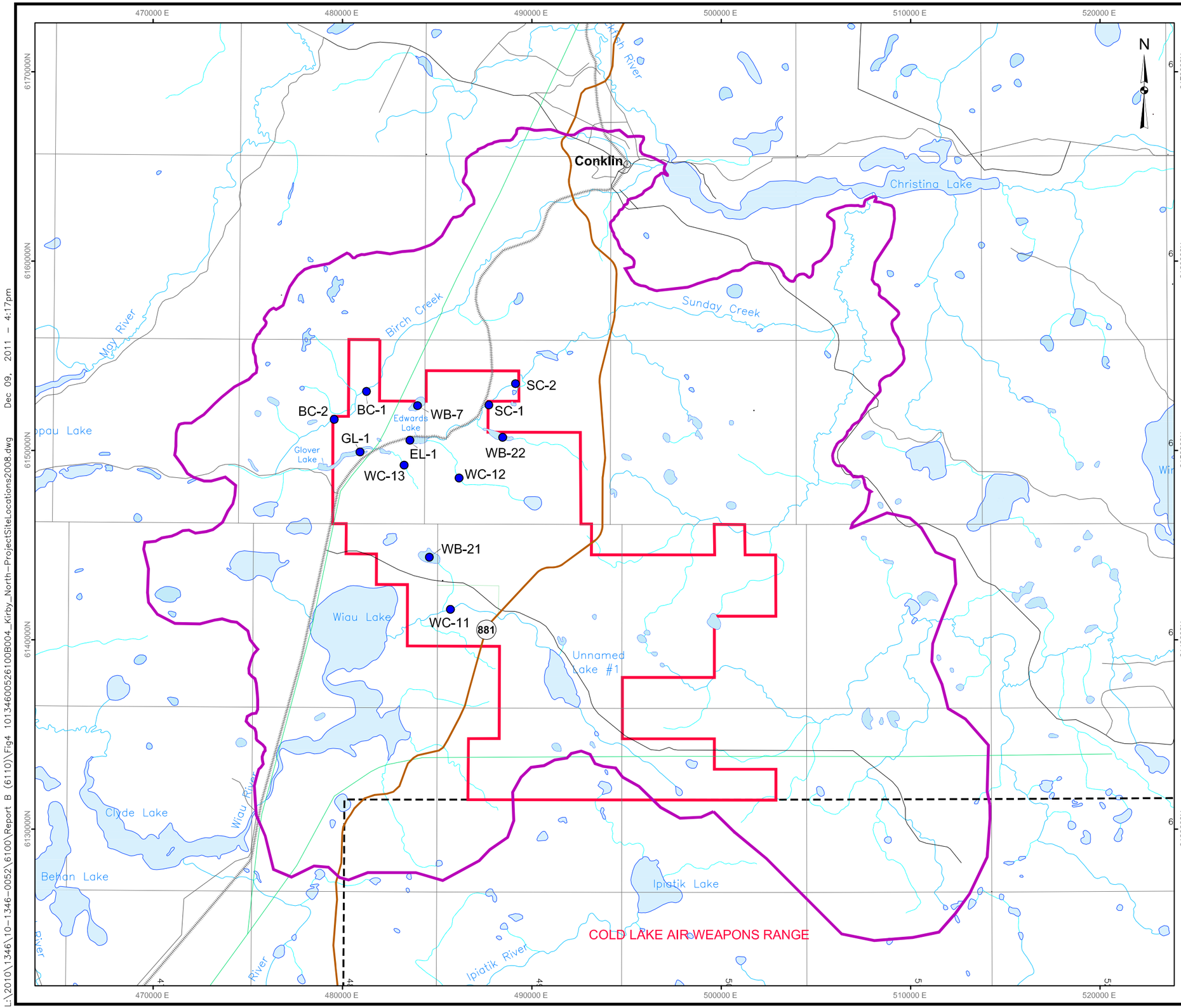
Christina River at Chard Sub-Basin

Waterbodies

Edwards Lake

Edwards Lake (Figure 4) was surveyed as part of the Kirby North 2010 baseline survey (Enermark 2008). The lake is approximately 0.3 km^2 in surface area and forms the headwaters of Sunday Creek (Figure 4). Edwards Lake has a maximum depth of about 9.7 m and has narrow inlet channel that flows into its east end. The bed substrate was predominantly sand and organic material, and the entire waterbody was inundated with submergent vegetation.

Edwards Lake provides suitable habitat for sport fish, non-sport fish and forage fish species. Spawning habitat during the spring survey was present only for those species that spawn on fine substrate or vegetation (e.g., northern pike, brook stickleback), as there was a lack of larger coarse substrate (gravel and cobble). Dissolved oxygen levels in the winter were relatively high, providing suitable overwintering habitat for most sport, non-sport and forage fish species common to the region.



L:\2010\1346\10-1346-0052\6100\Report B (6110)\Fig4 10134600526100B004_Kirby_North_ProjectSiteLocations2008.dwg Dec 09, 2011 - 4:17pm

LEGEND

- ROAD
- RAILWAY
- RIVER
- OPEN WATER
- KIRBY EXPANSION PROJECT LEASE AREA*
- AQUATICS LOCAL STUDY AREA (LSA)
- KIRBY NORTH 2006-2008

Note

*Includes Oil Sands Leases fully and partially held by Canadian Natural

REFERENCE

ALBERTA DIGITAL DATA OBTAINED FROM ALTALIS LTD. (SEPTEMBER 2004). USED UNDER LICENSE. DATUM: NAD83 PROJECTION: UTM ZONE 12. ALBERTA NTDB DIGITAL DATA OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.

5 0 5
SCALE KILOMETRES

PROJECT

Canadian Natural

KIRBY IN SITU OIL SANDS EXPANSION PROJECT

TITLE

KIRBY NORTH PROJECT SITE LOCATIONS 2008

Golder Associates Calgary, Alberta

PROJECT	10.1346.0052.6100		FILE	No.10134600526100B004	
DESIGN	MD	18/10/11	SCALE	1:250,000	REV. 0
CADD	TRE	07/12/11			
CHECK	MD	08/12/11			
REVIEW	KC	08/12/11			

FIGURE: 4

470000 E
480000 E
490000 E
500000 E
510000 E
520000 E

6170000N
6160000N
6150000N
6140000N
6130000N

N

Conklin

Christina Lake

Sunday Creek

May River

Birch Creek

Wiau River

Clyde Lake

Wiau Lake

Unnamed Lake #1

Ipiatik Lake

Ipiatik River

Behan Lake

WL

881

UL-11
TRIB-2
TRIB-5 (R 1)
TRIB-5 (R 2)
UL-8
TRIB-1
UL-1
UL-13
TRIB-5 (R 4)
UL-2
UL-12
UL-4
UL-5
UL-3
TRIB-4
TRIB-3

COLD LAKE AIR WEAPONS RANGE

LEGEND

- ROAD
- RAILWAY
- RIVER
- OPEN WATER
- KIRBY EXPANSION PROJECT LEASE AREA*
- AQUATICS LOCAL STUDY AREA (LSA)
- KIRBY SOUTH 2001, 2007

Note

*Includes Oil Sands Leases fully and partially held by Canadian Natural

REFERENCE

ALBERTA DIGITAL DATA OBTAINED FROM ALTALIS LTD. (SEPTEMBER 2004). USED UNDER LICENSE. DATUM: NAD83 PROJECTION: UTM ZONE 12. ALBERTA NTDB DIGITAL DATA OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.

5 0 5
SCALE KILOMETRES

PROJECT

Canadian Natural

KIRBY IN SITU OIL SANDS EXPANSION PROJECT

TITLE

KIRBY SOUTH PROJECT SITE LOCATIONS 2001, 2007

Golder Associates
Calgary, Alberta

PROJECT	10.1346.0052.6100		FILE	No.10134600526100B005	
DESIGN	MD	18/10/11	SCALE	1:250,000	REV. 0
CADD	TRE	08/12/11			
CHECK	MD	08/12/11			
REVIEW	KC	08/12/11			

FIGURE: 5

L:\20\01346\10-1346-0052\6100\Report B (6110)\Fig5 10134600526100B005_Kirby_South-ProjectSiteLocations2001,2007.dwg Dec 09, 2011 - 4:14pm

Fish species captured in Edwards Lake include northern pike and Iowa darter (Enermark 2008). The *2011 Alberta Guide to Sport Fishing Regulations* outlines specific restrictions for northern pike, lake whitefish and burbot in this waterbody (ASRD 2011b). The Fishing Regulations also includes a fish consumption advisory (mercury) for northern pike in Edwards Lake (ASRD 2011b).

Glover Lake

Glover Lake (Figure 4) was surveyed as part of the Kirby North 2010 Baseline (Enermark 2008). The lake is approximately 6.7 km^2 in surface area and forms the headwaters of Birch Creek (Figure 4). Glover Lake has a maximum depth of about 10.2 m and drains to the west.

Glover Lake provides suitable habitat for sport fish, non-sport fish and forage fish species. Dissolved oxygen levels in the winter were relatively high, providing suitable overwintering habitat for sport, non-sport and forage fish species.

Fish species captured in Glover Lake include northern pike and spottail shiner (Enermark 2008). The *2011 Alberta Guide to Sport Fishing Regulations* outlines specific restrictions for northern pike, lake whitefish and burbot in this waterbody (ASRD 2011b).

Unnamed Waterbodies Within the Christina River at Chard Sub-Basin

Several unnamed waterbodies within the LSA in the Christina River at Chard sub-basin have previously been evaluated as part of a baseline assessments for KS1 (Canadian Natural 2007) and the Kirby North 2010 (Enermark 2008). Fish species previously recorded include northern pike, white sucker, longnose sucker, lake chub and brook stickleback.

Two unnamed waterbodies were surveyed as part of the Kirby North 2010 baseline (Enermark 2008). Unnamed Waterbody 7 (WB-7) is approximately 0.4 km^2 in surface area located within the Christina River at Chard sub-basin. WB-7 is an isolated waterbody, with a maximum depth of 5.3 m and has no discernable inlet or outlet channels (Figure 4).

Unnamed Waterbody WB-7 was considered to have suitable habitat for forage fish, providing rearing, feeding and spawning habitat. However, the habitat suitability for sport fish (northern pike) and non-sport fish (suckers) may be limited by the lack of connectivity to streams in the area restricting migration into and out of the waterbody and low winter dissolved oxygen concentrations. Although this waterbody may provide suitable rearing and feeding habitat during

open-water seasons, the overwintering conditions would be severely limited for most sport or non-sport fish due to low dissolved oxygen concentrations. No fish were captured in WB-7 and there is no historical information identifying fish species in the waterbody (Enermark 2008).

Unnamed Waterbody 22 (WB-22) is approximately 0.5 km^2 in surface area and is located in Christina River at Chard sub-basin (Enermark 2008). This waterbody drains into Sunday Creek, a tributary of Christina River (Figure 4). Unnamed Waterbody WB-22 has a maximum measured depth of 10.2 m with abundant aquatic macrophytes. Unnamed Waterbody WB-22 provides suitable habitat for sport, non-sport and forage fish species. Dissolved oxygen levels in the winter were relatively high, providing suitable overwintering habitat for sport, non-sport and forage fish species. Yellow perch and unidentified forage fish were observed in the lake (Enermark 2008).

Other unnamed waterbodies evaluated were all shallow. The maximum depths for most of the lakes ranged between 1.6 m and 3.7 m, with some lakes having depths of less than 1.5 m. Most of these small lakes have significant oxygen depletion under ice or limited water depth during winter. Fish assemblages at these lakes consist primarily of brook stickleback and/or limited numbers of lake chub.

Watercourses

Birch Creek

Birch Creek is a tributary to Christina Lake (Figure 4). FRM Environmental Consulting Ltd. (1994) conducted a habitat survey on the lower portion of Birch Creek near its confluence with Christina Lake in 1993. Habitat in Birch Creek was dominated by runs with occasional pools and riffles (FRM 1994, 1995a). Channel width was measured to be between 8.3 m and 12.0 m, with maximum water depths ranging from 0.2 to 0.4 m. Substrate was composed of fines and sand with occasional rubble and boulders (FRM 1995a, 1996). Fish species captured in Birch Creek include northern pike, brook stickleback and slimy sculpin (FRM 1994, 1995a, 1996, 1998).

Birch Creek was surveyed at two locations (BC-1 and BC-2, Figure 4) as part of the Enerplus Kirby Oil Sands Project Phase 1 baseline surveys (Enermark 2008). The habitat-use potential in Birch Creek was low to moderate for all reaches, which consisted of mostly shallow runs. Although dissolved oxygen levels in winter were suitable to support overwintering for sport fish and non-sport fish species, shallow winter depths may be limiting. Fish species captured included longnose sucker, finescale dace, brook stickleback and slimy sculpin.

Sunday Creek

Sunday Creek (Figure 4), is a tributary to Christina Lake, and has been sampled by Devon (2004), EnCana (2008), FRM (1995b, 1996, 1998) and Van Horne (1998). Sunday Creek was characterized by run habitat and some pools and riffles (Devon 2004, 2006; FRM 1995b, 1996, 1998). At the surveyed sites, the substrate was composed of fines, sand, gravel, cobble and boulders (Devon 2004, 2006; FRM 1995b, 1996, 1998). Fish species captured in Sunday Creek include Arctic grayling, northern pike, lake whitefish, walleye, white sucker, brook stickleback, lake chub, slimy sculpin and spoonhead sculpin (FRM 1995b, 1996, 1998; Van Horne 1998; ASRD 2011a). Arctic grayling are listed as a "Species of Special Concern" in Alberta (ASRD 2010).

Sunday Creek was surveyed at two locations (SC-1 and SC-2, Figure 4) as part of the Enerplus Kirby Oil Sands Project Phase 1 baseline surveys (Enermark 2008). The habitat-use potential in Sunday Creek was low to moderate for all reaches, which consisted primarily of shallow run habitat, and is accessible to fish from Christina Lake. Relatively high winter dissolved oxygen levels would provide potential for overwintering, although much of Sunday Creek in the surveyed areas consisted of shallow run areas that could freeze to the bottom during winter. Fish species captured included northern pike, white sucker, spottail shiner and Iowa darter.

Unnamed Watercourses Within the Christina River at Chard Sub-Basin

Unnamed Watercourse 12 (WC-12) is a tributary to Edwards Lake and is located within the Christina Lake at Chard sub-basin (Figure 4). The watercourse was observed to be dry in the fall but water was observed in the spring. Habitat use potential for sport, non-sport and forage fish is nil to low. Overwintering habitat use potential was not likely due to the dry conditions observed in the fall. However, farther downstream near Edwards Lake, it is likely impounded areas could provide overwintering habitat use potential for forage fish (Enermark 2008). Brook stickleback were captured.

Unnamed Watercourse13 (WC-13) is a tributary to Glover Lake and is located within the Christina Lake at Chard sub-basin (Figure 4). Beaver impoundments were observed in the watercourse downstream of the site. Habitat use-potential for sport, non-sport and forage fish is nil to low (Enermark 2008). No fish were captured.

Lac la Biche Sub-Basin

Waterbodies

Wiau Lake

Wiau Lake is a large, shallow lake that drains to the south through the Wiau River to Clyde Lake (Figure 4). Clyde Lake is within the Lac la Biche watershed that flows into the Athabasca River. Wiau Lake consists of two large bays (north and south) separated by a long narrow channel with dense growths of aquatic vegetation.

Submergent and emergent macrophytes are abundant in the lake with large areas of yellow water lily. During bathymetric investigations of the south bay in 1998, depths varied from 1.5 to 3.0 m. The substrate was composed of a layer of soft, saturated silt overlaying a firmer clay/sand layer. Macrophyte growth was abundant, with dense mats observed even at the deepest parts of the lake (Golder 1998).

The Alberta Land Inventory (AENV 1976 to 1977) classified Wiau Lake as a Class 4 waterbody. Class 4 lakes are generally shallow, fed by seasonally intermittent streams, and show oxygen depletion during the winter with numerous and severe limitations on sport fish production. Although the tributaries to Wiau Lake are not seasonally intermittent, the lake is relatively shallow (maximum depth approximately 3 m), and oxygen depletion measured below the ice during the winter field survey in 2001 and 2007 indicated that low oxygen conditions below the ice may limit fish production in Wiau Lake and periodic winter kills may occur (Canadian Natural 2007). Surveys during the spring and summer 2001 found dissolved oxygen levels to be high (Canadian Natural 2007).

Wiau Lake has been found to provide overwintering habitat for northern pike and yellow perch. The abundance of aquatic vegetation provides habitat for spawning, rearing and feeding for resident fish populations, particularly northern pike. Northern pike and yellow perch are the two sport fish species that have been documented to occur in Wiau Lake (Canadian Natural 2007; Golder 1998).

Unnamed Waterbodies Within the Lac la Biche Sub-Basin

Numerous unnamed waterbodies within the Lac la Biche sub-basin are located within the LSA, all of which are contained within the smaller Wiau Lake watershed. Fish and fish habitat assessments were completed on eight of the unnamed waterbodies from 2001 and 2007 in support of KS1 (Canadian Natural

2007). The locations of the unnamed waterbodies referenced below are shown in Figure 5.

Unnamed Lake 1

Unnamed Lake 1, locally referred to as Big Muskeg Lake, is a large lake (3.1 km^2) located within the LSA (UL-1, Figure 5). Unnamed Lake 1 has moderate overwintering potential for fish with under ice depths of 1.1 m and Dissolved Oxygen (DO) ranges from 0.65 to 7.5 mg/L (Canadian Natural 2007).

Sedges and willow are found along the edge of UL-1, with black spruce coniferous forest 10 to 50 m back from the lake. UL-1 has upland ridges along the east and west shorelines. Aquatic macrophytes recorded in the lake include emergent common cattail, bulrushes and sparse yellow pond-lily. Submergent vegetation included water milfoil and pondweed. Northern pike and white sucker have been caught in the lake during spring indicating potential for spring spawning within the lake.

Water depth is fairly uniform, with depths primarily in the range of 1.5 to 2.0 m during the summer. The maximum depth measured in UL-1 is a small hole with a depth of 4.8 m along the east shoreline. Substrate throughout the lake consists of silt and sand, with silt, sand and occasional small gravel near the shoreline. Habitat quality for spawning, rearing and feeding of the resident northern pike, white sucker and minnow populations is considered moderate.

The inlet and outlet streams (sections of the unnamed tributary to Wiau Lake) are fairly wide, deep, slow-moving channels with flooded sedge vegetation along the margins and extensive submergent macrophyte growth. A series of beaver dams are present in the inlet and outlet, which may limit access for migrating fish. However, the channels between the lake and the first beaver dams provide suitable spawning and rearing habitat for fish species present in the lake, including white sucker and northern pike.

Northern pike, white sucker, lake chub and brook stickleback have been captured in UL-1. Given the depth and the presence of potential barriers to migration upstream and downstream of the lake, the fish species captured are likely resident and overwinter in UL-1. The abundance of aquatic vegetation provides habitat for spawning, rearing and feeding for resident minnow populations. The margins of the lake, as well as inlet and outlet streams also appear to provide spawning substrates for white sucker and northern pike.

Unnamed Lake 2

Unnamed Lake 2 is a small lake located along the tributary to Wiau Lake (UL-2, Figure 5). The lake is shallow (0.5 m) and hence unlikely to provide overwintering habitat for fish.

The lake is located in a wide sedge/moss wetlands. Emergent vegetation also includes yellow pond-lily and bulrushes along lake margins. Submergent vegetation includes milfoil and pondweed. Substrate throughout the lake consists of silt and detritus. Habitat quality in the lake for spawning, rearing and feeding is considered low for forage fish species.

Downstream of the lake, the stream would provide only approximately 100 m of habitat for resident lake fish before extensive beaver dams result in barriers to movement. Upstream of the lake, the channel is undefined and ponded, limiting fish potential. Only brook stickleback have been captured in the lake.

Unnamed Lake 3

Unnamed Lake 3 is located at the headwaters of the unnamed tributary flowing through the LSA (UL-3, Figure 5). Low winter DO concentrations have been recorded in Unnamed Lake 3 with limited water depth below the ice (1.1 m). Overwintering potential for fish populations is considered low.

A wide border of sedge and moss surrounds Unnamed Lake 3, with small black spruce set back from the lake. Yellow pond-lily and bulrushes are also present at the lake during the summer. Substrate throughout the lake consists of fine sediments and detritus. Dissolved oxygen levels of 8.1 mg/L have been measured during a summer survey (Canadian Natural 2007), which is relatively low conductivity compared to the other lakes. Habitat quality for spawning, rearing and feeding is low to moderate for resident minnow species.

No inlet streams are present and there is no defined outlet channel to the lake. At the northeast point of the lake, there is a wet, vegetated swale, with no channelization, preventing fish migration between the lake and the stream system.

Brook stickleback and lake chub have been captured in Unnamed Lake 3.

Unnamed Lake 4

Unnamed Lake 4 is located within the LSA in the Lac la Biche sub-basin, northeast of Unnamed Lake 3 (UL-4, Figure 5). Overwintering potential is considered to be low for sport fish and moderate for forage fish. No fish were caught in the winter 2007 fish survey.

A border of sedges and cattails surround the lake, within a black spruce forest. Water lilies are also present along the northwest and southeast shores of the lake. The substrate throughout the lake is primarily comprised of silt, fine sand and detritus. Unnamed Lake 4 is one of the deeper of the small lakes in the Lease Area. Most of the lake is less than 2.2 m in depth; however, a few small deep holes have been recorded with depths of 3.7 m. Unnamed Lake 4 is isolated, with no inlet or outlet streams present at the lake.

Numerous brook sticklebacks have been captured in the lake but no other fish species have been recorded during baseline surveys (Canadian Natural 2007). The overall habitat potential for Unnamed Lake 4 is low since it is not suspected to support large-bodied fish.

Unnamed Lake 7

Unnamed Lake 7 is a small, shallow lake to the south of Unnamed Lake 1 with limited overwintering potential for fish populations (UL-7, Figure 5).

A wide border of sedges surrounds Unnamed Lake 7, in a black spruce forest. In the summer, emergent vegetation is predominantly yellow pond-lily located along the lake margin. The lake is flat-bottomed and shallow with a maximum depth of 1.1 m. Substrate is primarily soft silt and sand. Spring DO levels are fairly low, but levels of 11 mg/L have been measured during the summer (Canadian Natural 2007). Unnamed Lake 7 is isolated, with no inlet or outlet streams.

Only brook stickleback have been captured in Unnamed Lake 7.

Unnamed Lake 11 / Unnamed Waterbody 21

The same waterbody was surveyed and called Unnamed Lake 11 (UL-11) for KS1 (Canadian Natural 2007) and Unnamed Waterbody 21 (WB-21) for Kirby North 2010 (Enermark 2008) (Figures 4 and 5).

UL-11/WB-21 is located to the northeast of Wiau Lake and drains into the unnamed tributary to Wiau Lake (Figures 4 and 5). The waterbody is shallow with a maximum depth of about 1.6 m with a large littoral zone. Winter surface

DO levels have been found to be relatively high in this small lake with a range of 2.2 to 5.2 mg/L (Canadian Natural 2007), although water depth below the ice was only 1.0 m. Overwintering potential for fish populations is considered low. The waterbody was considered to have habitat for forage fish, providing rearing, feeding and spawning habitat. However, the habitat suitability for sport fish (northern pike) and non-sport fish (suckers) may be low due to shallow depths and low winter dissolved oxygen. No fish have been captured although numerous forage fish were observed in the lake during surveys (Enermark 2008).

Unnamed Lake 12

Unnamed Lake 12 is a small lake between Unnamed Lake 2 and Unnamed Lake 7 (UL-12, Figure 5). Unnamed Lake 12 is located within a large sedge wetlands. Emergent vegetation at the lake includes sedges, bulrushes and yellow pond-lily. The lake contains an active beaver lodge and beaver dam. The lake is shallow, with most of the lake less than 2.0 m in depth, and a maximum depth of 2.5 m. Substrate is comprised primarily of silt and sand. Habitat for spawning, rearing and feeding is considered low to moderate for minnow species.

Unnamed Lake 12 is isolated with no inlet or outlet streams. Brook stickleback is the only fish species that has been captured in Unnamed Lake 12.

Unnamed Lake 13

Unnamed Lake 13 is a small lake to the west of Unnamed Lake 1 (UL-13, Figure 5). Unnamed Lake 13 is located in sedge wetlands, within a black spruce forest. During summer, the east end of the lake is normally covered with emergent water lilies. The lake is shallow, with a maximum depth of 1.2 m. Substrate consists of fine silt and sand. Spawning, rearing and feeding habitat quality is considered to be low for all fish species. Unnamed Lake 13 is isolated, with no inlet or outlet streams. No fish have been captured in Unnamed Lake 13.

Watercourses

Unnamed Watercourses Within the Lac la Biche Sub-Basin

Fish and fish habitat surveys have been conducted for several unnamed watercourses that drain into Wiau Lake (Figure 5) as part of KS1 (Canadian Natural 2007).

Unnamed Major Tributary to Wiau Lake

The major unnamed tributary of Wiau Lake, labelled as Tributary #5 (TRIB-5, Figure 5), has been assessed at multiple locations from its headwaters to the confluence with Wiau Lake (Canadian Natural 2007). Near the confluence with Wiau Lake, the watercourse is a low gradient (less than 0.5%), wide, flooded channel flowing through sedge/willow wetlands. The wetted width ranged from approximately 10 to 15 m during previous spring surveys (Canadian Natural 2007). The habitat is composed entirely of low to moderate quality runs (R3, R2), with silt substrate and depths of 0.5 to 1.0 m in depth. Cover is provided mainly by instream vegetation, with some overhanging willow present along margins. The tributary provides sufficient depth for fish to overwinter, however low DO in winter may preclude some fish species from utilizing the survey area. Also, it is likely that most fish would move into Wiau Lake to overwinter, if accessible. Spring DO levels have been found to be adequate for sport fish. Overall, this tributary to Wiau Lake would provide moderate to high rearing and feeding habitat for resident Wiau Lake fish, as well as suitable northern pike spawning habitat in the spring.

Most of the tributary to Wiau Lake is extensively influenced by beaver activity with low-quality runs (R3), beaver impoundments and limited riffle sections. Boulder/cobble riffle habitat is present downstream of Unnamed Lake 1. A spring survey conducted in 2007 indicated sufficient water levels and DO for fish with spawning and rearing habitat.

Seven fish species have previously been captured during baseline sampling in the major tributary to Wiau Lake. Northern pike, yellow perch, white sucker, finescale dace, brook stickleback, lake chub and fathead minnow have been captured in this tributary. Although spawning habitat exists for several species, no eggs have been recorded previously. White sucker adults were captured in a gill net set in 2001.

Other Unnamed Watercourses

Surveys have previously been completed for two secondary tributaries to the unnamed tributary to Wiau Lake, labelled as Tributary 1 (TRIB-1) and Tributary 2 (TRIB-2) (Figure 5). These watercourses are small and may provide rearing habitat for juvenile lake resident fish species. The substrate is primarily silt with limited cover provided by sedge vegetation at the margins. The presence of multiple small woody debris jams and beaver dams restrict fish migration. Water depth and flow is limited in these tributaries with most having no defined channels. Only brook stickleback have been captured in these watercourses.

Unnamed Watercourse 11 (WC-11) is a tributary to Wiau Lake within the Lac la Biche sub-basin (Figure 4). WC-11 consisted mainly of deeper runs accessible to fish from Wiau Lake and has low to moderate habitat potential for sport and non-sport fish species. Habitat potential for forage fish is moderate to high. Although dissolved oxygen levels in winter were suitable for sport fish and sucker overwintering, shallow winter depths may be limiting for these species (Enermark 2008). Fish captured included northern pike, yellow perch, white sucker, lake chub, brook stickleback, fathead minnow and logperch (Canadian Natural 2007; Rio Alto 2002).

3.1.1.3 Documented Fish Species Distribution

A list of fish species documented to occur in the RSA and LSA was compiled from the available literature (Table 16), including historical information, recent information collected from within the RSA, and recent baseline data collected by Canadian Natural. Information was available from various surveys conducted between 1967 and 2009. The distribution of fish species is shown with respect to the main watersheds and sub-basins in the RSA.

In total, 26 fish species have been recorded within the RSA, including 9 sport species, 2 non-sport (i.e., sucker) species and 15 small-bodied forage fish species. Sport fish distribution is widespread throughout the RSA. Fish communities in the smaller tributaries and waterbodies are dominated by forage fish species, with the most widely distributed of these species being brook stickleback and lake chub. The most widely distributed sport fish species documented within the RSA and LSA is northern pike.

No fish species previously recorded within the RSA are listed under the Canadian *Species at Risk Act* (SARA) (SARA 2011) or by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2011), which constitutes the federal lists of endangered species, threatened species and species of special concern. Provincially, Arctic grayling are classified as a “Species of Special Concern” (ASRD 2010).

3.1.1.4 Fishing Pressure and Fish Harvest

Aquatic resources in the LSA that provide exploitable fish populations of importance to sport or traditional fisheries are limited. Key resources are the mainstem tributaries of the Christina Lake, which supports key species such as Arctic grayling, burbot, northern pike and walleye, and Wiau Lake, which supports northern pike and yellow perch.

In the portion of the RSA directly adjacent to the LSA, key resources with exploitable fish populations include the mainstem of the Christina River, the mainstem of the Winefred River, Christina Lake and Winefred Lake. Christina and Winefred lakes both provide important sport fisheries. Sport fishing lodges or camps operate on Christina and Winefred lakes that target species such as Arctic grayling, northern pike and walleye.

Table 16 Documented Fish Species in the Aquatics Regional Study Area and Local Study Area

Guild	Species	Christina River at Chard Sub-Basin		Pony Creek and Kettle River Sub-Basin		Winefred River Sub-Basin		Sand River Basin		Lac la Biche Basin	
		Watercourses	Waterbodies	Watercourses	Waterbodies	Watercourses	Waterbodies	Watercourses	Waterbodies	Watercourses	Waterbodies
Sport fish	Arctic grayling	♦	♦	♦	□	♦	♦	□	□	□	□
	burbot	♦	♦	♦	□	♦	♦	□	♦	□	♦
	cisco	□	♦	□	□	□	♦	♦	♦	♦	♦
	goldeye	♦	□	□	□	□	□	□	□	□	□
	lake trout	□	□	□	□	□	♦	□	□	□	□
	lake whitefish	♦	♦	□	□	□	♦	♦	♦	□	♦
	northern pike[(a)]	♦	♦	□	□	♦	♦	♦	♦	♦	♦
	walleye	♦	♦	□	□	♦	♦	♦	♦	♦	♦
	yellow perch		♦	□	□	♦	♦	♦	♦	♦	♦
Suckers	longnose sucker	♦	♦	♦	□	♦	□	♦	♦	□	♦
	white sucker[(a)]	♦	♦	♦	□	♦	♦	♦	♦	♦	♦
Forage fish	brook stickleback[(a)]	♦	♦	♦	□	♦	♦	♦	♦	♦	♦
	fathead minnow	□	□	□	□	□	□	♦	♦	♦	□
	finescale dace[(a)]	□	□	♦	□	♦	♦	♦	□	♦	□
	Iowa darter	□	♦	□	□	□	□	♦	♦	□	♦
	lake chub[(a)]	♦	♦	♦	□	♦	□	♦	♦	♦	♦
	logperch	□	□	□	□	□	□	♦	□	♦	□
	longnose dace	□	□	□	□	♦	□	♦	□	□	□
	ninespine stickleback	□	♦	□	□	□	♦	♦	♦	□	♦
	northern redbelly dace[(a)]	□	□	♦	□	♦	♦	♦	□	□	□
	pearl dace	♦	□	♦	□	♦	□	□	□	♦	□
	river shiner	□	□	□	□	□	♦	□	□	□	□
	slimy sculpin[(a)]	♦	□	♦	□	□	♦	□	□	□	□
	spoonhead sculpin	♦	□	♦	□	□	□	□	□	□	□
	spottail shiner	♦	♦	□	□	♦	♦	♦	♦	□	♦
	trout-perch	♦	♦	♦	□	□	♦	□	□	□	□

(a) Indicates fish species captured during 2011 field surveys.

Note: ♦ Denotes documented fish presence. □Denotes absence of fish species captured.

The LSA does not have any potential to support commercial fisheries, and the potential within the RSA is limited to the larger named waterbodies in the Christina River, Sand River, Lac la Biche and Winefred River sub-basins. Many of these lakes have historically supported commercial fisheries but most have been shut down in recent years and are managed as sport fisheries. A small number of commercial fishing licenses remain active, but harvest is minimal within the RSA. Lac la Biche, Touchwood Lake and Wolf Lake are the only lakes within the RSA that supports an annual commercial harvest.

3.1.2 Baseline Field Surveys (2011)

Fish and fish habitat data collected specifically for the Project in winter and summer 2011 for selected waterbodies and watercourses within the LSA are presented in the following sections. Habitat maps and photographs for the surveyed sites are presented in Attachment B.

3.1.2.1 Fish Inventory

Fish Sampling

Winter Surveys

Waterbodies WL-1, WB-1 and WB-2 were sampled with minnow traps in March 2011 (Figure 3, Table 6). Brook stickleback was the only fish species captured at WB-2, where 11 fish were captured. Underwater video sampling was conducted at WL-1, WB-1, and WB-2; no fish were observed. Waterbodies WB-3 and WB-4 were not sampled in the winter.

Only one watercourse site, SCT-3, had conditions suitable for conducting under-ice fish sampling (Figure 3, Table 6). Six brook stickleback were captured at SCT-3 and one brook stickleback was captured at SCT-1 (Figure 3) in shallow water when removing the ice auger from the hole that was drilled. All other watercourse sites were too shallow for minnow trapping or frozen to the stream bed. No fish were observed during underwater video recording and viewing.

Open-Water Seasons

Seasonal open-water catch results by species are presented in Tables 17 and 18 for waterbodies and watercourses, respectively. Seasonal CPUE by species is summarized for waterbodies and watercourses in Attachment C, Tables C-1 and C-2, respectively.

Table 17 Fish Species Captured at Waterbody Sampling Sites, 2011

Site ID	Season	Number Captured		Total
		Sport Fish	Forage Fish	
		Northern Pike	Brook Stickleback	
WL-1	Winter	n/c	n/c	**0**
	Summer	4	n/c	**4**
WB-1	Winter	n/c	n/c	**0**
	Summer	n/c	269	**269**
WB-2	Winter	n/c	11	**11**
	Summer	n/c	26	**26**
WB-3	Winter	n/s	n/s	**0**
	Summer	n/c	26	**26**
WB-4	Winter	n/s	n/s	**0**
	Summer	n/c	25	**25**
Total		**4**	**357**	**361**

Notes: n/c = not captured; n/s = not sampled.

Table 18 Fish Species Captured at Watercourse Sampling Sites, 2011

Site ID	Season	Number Captured						Total
		Non-Sport Fish	Forage Fish					
		White Sucker	Slimy Sculpin	Northern Redbelly Dace	Brook Stickleback	Finescale Dace	Lake Chub	
WLT-1	Winter	n/s	n/s	n/s	n/s	n/s	n/s	**0**
	Summer	n/c	n/c	n/c	n/c	n/c	n/c	**0**
WLT-2	Winter	n/s	n/s	n/s	n/s	n/s	n/s	**0**
	Summer	n/c	n/c	n/c	22	n/c	n/c	**22**
SCT-1	Winter	n/s	n/s	n/s	n/s	n/s	n/s	**0**
	Summer	n/c	23	n/c	n/c	n/c	n/c	**23**
SCT-2	Winter	n/s	n/s	n/s	1	n/s	n/s	**1**
	Summer	n/c	n/c	n/c	107	n/c	n/c	**107**
SCT-3	Winter	n/c	n/c	n/c	6	n/c	n/c	**6**
	Summer	4	n/c	n/c	114	1	n/c	**119**
UNT-1	Winter	n/s	n/s	n/s	n/s	n/s	n/s	**0**
	Summer	7	n/c	1	54	213	94	**369**
Total		**11**	**23**	**1**	**304**	**214**	**94**	**647**

Notes: n/c = not captured; n/s = not sampled.

Listed Species

No fish species recorded within the LSA in the immediate vicinity of the Lease Area during the current field sampling program are listed under the Canadian *Species at Risk Act* (Government of Canada 2003) or by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2011), which constitute the federal lists of endangered species, threatened species and species of special concern.

3.1.2.2 Habitat Evaluation and Fish Use

Waterbodies

Christina River at Chard Sub-Basin

Unnamed Waterbody 1 (WB-1)

Unnamed Waterbody WB-1 is located in the centre of the LSA and has a surface area of 0.6 km^2 (Figure 3). The maximum depth of WB-1 was 1.2 m, measured during the summer sampling season (Table 19).

Winter Habitat Survey

During the winter survey at WB-1, ice thickness was 0.6 m, with a maximum under-ice water depth of 0.9 m (Table 19). Dissolved oxygen was low, ranging from 0.9 to 1.7 mg/L. Water temperature varied slightly throughout the water column ranging from 0.6°C near the surface to 2.1°C near the bottom. Conductivity ranged from 247 to 282 µS/cm. The waterbody may provide overwintering habitat for fish due to the sufficient under ice water depth but might be limited due to the low DO levels. The conditions would be mainly useable by small-bodied species that are tolerant of low DO levels (e.g., brook stickleback).

Underwater video sampling was conducted at WB-1 (Table 6); no fish were observed however, visibility was limited due to poor water clarity.

Open Water Habitat Survey

Unnamed Waterbody WB-1 is situated in a coniferous forest setting with shallow to moderate sloped shoreline (Attachment B, Figure B-1). A large portion of the lake was covered in dense floating and submergent vegetation. Unnamed Waterbody WB-1 was well oxygenated during summer, with DO levels ranging from 7.2 to 9.3 mg/L (Table 19). In the summer, water temperature near the surface averaged 18.5°C and 17.5°C near the bottom.

Table 19 Water Quality Profiles for Unnamed Waterbody (WB-1)

Season	Point or Profile	Station	Maximum Depth [m]	Sample Depth [m]	Dissolved Oxygen [mg/L]	pH	Temperature [°C]	Conductivity [µS/cm]
winter	profile	1	0.8	0.1	1.7	7.1	0.6	254
				0.5	1.1	7.0	2.1	247
	point	2	0.9	0.4	0.9	6.9	0.6	275
	point	3	0.3	0.1	1.0	6.9	0.2	282
summer	profile	1	1.05	0.1	9.3	8.0	18.2	153
				0.8	7.2	7.6	17.4	152
		2	1.2	0.1	8.0	8.1	18.5	154
				1	8.8	8.0	17.5	153
		3	1.2	0.1	8.6	8.0	18.5	154
				1	8.5	8.0	17.9	154
		4	1.1	0.1	8.8	8.1	18.5	154
				1	9.1	8.0	18.3	154
		5	1.1	0.1	8.4	8.0	18.3	154
				1	8.5	8.0	18.2	154

Note: Point measurements are taken at a single depth. Profile measurements are taken from a series of depths at the same location.

Fish Use

No gill net sampling was conducted at WB-1 during summer due to abundant aquatic vegetation growth not allowing the net to be set correctly. Brook stickleback were captured during trap minnow sampling conducted during summer (Table 17). Numbers of fish recorded are presented in Table 17 and CPUE data are presented in Attachment C, Table C-1.

Fish Habitat Suitability

Unnamed Waterbody WB-1 was considered to provide habitat for use by forage fish species. However, the habitat suitability for sport fish (northern pike) and suckers may be low due to the shallow depth and lack of a defined outlet channel. Spawning habitat was limited to species that spawn on vegetation or fine sediments (e.g., northern pike, brook stickleback). Although the waterbody may provide rearing and feeding habitat during open-water seasons, the waterbody did not have suitable conditions for sport fish or sucker overwintering due to low DO levels.

The habitat use potential of WB-1 was rated as follows:

- sport fish (northern pike) – nil to low for overwintering, and moderate for spawning, nursery, rearing and feeding;
- suckers – nil to low for overwintering, nil for spawning, and moderate for nursery, rearing and feeding; and

- forage fish – low for overwintering (species tolerant of low DO concentration), and moderate for spawning, nursery, rearing and feeding.

Unnamed Waterbody 2 (WB-2)

Unnamed Waterbody WB-2 is located within the LSA within the drainage area of Christina Lake (Figure 3). It has a surface area of 0.4 km^2. The maximum depth of WB-2 was 2.2 m, measured during the summer sampling season and 2.4 m during the winter, indicating year-to-year variability in lake level can occur (Table 20).

Table 20 Water Quality Profiles for Unnamed Waterbody (WB-2)

Season	Point or Profile	Station	Maximum Depth [m]	Sample Depth [m]	Dissolved Oxygen [mg/L]	pH	Temperature [°C]	Conductivity [µS/cm]
winter	profile	1	2.40	0.5	2.7	7.3	1.7	127
				1	1.0	7.1	3.5	158
				1.5	0.6	7.0	4.2	201
summer	profile	1	1.95	0.1	9.0	8.0	19.3	122
				1	8.6	8.0	17.9	123
				1.8	8.5	8.0	17.3	122
		2	2.00	0.1	9.3	8.0	19.2	123
				1	9.1	8.1	17.6	122
				2	8.8	8.0	17.5	122
		3	2.15	0.1	9.2	8.2	19.0	122
				1	8.9	8.2	17.6	122
				2	8.0	8.2	17.4	122
		4	2.10	0.1	9.5	8.2	19.0	122
				1	9.1	8.2	18.4	122
				2	8.9	8.1	17.4	122
		5	2.20	0.1	9.7	8.3	18.5	122
				1	9.9	8.3	17.5	122
				2	9.6	8.2	16.9	122

Note: Point measurements are taken at a single depth. Profile measurements are taken from a series of depths at the same location.

Winter Habitat Survey

During the winter survey at WB-2, ice thickness ranged from 0.5 to 0.6 m, with a maximum under-ice water depth of 2.4 m (Table 20). Dissolved oxygen was fairly low throughout the water column, ranging from 0.6 to 2.7 mg/L. Water temperature varied throughout the water column with cooler temperatures near the surface (1.7˚C) and warmer near the bottom (4.2˚C), which would indicate a groundwater source feeds the lake during the winter to maintain the increased temperatures. Conductivity was higher than during the open-water season, with an average measurement of 162 µS/cm. Although the waterbody has sufficient water depth to provide overwintering habitat for fish, it is considered low due to

the low DO levels. The conditions would be mainly useable for small-bodied species that are tolerant of low DO (e.g., brook stickleback).

Underwater video sampling was conducted at WB-2; however, no fish were observed (Table 6).

Open Water Habitat Survey

Unnamed Waterbody WB-2 is situated in a conifer forest setting with grass, forbs and shrubs linking the shallow sloped shoreline (Attachment B, Figure 3). During the summer field survey, almost the entire surface of WB-2 was sparsely covered with floating aquatic vegetation. An outlet stream flows out of the north end of the waterbody.

Water quality conditions at WB-2 were suitable to support fish during the open-water season. Water temperature was fairly uniform throughout the water column during summer sampling, with a minimum temperature of 16.9°C, and a maximum temperature of 19.3°C (Table 20). Dissolved oxygen levels in WB-2 were uniform throughout the water column at 8.0 to 9.9 mg/L (Table 20).

Fish Use

No fish were captured at WB-2 during gill-net sampling conducted during summer (Table 17). Twenty-six brook stickleback were captured during minnow trap sampling in the summer. Eleven stickleback were captured during minnow trap sampling conducted in the winter. Numbers of fish recorded are presented in Table 17 and CPUE data are presented in Attachment C, Table C-1.

Fish Habitat Suitability

Although very few fish were captured during baseline sampling, WB-2 was considered to provide overwintering habitat for use by sport fish, suckers, and forage fish species because of the sufficient water depth during winter. However, overwintering habitat may be considered low due to the low DO levels in the winter. Spawning habitat was available for species that spawn on vegetation or fine sediments (e.g., northern pike, brook stickleback). The habitat use potential of WB-2 was rated as follows:

- sport fish (northern pike) – nil to low for overwintering, and moderate for spawning, nursery, rearing and feeding;
- suckers – nil to low for overwintering, nil for spawning, and moderate for nursery, rearing and feeding; and

- forage fish – low for overwintering (except species tolerant of low DO concentration), and moderate for spawning, nursery, rearing and feeding.

Unnamed Waterbody (WB-3)

Unnamed Waterbody WB-3 is a small waterbody with a surface area of 0.2 km^2. Unnamed Waterbody WB-3 is located within the LSA within the drainage area of Christina Lake (Figure 3). The maximum depth of the WB-3 was 1.7 m, measured during the summer sampling season (Table 21).

Table 21 Water Quality Profiles for Unnamed Waterbody (WB-3)

Season	Point or Profile	Station	Maximum Depth [m]	Sample Depth [m]	Dissolved Oxygen [mg/L]	pH	Temperature [°C]	Conductivity [µS/cm]
summer	profile	1	0.89	0.1	9.4	8.5	14.9	69.0
				0.8	9.0	8.3	14.8	69.0
		2	1.70	0.1	9.5	8.2	15.0	68.9
				1	9.4	8.2	14.9	68.8
				1.6	9.5	8.3	14.9	68.8
		3	1.19	0.1	9.6	8.2	14.9	68.9
				1	8.5	8.2	14.9	69.4
		4	1.03	0.1	9.7	8.2	15.0	68.8
				1	9.8	8.2	15.0	68.8
		5	0.90	0.1	9.2	7.9	15.0	69.6
				0.8	9.1	7.9	15.0	69.4

Winter Habitat Survey

Unnamed Waterbody WB-3 was not sampled during winter sampling.

Open Water Habitat Survey

Unnamed Waterbody WB-3 is situated in a conifer forest setting with grass, forbs and shrubs linking the shallow sloped shoreline (Attachment B, Figure B-3). The bed substrate was predominantly silt and organic material. During the summer field survey, parts of the surface of WB-3 were covered with submergent or floating-leaved aquatic vegetation. An inlet stream flows into the southeast end of the waterbody, and an outlet stream flows out of the northeast end of the waterbody.

Water quality conditions at WB-3 were suitable to support fish during the open-water season. Water temperature was uniform throughout the water column during the summer sampling, with average temperature of 14.9°C (Table 21). Dissolved oxygen levels were fairly uniform throughout the water column, ranging from 8.5 to 9.8 mg/L (Table 21).

Fish Use

No fish were captured at WB-3 during gill-net sampling conducted during summer (Table 17). Twenty-six brook stickleback were captured during minnow trap sampling in the summer sampling. No fish sampling was conducted at WB-3 during the winter. Numbers of fish recorded are presented in Table 17 and CPUE data are presented in Attachment C, Table C-1.

Fish Habitat Suitability

Unnamed Waterbody WB-3 was considered to provide habitat for use by forage fish species during the open-water season. However, the habitat suitability for sport fish (northern pike) and suckers may be low due to the shallow depths. The suitability of WB-3 to provide overwintering habitat is assumed to be low, similar to other small waterbodies examined within the LSA. Unnamed Waterbody WB-3 provided spawning habitat for species that spawn on vegetation or fine sediments (e.g., northern pike, brook stickleback). Although the waterbody may provide suitable rearing and feeding habitat during open-water seasons, the waterbody may not provide suitable conditions for sport fish or sucker overwintering due to the shallow depth.

The habitat use potential of WB-3 was rated as follows:

- sport fish (northern pike) – nil to low for overwintering, and moderate for spawning, nursery, rearing and feeding;
- suckers – nil to low for overwintering, nil for spawning, and moderate for nursery, rearing and feeding; and
- forage fish – nil to low for overwintering (shallow depth), and moderate for spawning, nursery, rearing and feeding.

Unnamed Waterbody (WB-4)

Unnamed Waterbody WB-4 is a waterbody with a surface area of less than 0.1 km^2. Unnamed Waterbody WB-4 is located within the LSA within the drainage area of Christina Lake (Figure 3). The maximum depth of the WB-4 was 1.7 m, measured during the summer sampling season (Table 22).

Winter Habitat Survey

Unnamed Waterbody WB-4 was not sampled during winter sampling.

Table 22 Water Quality Profiles for Unnamed Waterbody (WB-4)

Season	Point or Profile	Station	Maximum Depth [m]	Sample Depth [m]	Dissolved Oxygen [mg/L]	pH	Temperature [°C]	Conductivity [µS/cm]
summer	profile	1	0.65	0.1	9.4	8.3	16.6	53.8
				0.5	9.2	8.0	16.3	50.7
		2	1.50	0.1	9.2	7.9	16.8	51.3
				1	9.2	7.9	16.5	51.5
				1.4	7.5	7.9	16.1	51.4
		3	1.70	0.1	9.2	7.8	16.9	50.7
				1	9.2	7.8	16.8	51.2
				1.6	9.1	7.8	16.7	51.1
		4	0.90	0.1	9.3	7.9	17.1	51.0
				0.8	9.0	7.9	17.1	51.0
		5	0.80	0.1	9.3	7.7	17.2	51.1
				0.7	9.0	7.7	17.2	51.1

Seasonal Habitat Survey

Unnamed Waterbody WB-4 is situated in a conifer forest setting with shallow sloped shoreline (Attachment B, Figure B-4). The bed substrate was predominantly silt and organic material. During the summer field survey, almost the entire surface of WB-4 was sparsely covered with submergent aquatic vegetation. An inlet stream flows into the west end of the waterbody but there was no visible outlet. A beaver lodge was present on the eastern shores of the waterbody.

Water quality conditions at WB-4 were suitable to support fish during the open-water season. Water temperature was fairly uniform at each location throughout the water column but varied slightly between locations during summer sampling. Temperature varied from 16.1°C to 17.2°C (Table 22). Dissolved oxygen levels in WB-4 were fairly uniform throughout the water column at 7.5 to 9.4 mg/L in the summer (Table 22).

Fish Use

No fish were captured at WB-4 during gill-net sampling conducted during summer (Table 17). Twenty-five brook stickleback were captured during minnow trap sampling in the summer. No fish sampling was conducted at WB-4 during winter. Numbers of fish recorded are presented in Table 17 and CPUE data are presented in Attachment C, Table C-1.

Fish Habitat Suitability

Although few fish were captured during baseline sampling, WB-4 was considered to provide habitat for use by forage fish species. Habitat suitability for sport fish

(northern pike) and suckers may be limited by the shallow depth. Spawning habitat was available to species that spawn on vegetation or fine sediments (e.g., northern pike, brook stickleback). The waterbody may provide rearing and feeding habitat during open-water seasons. Potential for overwintering habitat is considered to be low, similar to other small waterbodies examined within the LSA.

The habitat use potential of WB-4 was rated as follows:

- sport fish (northern pike) – nil to low for overwintering, and low for spawning, nursery, rearing and feeding;
- suckers – nil to low for overwintering, nil for spawning, and low for nursery, rearing and feeding; and
- forage fish – low for overwintering (except species tolerant of low DO concentration), and moderate for spawning, nursery, rearing and feeding.

Lac la Biche Sub-Basin

Wiau Lake (WL-1)

Wiau Lake is a large, shallow lake with a surface area of approximately 26 km^2 (Golder 1998). Wiau Lake drains to the south through the Wiau River to Clyde Lake, which is within the Lac la Biche watershed that flows into the Athabasca River (Figure 3). The lake consists of two large bays (north and south) separated by a long (approximately 3 km), narrow channel, with dense growths of aquatic vegetation (Golder 1998).

Winter Habitat Survey

During the winter survey at WL-1, ice thickness was 0.6 m, with a maximum under-ice water depth of 1.0 m (Table 23). Dissolved oxygen was low, ranging from 1.4 to 3.1 mg/L. Water temperature varied slightly throughout the water column ranging from 0°C near the surface to 2.0°C near the bottom. Conductivity ranged from 226 to 254 µS/cm. The waterbody provides overwintering habitat for fish due to the sufficient under ice water depth but might be limited due to the low DO levels. Sport fish tolerant to lower DO concentrations (e.g., northern pike) would be able to tolerate the concentrations observed. The conditions would be mainly useable by small-bodied species that are tolerant of low DO levels (e.g., brook stickleback).

Underwater video sampling was conducted at WL-1; however, visibility was limited due to poor water clarity and no fish were observed.

Table 23 Water Quality Profiles for Wiau Lake (WL-1)

Season	Point or Profile	Station	Maximum Depth [m]	Sample Depth [m]	Dissolved Oxygen [mg/L]	pH	Temperature [°C]	Conductivity [µS/cm]
winter	profile	1	1	0.1	3.1	7.0	0.3	244
				0.5	2.7	7.0	1.0	243
				0.9	1.4	7.0	2.0	254
	point	2	1	0.5	2.8	7.2	1.1	241
	point	3	1	0.5	2.8	7.1	1.6	226
summer	profile	1	1.05	0.1	6.4	7.6	16.9	162
				1	6.4	7.6	16.8	162
		2	1.95	0.1	8.0	8.0	17.2	159
				1	7.9	8.0	17.1	169
				1.8	7.9	7.9	17.1	160
		3	1.5	0.1	8.3	8.0	17.1	159
				1	7.9	8.0	17.0	159
				1.4	7.9	8.0	17.0	159
		4	1.75	0.1	8.6	8.1	16.9	158
				1	8.4	8.1	16.8	158
				1.5	6.9	7.7	16.8	160
		5	1.6	0.1	8.6	8.1	17.0	158
				1	8.6	8.1	16.9	159

Note: Point measurements are taken at a single depth. Profile measurements are taken from a series of depths at the same location.

Open Water Habitat Survey

Habitat surveys were not completed at Wiau Lake during the current assessment because sufficient information exists from previous assessments on the lake. Wiau Lake is situated in a mixedwood forest setting with emergent vegetation lining the shallow sloped shoreline. Submergent and emergent macrophytes are abundant in the lake, with large areas of yellow water lily covering several square kilometres. During bathymetric investigations of the south bay in 1998, depths varied from 1.5 to 3.0 m. The water depths observed during the current assessment ranged between 1.05 m and 1.95 m deep. The substrate was composed of a layer of soft, saturated silt overlaying a firmer clay/sand layer. Macrophyte growth was abundant, with dense mats observed even at the deepest parts of the lake (Golder 1998).

During the current assessment, water quality conditions at Wiau Lake were suitable to support fish during the open-water season. Wiau Lake was well oxygenated during the summer, with dissolved oxygen levels ranging from 6.9 mg/L near the bottom to 8.6 mg/L near the surface. Water temperature was fairly uniform across the lake during the open-water season (Table 23), with temperatures between 16.8°C and 17.2°C.

Fish Use

During the winter survey several fishermen were observed on Waiu Lake, thus suggesting sport fish were available to sustain a recreational harvest. Adult northern pike were captured during gill net sampling in the summer. No fish were captured at Wiau Lake during minnow trap sampling conducted during the winter or summer despite considerable effort during the summer sampling (Table 17). Although expected to be present, forage fish have not been captured during recent surveys and have not been reported in historic catch records either. Based on the literature review, only northern pike and yellow perch have been documented in Wiau Lake, with only northern pike captured in recent surveys. A larger number of species have been documented in the tributaries to Wiau Lake, so it is reasonable that a larger fish community is present in Wiau Lake than what has been documented with recent sampling efforts. Numbers of fish recorded are presented in Table 17 and CPUE data are presented in Attachment C, Table C-1.

Fish Habitat Suitability

Although only northern pike were captured during baseline sampling, Wiau Lake was considered to have habitat for use by sport fish, suckers and forage fish species. The habitat suitability for sport fish (northern pike) and suckers may be low due to the shallow depths. Wiau Lake provides suitable rearing and feeding habitat during open-water seasons, but suitable conditions for sport fish or sucker overwintering may be limited by the low dissolved oxygen during winter (Table 23).

The habitat use potential of Wiau Lake was rated as follows:

- sport fish (northern pike) – low for overwintering (low dissolved oxygen concentration); moderate for spawning, nursery use, rearing and feeding;
- suckers – moderate for spawning, nursery use, rearing and feeding; low for overwintering; and
- forage fish – low for overwintering; moderate for spawning, nursery use, rearing and feeding.

Watercourses

Christina River at Chard Sub-Basin

Unnamed Watercourse (SCT-1)

Unnamed WatercourseSCT-1 is a wide, low-gradient watercourse that flows through a boreal mixedwood and coniferous forest setting (Attachment B,

Figure B-6). Unnamed Watercourse SCT-1 is an unnamed tributary of Sunday Creek and drains from the northeast end of the LSA (Figure 3).

Winter Habitat Survey

Water quality parameters at SCT-1 were recorded during the winter sampling. Within the assessed reach covering 40 m in length only one site was not frozen to the substrate. The dissolved oxygen level was 8.6 mg/L with a water temperature of 0.1°C (Table 24). Conductivity was higher in the winter compared to the open-water season with a recording of 274 µS/cm. Discharge was not determined at unnamed watercourse SCT-1 during winter sampling due to the limited amount of water available. The dissolved oxygen level recorded in winter was adequate to provide a suitable environment for overwintering fish populations, but potential overwintering may be limited to the lack of connectivity of areas with suitable depth.

Table 24 Water Quality and Discharge Results for the Watercourses

Site ID	Season	Dissolved Oxygen [mg/L]	pH	Temperature [°C]	Conductivity [µS/cm]	Discharge [m^3/s]
WLT-1	winter	-[a]	-[a]	-[a]	-[a]	-[a]
	summer	8.7	6.9	15.3	102	0.002
WLT-2	winter	1.3	6.9	1.7	446	-[b]
	summer	6.0	7.0	8.9	115	0.006
SCT-1	winter	8.6	7.2	0.1	274	-[b]
	summer	9.0	7.8	12.6	226	0.075
SCT-2	winter	3.4	7.0	0.1	302	-[b]
	summer	5.9	7.1	10.4	215	0.006
SCT-3	winter	3.4	7.4	0.1	160	-[b]
	summer	6.7	7.5	19.0	155	0.013
UNT-1	winter	7.2	7.1	0.6	280	-[b]
	summer	8.4	7.8	16.0	142	0.013

[a] Stream frozen to substrate.

[b] No discharge measured.

Open Water Habitat Survey

Unnamed Watercourse SCT-1 had a maximum channel width of 7 m and wetted width of 6.4 m in pool habitat. The maximum channel depth was 1.3 m (Table 25).

The area surveyed was composed of riffle, run and pool habitat types, with areas of submergent and emergent vegetation (Attachment B, Figure 6). Several large wood debris jams were present at the sampling location. The substrate in the surveyed section consisted of cobble, sand, gravel and boulder.

Table 25 Summary of Open-Water Season Watercourse Habitat Assessment

Site ID	Length Surveyed [m][a]	Channel Type[b]	Maximum Depth [m]	Channel Width [m]	Wetted Width [m]	Habitat Unit [%][c]			Bed Material Type[d]		Overall Habitat Quality Rating
						R	RF	PL	Dominant	Sub-Dominant	
WLT-1	200	IP3	0.4	NA	NA	-	-	100	Or	C/S	low
WLT-2	250	R2	0.8	1.6	1.6	59	-	41	C/S	Sa	low
		R3	0.5	1.7	1.7				C/S	Sa	
		IP2	0.9	4.1	4.1				C/S	Sa	
SCT-1	200	RF	0.2	3.8	3.3	68	14	18	Co	Sa, Gr, Bo	moderate
		R3	0.9	4.1	3.9				Co	Sa, Gr, Bo	
		P1	1.3	7.0	6.4				Sa	Gr, Co	
		P2	1.1	6.3	5.5				Sa	Gr, Co	
SCT-2	100	R3	0.5	2.1	1.6	100	-	-	C/S	-	low
SCT-3	120	R3	0.7	2.6	1.8	59	-	41	Sa	C/S	low
		IP3	0.5	28	28				C/S	Sa	
UNT-1	205	RF	0.2	4.3	4.2	35	40	25	Co	Sa, Gr, Bo	moderate
		R3	0.6	3.7	3				Sa, Gr	Co, Bo	
		P1	1.5	5	5.6				Sa	Gr, Co, Bo	
		P3	0.8	6.4	6.2				Sa	Gr, Co, Bo	

[a] Length surveyed in the field.

[b] Where IP2 = impoundment pool class 2; IP3 = impoundment class 3; R2 = run class 2; R3 = run class 3; RF = riffle; P1 = pool class 1; P2 = pool class 2; and P3 = pool class 3.

[c] Where R = run; RF = riffle; and PL = pool.

[d] Where Or = organics; C/S = clay and silt; Sa = sand; Gr = gravel; Co = cobble; and Bo = boulder.

Instream cover was provided by substrate, submergent aquatic vegetation, emergent vegetation, overhanging vegetation and large wood debris. The surveyed reach provided habitat for fish.

Data from the open-water seasons show that water quality conditions at SCT-1 are suitable for fish during summer. Dissolved oxygen was 9.0 mg/L, and temperature was 12.6°C (Table 24). Conductivity was lower compared to winter at 226 µS/cm (Table 24). Discharge measured in the summer was 0.075 m^3/s.

Fish Use

Slimy sculpin were captured in the summer survey using backpack electrofishing (Table 18). No fish were captured during minnow trap sampling. No fish sampling took place in the winter because there was insufficient water depth for minnow traps. Numbers of fish recorded are presented in Table 18 and CPUE data are presented in Attachment C, Table C-2.

Fish Habitat Suitability

The habitat use potential at SCT-1 was considered low to moderate. The site was comprised of riffle, run and pool habitat that provided habitat for different fish guilds. Spawning habitat was present for species that require swift flow and rocky substrates, as well as for those species that prefer low-velocity areas with submerged vegetation. The presence of large woody debris jams provided an impediment to migration of large-bodied fish. Water quality sampling during the winter survey indicated that dissolved oxygen concentration (8.6 mg/L) was suitable for overwintering for some large-bodied and small-bodied fish species such as northern pike, slimy sculpin, and brook stickleback. However, overwintering habitat for large-bodied fish would be limited by the shallow water depth and intermittent areas of flowing water with many areas found frozen to the bottom.

Based on the types and proportions of channel unit types present, the habitat use potential in SCT-1 was rated as follows:

- sport fish (northern pike) – low for overwintering, low for spawning, and low to moderate for nursery, rearing and feeding;
- non-sport fish (suckers) – low for overwintering, low to moderate for spawning, and low to moderate for nursery, feeding and rearing; and
- forage fish – moderate for overwintering, spawning, nursery, feeding and rearing (all life stages).

Unnamed Watercourse (SCT-2)

Unnamed Watercourse SCT-2 is a narrow, low-gradient watercourse that flows through shrubs and mixedwood forest setting (Attachment B, Figure B-7). Unnamed Watercourse SCT-2 is an unnamed tributary of Sunday Creek and drains from the northeast end of the LSA (Figure 3).

Winter Habitat Survey

Water quality parameters at unnamed watercourse SCT-2 were recorded in winter. Ice thickness was 0.5 m and a water depth of 0.45 m. Dissolved oxygen level in winter was 3.4 mg/L and the water temperature was 0.1°C (Table 24). Conductivity was higher in the winter compared to the open-water season with a recording of 302 µS/cm. Unnamed Watercourse SCT-2 did not have a measurable discharge during winter sampling. Based on the dissolved oxygen level recorded in winter sampling, unnamed watercourse SCT-2 may be able to provide overwintering habitat for some forage fish species. However, water depth may limit suitability for large-bodied fish.

Open Water Habitat Survey

Unnamed Watercourse SCT-2 had a defined channel upstream of an old, blown out beaver dam at the sampling location. The unnamed watercourse was composed of run habitat. The large beaver dam downstream of the surveyed reach had failed and the channel weaved its way through the area that was previously part of a large impoundment. The unnamed watercourse had a maximum observed depth of 0.5 m, a channel width of 2.1 m and wetted width of 1.6 m (Table 25).

The area surveyed was run habitat (Attachment B, Figure B-7). Occasional woody debris was observed in the surveyed section. The substrate in the surveyed section consisted predominantly of clay and silt.

Instream cover was provided by submergent and emergent vegetation and depth. Overhead cover consisted of overhanging vegetation. No suitable spawning gravel substrate was found at the site at the time of survey.

Data from the open-water seasons show that water quality conditions at SCT-2 are marginally suitable for fish during summer. Dissolved oxygen was 5.9 mg/L and a temperature of 10.4°C (Table 24). Discharge measured in the summer was 0.006 m^3/s.

Fish Use

Brook stickleback were captured in the summer survey using backpack electrofishing and minnow trap sampling (Table 18). No fish sampling took place in the winter because there was insufficient water depth for minnow traps. Numbers of fish recorded are presented in Table 18 and CPUE data are presented in Attachment C, Table C-2.

Fish Habitat Suitability

The habitat use potential for site SCT-2 was considered to be low. The surveyed reach was comprised of a shallow run habitat. Suitable spawning habitat was absent for species that require swift flow and rocky substrates, but was present in small amounts for species that prefer low-velocity areas with submerged vegetation. Dissolved oxygen concentrations were suitable to provide overwintering habitat for lower DO concentration tolerant large-bodied and small-bodied fish species.

Based on the types and proportions of channel unit types present, the habitat use potential in SCT-2 was rated as follows:

- sport fish (northern pike) – low for overwintering, spawning, nursery, rearing and feeding (all life stages);
- non-sport fish (suckers) – low for overwintering, spawning, nursery, rearing and feeding (all life stages); and
- forage fish – low for overwintering, spawning, nursery, feeding and rearing (all life stages).

Unnamed Watercourse (SCT-3)

Unnamed Watercourse SCT-3 is a medium, low-gradient watercourse within a muskeg setting bordered by coniferous forest. Unnamed Watercourse SCT-3 is an unnamed tributary of Sunday Creek and drains from the northeast end of the LSA (Figure 3).

Winter Habitat Survey

The unnamed watercourse was assessed during winter sampling. Dissolved oxygen level in winter was 3.4 mg/L with a temperature of 0.1°C (Table 24). Conductivity during winter sampling was 160 µS/cm and was similar to readings recorded during summer sampling. Dissolved oxygen concentrations are suitable for species that are tolerant to lower levels. The water sampling was conducted in a beaver impoundment as it was the only location accessible during the winter survey. These conditions would be suitable for small-bodied fish species and the impoundment provides suitable depth of water for overwintering

habitat. Discharge was not recorded at unnamed watercourse SCT-3 during winter sampling.

Open Water Habitat Survey

Unnamed Watercourse SCT-3 had a defined channel with an average width of 2.6 m and wetted width of 1.8 m at the point of survey (Table 25). The maximum observed channel depth was 0.7 m. A large impoundment, 28 m wide and 49 m long, with a maximum depth 0.5 m, comprised a large proportion of the surveyed reach.

The area surveyed was mainly a run and impounded habitat (Attachment B, Figure B-8). The substrate in the surveyed section consisted predominantly of sand, clay and silt. Instream cover was provided by woody debris, depth of water, submergent and emergent vegetation. Overhead cover consisted of undercut banks and overhanging vegetation.

Data from the open-water season show that water quality conditions at SCT-3 are suitable for fish during summer. Dissolved oxygen was 6.7 mg/L and temperature was 19°C (Table 24). Discharge measured in the summer was 0.013 m^3/s.

Fish Use

White sucker, brook stickleback and finescale dace were captured in the summer survey using backpack electrofishing and minnow trap sampling (Table 20). Brook stickleback were captured in the winter during minnow trap sampling. Numbers of fish recorded are presented in Table 18 and CPUE data are presented in Attachment C, Table C-2.

Fish Habitat Suitability

The habitat use potential for unnamed watercourse SCT-3 was considered low for overwintering potential. Spawning habitat was absent for species that require swift flow and rocky substrates, but was present in small amounts for species that prefer low-velocity areas with submerged vegetation. The surveyed reach was comprised of run and impounded habitat. Beaver dams provided impediments to fish migration but provide potential overwintering habitat. Dissolved oxygen concentrations were suitable to provide overwintering habitat for lower DO concentration tolerant large-bodied and small-bodied fish species.

The habitat use potential in unnamed watercourse SCT-3 was rated as follows:

- sport fish – low for overwintering, and nil to low for spawning, nursery, rearing and feeding;
- non-sport fish (suckers) – low for overwintering, and low for spawning, nursery, rearing and feeding (all life stages); and
- forage fish – low to moderate for all life stages.

Winefred River Sub-Basin

Unnamed Watercourse (UNT-1)

Unnamed Watercourse UNT-1 is a medium, low-gradient watercourse that flows through a boreal mixedwood and coniferous forest setting (Attachment B, Figure B-9). The unnamed watercourse UNT-1 drains from the east end of the LSA and discharges into Winefred Lake (Figure 3).

Winter Habitat Survey

Water quality parameters at unnamed watercourse UNT-1 were recorded during the winter sampling. The dissolved oxygen level was 7.2 mg/L with a water temperature of 0.6°C (Table 24). Conductivity was nearly twice as high in the winter compared to the open-water season with a recording of 280 µS/cm. Discharge was not determined at unnamed watercourse UNT-1 during winter sampling. The dissolved oxygen level recorded in winter was adequate to provide a suitable environment for overwintering fish populations.

Seasonal Habitat Survey

Unnamed Watercourse UNT-1 had a maximum channel width of 6.4 m and wetted width of 6.2 m in the pool habitat (Table 25). The maximum channel depth was 1.5 m.

The area surveyed was composed of riffle, run and pool habitat types, with areas of submergent and emergent vegetation. Large wood debris was present at the sampling location. The substrate in the surveyed section was dominated by gravel and sand. Cobble and boulders were also present in the surveyed section.

Instream cover was provided by substrate, depth of water, submergent and emergent vegetation and woody debris. Overhanging vegetation was comprised primarily of overhanging vegetation.

Data from the open-water seasons show that water quality conditions at UNT-1 are suitable for fish during summer. Dissolved oxygen was 8.4 mg/L, and temperature was 16°C (Table 24). Conductivity was 142 µS/cm. Discharge measured in the summer was 0.013 m^3/s.

Fish Use

White sucker, northern redbelly dace, brook stickleback, finescale dace and lake chub were captured during the summer survey using backpack electrofishing and minnow trap sampling (Table 18). No fish sampling took place in the winter because there was insufficient water depth for minnow traps. Numbers of fish recorded are presented in Table 18 and CPUE data are presented in Attachment C, Table C-2.

Fish Habitat Suitability

The habitat use potential at UNT-1 was considered to be low to moderate. The site was comprised of riffle, run and pool habitat that provided habitat for various fish species. Spawning habitat was present for species that require swift flow and rocky substrates, as well as for those species that prefer low-velocity areas with submerged vegetation. Water quality sampling during the winter survey indicated that dissolved oxygen concentrations were suitable for overwintering for some large-bodied and small-bodied fish species such as northern pike, white sucker, lake chub, and brook stickleback. However, overwintering habitat for large-bodied fish may be limited by the shallow water depth.

Based on the types and proportions of channel unit types present, the habitat use potential in UNT-1 was rated as follows:

- sport fish (northern pike) – low for overwintering and spawning, and low to moderate for nursery, rearing and feeding;
- non-sport fish (suckers) – low to moderate for overwintering, low to moderate for spawning, and low to moderate for nursery, feeding and rearing; and
- forage fish – moderate for overwintering, spawning, nursery, feeding and rearing (all life stages).

Lac la Biche Sub-Basin

Unnamed Watercourse (WLT-1)

Unnamed Watercourse WLT-1 is a small, low-gradient watercourse that flows into Wiau Lake, within the Lac la Biche sub-basin (Figure 3).

Winter Habitat Survey

Unnamed Watercourse WLT-1 was frozen to the bottom during the winter survey and was assessed as having no overwintering potential.

Open Water Habitat Survey

Unnamed Watercourse WLT-1 did not have a defined channel upstream or downstream of Highway 881 and water was not confined except in a ditchline. Downstream of the highway the watercourse was unconfined with evidence of beaver activity. The maximum depth at the watercourse was 0.4 m (Table 25).

The area surveyed was mainly an impoundment pool, with some areas of submerged and emergent vegetation (Attachment B, Figure B-10). The substrate in the surveyed section consisted predominantly of organics with some clay and silt.

Instream cover was provided by woody debris, submergent aquatic vegetation, emergent vegetation, and depth of water. Overhead cover consisted of overhanging vegetation. Data from the open-water seasons indicate that water quality conditions at WLT-1 are suitable for fish during summer. In summer, dissolved oxygen was 8.7 mg/L and temperature was 15.3°C (Table 24).

Fish Use

No fish were captured during minnow trap sampling in the summer. Backpack electrofishing was not conducted as the watercourse was unconfined.

Fish Habitat Suitability

The habitat use potential in WLT-1 was considered to be nil to low. The watercourse lacked a defined channel in most areas therefore impeding fish migration. Spawning habitat was absent at this location for species that require swift flow and rocky substrates, but was present in small amounts for species that prefer low-velocity flow with submerged vegetation. Water quality sampling during summer sampling indicated that dissolved oxygen concentrations (8.7 mg/L) were suitable for fish. Overwintering habitat for all fish was absent during winter because the watercourse was frozen to the bottom within the surveyed reach.

Based on the types and proportions of channel unit types present, the habitat use potential in unnamed watercourse WLT-1was rated as follows:

- sport fish (northern pike) – nil for overwintering, nil to low for spawning and nursery, nil to low for rearing and feeding;
- non-sport fish (suckers) – nil for overwintering and spawning; nil to low for nursery, feeding and rearing;
- forage fish – nil for overwintering, nil to low for all other life stages.

Unnamed Watercourse (WLT-2)

Unnamed WatercourseWLT-2 is a narrow, low-gradient watercourse that flows through a mixedwood forest (Attachment B, Figure B-11). The unnamed watercourse WLT-2 is a tributary that empties into Wiau Lake (Figure 3).

Winter Habitat Survey

Water quality parameters at unnamed watercourse WLT-2 were recorded during winter sampling. The maximum water depth was 0.35 m (Table 25). Dissolved oxygen in winter was 1.3 mg/L with a water temperature of 1.7°C. Conductivity was 446 µS/cm (Table 24). Discharge could not be measured in the winter because of insufficient depth. Dissolved oxygen level recorded in winter was not adequate to provide a suitable environment for overwintering fish populations.

Open Water Habitat Survey

Unnamed WatercourseWLT-2 had a maximum channel and wetted width of 6.0 m within the impounded habitat. The maximum channel depth was 0.9 m (Table 25).

The area surveyed was composed of run and impoundment habitat (Table 25). The habitat was generally flat, with areas of submergent and emergent vegetation (Attachment B, Figure B-11). Highway 881 cut through the surveyed reach. The substrate in the surveyed section consisted mainly of clay and silt with some sand.

Instream cover was provided by woody debris, depth of water and aquatic vegetation. Overhead cover was comprised of undercut banks and overhanging vegetation. Data from the open-water seasons show that water quality conditions at WLT-2 are suitable for fish during summer. Dissolved oxygen was 6.0 mg/L and temperature was 8.9°C (Table 24).

Fish Use

Brook stickleback were captured in the summer survey using minnow trapping. No fish were captured in the summer using backpack electrofishing. Numbers of fish recorded are presented in Table 18 and CPUE data are presented in Attachment C-2.

Fish Habitat Suitability

The habitat use potential in unnamed watercourse WLT-2 was considered to be low. The sampled reach consisted of run and pool habitat. Beaver dams that might impede fish migration were present in the channel. Spawning habitat was absent at this location for species that require swift flow and rocky substrates, but was present in small amounts for species that prefer low-velocity flow with submerged vegetation. Water quality sampling during the winter survey indicated that low dissolved oxygen concentrations (1.3 mg/L) reduce the potential to provide suitable overwintering habitat for large-bodied fish species, but would be suitable for forage fish species that can tolerate low dissolved oxygen concentrations.

Based on the types and proportions of channel unit types present, the habitat use potential in unnamed watercourse WLT-1 was rated as follows:

- sport fish (northern pike) – nil for overwintering, nil to low for spawning, nursery, rearing and feeding;
- non-sport fish (suckers) – nil to low for overwintering, nil to low for all life stages; and
- forage fish – low for all life stages.

4 BENTHIC INVERTEBRATE COMMUNITIES

4.1 RESULTS

4.1.1 Literature Review

Benthic invertebrates were sampled previously in the LSA and RSA by the studies listed in Table 26 during a period that covers 40 years. Aside from the methods used in the earliest studies carried out in the 1960s and 1970s, sampling methods were consistent in the more recent studies in waterbodies and watercourses. During the RAMP studies, the same lotic depositional site was sampled annually in the Christina River between 2002 to 2006 and 2009. Given the consistent use of sampling equipment (Ekman grab), sample processing mesh sizes, level of taxonomy and the level of detail reported, data from the 2002 to 2006 and 2009 historical studies are comparable, but comparisons between early (1960s and 1970s) and recent (2002 to 2006) results can only be made at a general community level.

Historical data for waterbodies in and around the Christina River at Chard sub-basin were variable with mean density ranging from 534 organisms/m² to nearly 11,000 organisms/m². Taxonomic richness was also variable with total richness ranging from 2 taxa/site to 30 taxa/site. The historical benthic invertebrate community in waterbodies in and around the study area was dominated by the midges (Chironomidae), aquatic worms (Oligochaeta) and molluscs (Mollusca). Christina River and unnamed tributaries were also sampled. Christina River had similar mean densities compared to the tributaries. The mean density for Christina River ranged from 1,305 to 63,968 no/m² compared to 9,426 to 56,588 no/m² for the unnamed tributaries. A similar relationship was revealed in the total richness with Christina River ranging from 5 to 44 taxa/site compared to the tributaries ranging from 12 to 32 taxa/site.

Data were available for samples taken within the LSA from Sunday Creek and unnamed tributaries. The mean densities in Sunday Creek are considered to be low ranging from 986 to 5,322 no/m² however are similar to other tributaries sampled within the LSA. The total richness was moderate in Sunday Creek ranging from 7 to 22 taxa/site.

Table 26 Historical Benthic Invertebrate Studies Sampled in the Regional Study Area and the Local Study Area

Reference	Locations Sampled	Sample Date	Habitat type	Sampling Device (bottom area)	No. of Replicates	Mesh Size	Taxonomy Level	Comment
Waterbodies								
McDonald (1967)	Winefred Lake	August to September 1966	-	Ekman grab (0.023 m^2)	4	n/a	major group	sample sites located in RSA
Bradley (n.d.)	Christina Lake	June 14 and 15, 1969	-	Ekman grab (0.023 m^2)	1	n/a	major group	sample sites located in LSA
NAOSC (2007)	three unnamed waterbodies	September 27 to October 4, 2005	-	Ekman grab (0.023 m^2)	5	250 µm	lowest practical level (usually genus)	sample sites located in RSA
MEG (2008)	Christina Lake, Winefred Lake and five unnamed waterbodies	August 26 to 31, 2005 and September 24 to 27, 2007	-	Ekman grab (0.023 m^2)	5	250 µm	lowest practical level (usually genus; family for oligochaete worms)	sample sites located in the RSA
Watercourses								
Rhude (1976)	Winefred River (erosional habitat)	August 2, 1973 and July 20, 1975	-	Dipnet used as kicknet; sampling area not reported	3	n/a	genus; major group	sampling was not quantitative; sample sites located in RSA
Gulf (1979)	Cottonwood Creek, Meadow Creek, Kettle River basin, and two unnamed watercourses.	May, July and August, 1978	erosional and depositional	Surber used as kicknet	3	850 µm	lowest practical level	sampling was not quantitative, sample sites located in RSA
Gulf (2001)	Cottonwood Creek, Meadow Creek, Kettle River	August, 1998	erosional	Surber	3	250 µm	lowest practical level	sample sites located in RSA
Rio Alto (2002)	two unnamed tributaries	May 2002	depositional	Ekman grab (0.023 m^2)	3	500 µm	lowest practical level	sample sites located in LSA
Golder (2003)	Christina River upstream of Janvier	September 26, 2002	depositional	Ekman grab (0.023 m^2)	15 per sample reach	250 µm	lowest practical level (usually genus; family for oligochaete worms)	sample sites located in RSA
RAMP (2004)	Christina River upstream of Janvier	September 6, 2003	depositional	Ekman grab (0.023 m^2)	15 per sample reach	250 µm	lowest practical level (usually genus; family for oligochaete worms)	sample sites located in RSA
RAMP (2005)	Christina River upstream of Janvier	September 8 to 22, 2004	depositional	Ekman grab (0.023 m^2)	15 per sample reach	250 µm	lowest practical level (usually genus; family for oligochaete worms)	sample sites located in RSA

Table 26 Historical Benthic Invertebrate Studies Sampled in the Regional Study Area and the Local Study Area (continued)

Reference	Locations Sampled	Sample Date	Habitat type	Sampling Device (bottom area)	No. of Replicates	Mesh Size	Taxonomy Level	Comment
RAMP (2006)	Christina River upstream of Janvier	September 7 to 24, 2005	depositional	Ekman grab (0.023 m^2)	10 per sample reach	250 µm	lowest practical level (usually genus; family for oligochaete worms)	sample sites located in RSA
Devon (2006)	Sunday Creek and one unnamed tributary	October 2005	-	Ekman grab (0.023 m^2)	3	500 µm	lowest practical level (usually genus)	sample sites located in RSA
NAOSC (2007)	Christina River and unnamed tributaries	September 27 to October 4, 2005	-	Ekman grab (0.023 m^2)	5	250 µm	lowest practical level (usually genus)	sample sites located in RSA
RAMP (2007)	Christina River upstream of Janvier	September 10, 2006	depositional	Ekman grab (0.023 m^2)	10 per sample reach	250 µm	lowest practical level (usually genus; family for oligochaete worms)	sample sites located in RSA
MEG (2008)	Christina River, Winefred River and two unnamed tributaries	August 26 to 31, 2005 and September 24 to 27, 2007	-	Ekman grab (0.023 m^2)	5	250 µm	lowest practical level (usually genus; family for oligochaete worms)	sample sites located in the RSA
EnCana (2009)	Sunday Creek	September 14, 2006	depositional	Ekman grab (0.023 m^2)	5	250 µm	lowest practical level (usually genus; family for oligochaete worms)	sample sites located in the LSA
RAMP (2010)	Christina River upstream of Janvier	September 17, 2009	depositional	Ekman grab (0.023 m^2)	10 per sample reach	250 µm	lowest practical level (usually genus; family for oligochaete worms)	sample sites located in RSA

- = information not available.

Historical data from Pony Creek and Kettle River sub basin was collected from Kettle Creek in 1978 and 1998. The initial study collected qualitative data and density was not calculated, however, in 1998 a smaller study was repeated and the Kettle Creek site had a moderate density of 36,742 no/m². The historical benthic invertebrate community was notably different in 1998 because midges consisted of 91% of the community and there was no pollution sensitive taxa found (mayflies (Ephemeroptera), stoneflies (Plecoptera) and caddisflies (Tricoptera).

Historical data from Winefred sub basin was collected from Winefred Lake in 1996 and 2007 and Winefred River from 1975 to 1977 and 2007. The density in 1966 was low (534 no/m^2) due to the sample location in the profundal zone. In 2007 the density was higher than 1966 and considered to be moderate (8,918 no/m^2). The community composition was similar in 1966 and 2007 with the exception of chironomids and amphipods which may be an artefact of sample location. The samples taken from Winefred River in 1975 to 1977 were qualitative and density could not be calculated. In 2007 the density was calculated and considered to be moderate with over 13,000 no/m². The richness was high in the Winefred River and was dominated by mayflies, stoneflies, caddisflies and midges.

4.1.2 Regional Study Area

Christina River at Chard Sub-Basin

Christina Lake and Unnamed Waterbodies

The first known historical data for the benthic invertebrate community in Christina Lake dates from June 14 to 15, 1969 (Bradley n.d.; reported in MEG 2008). Single Ekman grab samples were collected at 44 sites distributed throughout the lake. Bradley did not report sieve mesh size used in the study. Data were pooled and presented as mean abundances for the lake (Table 27).

Table 27 Historical Benthic Invertebrate Data from Christina Lake, June 1969

Organisms	Mean Density [no./m^2]	Percent of Total
Chironomidae	833	51.3
Amphipoda	691	42.6
Pelecypoda	41	2.5
Oligochaeta	33	2.0
Gastropoda	12	0.7
Trichoptera	8	0.5
Ephemeroptera	5	0.3
Hirudinea	1	<0.1
Total	**1,624**	**100**

Source: Bradley (n.d.); cited in MEG (2008).

The largest-scale study in the Christina Lake LSA was conducted in 2004 and 2007 during which two sites in Christina Lake and five small unnamed waterbodies were sampled (MEG 2008). The benthic invertebrate community in 2004 and 2007 appeared to reflect waterbody type, suggesting that habitat difference played a role in community structure (MEG 2008). Mean density was low at all sites. In most of the smaller waterbodies (WB-6-04, WB-7-04, WB-12-04 and WB-3-07), mean density ranged between 1,600 organisms/m^2 and 4,600 organisms/m^2, with the exception being WB-2-07 which had just over 10,000 organisms/m^2 (Table 28). Mean density in Christina Lake at Site CL-1 was above this range and density at CL-2 was below this range. Total richness was lower in Christina Lake than in the smaller waterbodies (Table 28; MEG 2008).

Mean density of the most dominant taxon was greatest at the two sites in Christina Lake. Ostracods (seed shrimp) at Site CL-1 and nematodes (roundworms) at Site CL-2 both accounted for greater than 56% of total density. The group defined as “other” at Site CL-1 consisted mainly of copepods (Harpacticoida). A large part of the remaining community at Site CL-2 consisted of aquatic worms, midges in the subfamily Orthocladiinae and ceratopogonid (biting) midges (Table 28; MEG 2008).

In the smaller waterbodies, individual taxonomic groups contributed less than 35% of the overall mean density (Table 28). Large dominant groups included Pelecypoda (Sphaeriidae; fingernail clams), amphipods, aquatic worms, and various midge taxa (Table 28; MEG 2008).

Table 28 Benthic Invertebrate Community Structure in Waterbodies, 2004 and 2007

Variable	Christina Lake (CL-1) 2004	Christina Lake (CL-2) 2004	Unnamed Waterbody 6 (WB-6-04) 2004	Unnamed Waterbody 7 (WB-7-04) 2004	Unnamed Waterbody 12 (WB-12-04) 2004	Unnamed Waterbody 2 (WB-2-07) 2007	Unnamed Waterbody 3 (WB-3-07) 2007
Density and Richness							
mean total density [no./m^2]	5,475	946	3,904	4,618	3,191	10,389	1,600
standard error	1,206	741	709	1,344	165	3,191	400
total richness	10	9	21	17	16	30	16
Community Composition by Major Group [(a)]							
Nematoda	0.5	56.1	0	0	2.7	0	0
Oligochaeta	1.6	19.7	25.6	5.6	0	12.1	3.2
Pelecypoda	5.5	1.5	0	24.2	25.3	6.9	20.4
Gastropoda	0	0	0.2	2.2	12.9	2.1	7.0
Ostracoda	56.5	0	9.3	5.6	0	4.7	4.8
Amphipoda	0.5	1.5	11.7	4.7	34.8	15.3	15.6
EPT[(b)]	0	0	0.2	3.7	0	0.8	0.5
Chironomidae (all taxa combined) [(c)]	8.8	15.1	52.6	53.6	14.2	55.1	45.2
Chironominae [(c)]	3.9	1.5	33.5	24.2	1.3	16.0	12.9
Tanypodinae [(c)]	3.1	0	5.9	17.9	10.2	5.2	14.0
Tanytarsini [(c)]	1.8	0	13.2	9.3	2.7	23.3	18.3
Orthocladiinae [(c)]	0	13.6	0	1.9	0	10.7	0
other Diptera	0	6.1	0	0	3.5	0	1.1
other taxa	26.4	0	0.4	0.8	6.5	3.0	2.2

(a) Percent composition of major groups is shown as percent contribution to mean total density.

(b) EPT = Ephemeroptera, Plecoptera and Trichoptera combined.

(c) % composition values presented by subfamily are those that contributed to the % composition of all Chironomidae taxa combined.

Note: Data from MEG (2008).

Comparison of the mean density of benthic invertebrates sampled in Christina Lake in 1969 (Table 27), and 2004 (MEG 2008) (Table 28) revealed some differences. The dominant organisms in 1969 consisted of chironomid midges and amphipods. Other common taxa reported from 1969 were oligochaete worms and fingernail clams. In 2004, the dominant benthic invertebrates were seed shrimp (Ostracoda) and roundworms (Nematoda). These differences between the 1969 and 2004 data may have been the result of using a larger mesh size or sampling more sites (i.e., a greater variety of habitats) during the 1969 study (44 sites in 1969 vs. two sites in 2004).

Three unnamed waterbodies were sampled as part of North American Oil Sands Corporation's Kai Kos Dehseh SAGD Project baseline (NAOSC 2007). Five replicate Ekman grab samples were collected at each site. Mean benthic invertebrate density and richness ranged from low to moderate in all three unnamed waterbodies (Table 29). Benthic invertebrate mean density and richness ranged from low (LL2 and LL4) to moderate (LH1). The benthic invertebrate community was dominated by the aquatic worms (Oligochaeta) and midges at LL2, by the midges and other taxa at LH1 and by the midges and no-see-ums (Ceratopogonidae) at LL4. This is typical of the benthic invertebrate community in small waterbodies in the Athabasca Oil Sands Region.

Table 29 Total Density, Richness and Composition of the Benthic Invertebrate Community in Unnamed Waterbodies, Fall 2005

Variable	Unnamed Waterbodies		
	LL2	LH1	LL4
Density and Richness			
mean total density (± 1 SE, number/m²)	624 ± 533	1,750 ± 1,154	353 ± 34
total richness (total number of taxa/site)	8	17	7
Percent Composition by Major Group [a]			
Ostracoda	0.0	0.2	0.0
Nematoda	0.0	6.6	4.9
Pelecypoda	0.0	0.0	0.0
Amphipoda	0.0	0.0	2.4
Oligochaeta	43.8	0.2	0.0
Gastropoda	1.4	0.0	0.0
Ceratopogoninae	11.0	3.9	39.0
EPT [b]	0.0	2.0	0.0
Hirudinea	0.0	8.1	0.0
Chironomidae (i/d)	0.0	4.7	0.0
Chironomini [c]	8.2	15.7	24.4
Tanypodinae [c]	34.2	6.9	26.8
Tanytarsini [c]	1.4	27.5	2.4
Orthocladiinae [c]	0.0	2.5	0.0
Other Chironomidae [c]	0.0	0.0	0.0
total Chironomidae	***43.8***	***57.2***	***53.7***
other Diptera	0.0	0.0	0.0
other taxa	0.0	21.6	0.0
Total	**100**	**100**	**100**

(a) Percent composition of major groups is shown as percent contribution to mean total density.

(b) EPT = Ephemeroptera, Plecoptera and Trichoptera combined.

(c) % composition values presented by subfamily are those that contributed to the % composition of all Chironomidae taxa combined.

(i/d) = immature or damaged specimen.

Notes: Data from NAOSC (2007).

Christina River at Chard Sub-Basin

Christina River (Within the Regional Study Area)

Benthic invertebrate community assessments are a component of RAMP within the Oil Sands Region. The benthic invertebrate component of RAMP focuses on shallow lakes and major tributaries of the Athabasca River, one of which is the Christina River. There is one RAMP study reach located within the Christina Lake RSA on the Christina River mainstem upstream of Janvier. The RAMP studies have collected benthic invertebrate community data from this reach for the years 2002 through 2006, and 2009 (Table 30).

Benthic invertebrate abundances and richness in the Christina River reach upstream of Janvier (Site CHR-D-2) were lower in 2002 to 2006 compared to 2002 and 2009 (Table 30). In all six years for which the data are summarized, the overall community was dominated by benthic invertebrates characteristic of depositional habitats. In 2003, 2005, 2006 and 2009 the community was dominated by chironomid midge larvae. Although the numbers were lower in 2002 and 2004, chironomids accounted for a substantial portion of the invertebrate community at the site in all sample years (Table 30). In 2003, 16 chironomid taxa were collected in the sample reach; dominant genera were *Rheosmittia*, *Polypedilum* and *Robackia* (RAMP 2004). During the 2004 sampling period, chironomids and ostracods (seed shrimp) dominated the benthic community in sample reach CHR-D-2. Ephydridae, Tubificidae, Tipulidae and nematodes were also abundant (Table 30). Although 2009 was dominated by chironomids the richness was high due to a large number of chironomid taxa in the samples.

Table 30 Summary of Major Taxon Abundances and Benthic Invertebrate Community Measurement Endpoints in Christina River Upstream of Janvier Site CHR-D-2, 2002 to 2006, and 2009

Taxon[a]	Reach CHR-D-2					
	2002	2003	2004	2005	2006	2009
Anisoptera	<1	<1	0	<1	<1	0
Bivalvia	3	<1	7	0	<1	<1
Ceratopogonidae	2	0	2	1	<1	1
Chironomidae	44	99	28	89	91	96
Cladocera	<1	0	0	0	0	0
Coleoptera	0	0	<1	0	<1	0
Copepoda	<1	0	<1	0	0	0
Dolichopodidae	0	0	4	0	0	0
Empididae	<1	0	0	1	<1	0
Enchytraeidae	0	0	3	<1	0	<1
Ephemeroptera	2	<1	<1	<1	<1	<1
Ephydridae	0	0	4	0	0	0
Erpobdellidae	0	0	0	0	0	0
Gastropoda	<1	0	0	0	0	0
Glossiphoniidae	<1	0	0	0	0	0
Heteroptera	<1	0	0	0	0	0
Hydracarina	0	<1	0	0	0	0
Lumbriculidae	0	0	0	0	0	0
Macrothricidae	<1	0	0	0	0	0
Naididae	0	<1	4	0	0	1
Nematoda	1	<1	11	<1	0	1
Ostracoda	24	<1	2	0	0	0
Plecoptera	0	0	0	<1	0	<1
Tabanidae	<1	0	<1	1	0	0
Tipulidae	<1	0	2	0	0	<1
Trichoptera	<1	<1	0	4	4	0
Tubificidae	23	<1	33	4	3	1
total density (no./m²)	**63,968**	**12,963**	**1,305**	**3,848**	**3,090**	**31,462**
richness	**20**	**5**	**6**	**6**	**6**	**12**
Simpson's Diversity	**0.67**	**0.37**	**0.55**	**0.44**	**0.45**	**0.51**
evenness	**0.71**	**0.49**	**0.81**	**0.63**	**0.47**	**0.56**
% EPT [b]	**3**	**3**	**1**	**7**	**5**	**2**

[a] Percent composition of major groups is shown as percent contribution to mean total density.

[b] EPT = Ephemeroptera, Plecoptera and Trichoptera combined.

Source: RAMP (2010).

In 2005, chironomids were dominant in CHR-D-2 followed by tubificid worms and caddisflies (Table 30). Pollution-sensitive taxa identified in the reach were the mayfly *Ametropus neavei*, the stonefly *Isoperla*, and the empidid fly *Hemerodromia* (RAMP 2006). The most common chironomid genus in reach CHR-D-2 in 2005 was *Polypedilum*, which is common in lotic depositional habitats.

The benthic invertebrate community at CHR-D-2 in fall 2009 was dominated by chironomids (96%) (Table 30). Taxa that were less abundant included fingernail clams, ceratopogonids, various worms, mayflies (Hexagenia, Ametropus neavei), caddisflies (Brachycentrus) and stoneflies (Isoperla, Capniidae). The 2009 RAMP report indicated that the benthic invertebrate community endpoints were within the ranges for regional depositional baseline reaches, with the exception of Simpson's Diversity Index and evenness which was slightly below average for other regional depositional baseline reaches within the RAMP focus study area (RAMP 2010).

The Christina River and three unnamed tributaries were also sampled in Fall 2005 as part of the Kai Kos Dehseh Project (NAOSC 2007) (Table 31). Mean density and total richness are moderate in all three sites sampled on the Christina River (Table 31). The benthic invertebrate community at WCL11e (erosional habitat) was dominated by the EPT and the midges, site WCL11d (depositional habitat) was dominated by the midges and aquatic worms, and WCL1 (erosional habitat) was dominated by the EPT. In the three unnamed tributaries benthic invertebrate density ranged from moderate to high and total richness was moderate at all three sites sampled (Table 31). The benthic invertebrate community at two of these sites (WCC3 and WCL6) were dominated by the midges and the other site was dominated by the aquatic worms.

Table 31 Total Density, Richness and Composition of the Benthic Invertebrate Community in Christina River and Unnamed Tributaries, Fall 2005

Variable	Christina River			Unnamed Tributaries		
	WCL11e	WCL11d	WCL1	WCC3	WCH3	WCL6
Density and Richness						
total Density (mean ± 1 SE number/m²)	18,735 ± 6,783	28,982 ± 13,386	13,924 ± 4,112	9,288 ± 4,266	9,426 ± 1,680	56,588 ± 7,910
total richness (total number of taxa/site)	44	19	29	19	12	29
Community Composition (mean %)						
Ostracoda	0.0	2.4	0.0	1.5	0.0	2.0
Nematoda	8.0	0.9	5.3	8.1	0.0	3.8
Pelecypoda	0.1	1.2	0.1	2.2	7.3	1.8
Amphipoda	0.0	0.0	0.0	0.0	0.0	0.1
Oligochaeta	1.7	39.3	4.4	2.2	56.2	0.9
Gastropoda	0.0	0.0	0.0	0.0	0.0	0.0
Ceratopogoninae	0.1	3.4	0.0	2.2	10.2	1.0
EPT	51.3	0.5	68.1	0.0	2.2	0.4
Hirudinea	0.0	0.0	0.0	0.7	0.0	0.1
Chironomidae (i/d)	1.6	0.9	0.0	5.9	0.0	2.3
Chironomini	1.1	37.4	1.5	25.2	0.7	2.9
Tanypodinae	0.1	0.8	0.1	8.9	15.3	6.2
Tanytarsini	1.1	1.9	0.6	23.0	5.1	66.2
Orthocladiinae	5.3	10.5	10.9	17.8	2.9	11.1
other Chironomidae	0.1	0.0	1.0	0.0	0.0	0.2
total Chironomidae	***28.1***	***51.8***	***17.6***	***80.7***	***24.1***	***88.8***
other Diptera	18.8	0.2	3.4	0.0	0.0	0.2
other taxa	10.8	0.7	4.5	2.2	0.0	0.8
Total	**100**	**100**	**100**	**100**	**100**	**100**

i/d = immature or damaged specimens**;** SE = standard error of the mean**.**

Notes: Data from NAOSC (2007).

Overall, benthic invertebrate abundances were variable in the Christina River, ranging from high (greater than 50,000 organisms/m^2 in 2002, [RAMP 2007]) to low (less than 2,000 organisms/m^2 in 2004 [RAMP 2007]) during the five years of sampling conducted as part of the RAMP sampling program in Christina River reach CHR-D-2. Mean richness was low to moderate during the study years 2002 through 2006. Benthic invertebrate abundances were within this range in 2005 for the Kai Kos Dehseh baseline study (NAOSC 2007), however, the densities were much higher (13,000 to 29,000 organisms/m^2) compared to the RAMP site (3,848 organism/m^2) for 2006. The invertebrate community was generally representative of taxa expected in lotic depositional habitats in the Athabasca Oil Sands Region.

A study was conducted within the Christina Lake RSA on behalf of MEG Energy Corp. in 2004 and 2007 (MEG 2008). Three lotic depositional sites were sampled from unnamed streams within the LSA. Two of the streams sampled (WC-1-04 and WC-6-04) are tributaries to Christina Lake. Mean benthic invertebrate Density was moderate at the tributary sites, ranging from approximately 10,700 organisms/m^2 at WC-4-07 to 21,700 organisms/m^2 at WC-1-04 (Table 32, MEG 2008). Total richness ranged from 24 taxa/site to (WC-1-04) to 32 taxa/site (WC-4-07) (Table 32).

Pony Creek and Kettle River Sub-Basin

Kettle River

Kettle River was sampled within the RSA in the spring, summer and fall in 1978 and in the summer of 1998 (Gulf, 1979, 2001) (Table 33). In 1978 the data were collected qualitatively using a kick net with an 850 µm mesh thus density could not be calculated. However in 1998 the samples were collected using an Ekman using a 250 µm mesh. The density was moderate (36,742 no/m^2). In 1978 the mayflies, stoneflies and caddisflies composed of 46% of the sample and midges consisted of 18% of the sample. In 1998 the samples composed mainly of midges and other pollutant tolerant true flies (Diptera) and had no mayflies, stoneflies and caddisflies. The unnamed tributary sampled in 1978 consisted of midges and aquatic worms with other molluscs, leeches and snails composing the remaining of the sample. The mesh size alone cannot account for the differences in community as the larger mesh size was used in 1978.

Table 32 Benthic Invertebrate Community Structure in Watercourses in the Christina Lake Local Study Area, August 2004

Variable	"Sawbones Creek" (WC-1-04) 2004	Tributary to the East Shore of Christina Lake (WC-6-04) 2004	Unnamed Watercourse 4 (WC-4-07) 2007
Density and Richness			
mean total density [no./m^2]	21,758	12,375	10,707
standard error	6,309	3,880	2,769
total richness	24	28	32
Percent Composition by Major Group [(a)]			
Nematoda	2.8	10.4	0
Oligochaeta	1.0	0.7	2.1
Hirudinea	0.1	0.8	0
Pelecypoda	20.4	12.3	12.9
Gastropoda	5.4	27.2	13.5
Ostracoda	34.8	21.2	34.1
EPT [(b)]	0.1	0.8	1.7
Chironomidae (all taxa combined)[(c)]	32.1	17.1	29.9
Tanytarsini[(c)]	18.2	2.1	11.6
Tanypodinae[(c)]	12.4	4.2	12.9
Chironominae[(c)]	0.7	10.8	4.7
Orthocladiinae[(c)]	0.8	0	0.6
other Diptera	3.0	0.3	0.6
other taxa	0.4	9.2	5.1

(a) Percent composition of major groups is shown as percent contribution to mean total density.

(b) EPT = Ephemeroptera, Plecoptera and Trichoptera combined.

(c) % composition values presented by subfamily are those that contributed to the % composition of all Chironomidae taxa combined.

Note: Data from MEG (2008).

Table 33 Benthic Invertebrate Summary Variables for Kettle River and Unnamed Tributary of Christina River, 1978

Variable	Kettle River		Unnamed Tributary
	1978	1998	1978
Density and Richness			
mean density (no./m^2)-[(a)]	-)	36,742	-
total richness	44	28	18
Percent Composition			
Oligochaeta	2	<1	14
Ephemeroptera	19	<1	0
Plecoptera	9	<1	0
Trichoptera	18	<1	0
Coleoptera	1	<1	0
Chironomidae	18	91	64
Other	34	9	21
Total	**100**	**100**	**100**

(a) Percent composition of major groups is shown as percent contribution to mean total density.

- = data not available.

Note: Data from Gulf (1979) and Gulf (2001).

Winefred River Sub-Basin

Waterbodies

Winefred Lake

Benthic invertebrate data were collected for Winefred Lake in August to September 1966 from 25 randomly selected sites using an Ekman grab within water ranging in depth from 1.5 to 13.4 m (McDonald 1967). Benthic invertebrates were identified to major group (Table 34). Winefred Lake supported a "sparse bottom fauna" compared to the standing crop of benthic invertebrates reported for other central Alberta lakes (McDonald 1967). Based on the depths sampled, it appeared that the majority of the samples were collected from the profundal zone. The low density of amphipods in the samples may have reflected sampling from depths greater than 1.5 m, as amphipods are more common in shallow areas of lakes (McDonald 1967; Clifford 1991). The benthic community was dominated by chironomid midge larvae.

In 2007, Winefred Lake was sampled using an Ekman grab at a depth of 1 to 1.5 m (Table 34). Mean density and total richness were moderate and mean density was much higher than the 1966 field survey (MacDonald 1967) (Table 34). The benthic invertebrate community in these shallow samples were dominated by the amphipods (Amphipoda) and the midges (Chironomidae).

Watercourses

Winefred River Sub-Basin

Winefred River

Studies were conducted in the Winefred River by the Recreation, Parks and Wildlife Branch of the Alberta Fish and Wildlife division in 1973 and 1975 (Rhude 1976). As part of these fishery-potential surveys, benthic invertebrates were sampled from erosional habitat at three stations in the Winefred River. The data were not collected quantitatively, but provided a qualitative summary of the taxonomic groups present in the river at that time (Table 35). The Winefred River was also sampled in 2007 as part of the baseline component of the MEG Energy baseline studies for the Christina Lake Regional Project (MEG 2008). In 2007, the Winefred River was dominated by the EPT (Ephemeroptera [mayflies], Plecoptera [stoneflies] and Trichoptera [caddisflies]) and the midges (Table 36). Mean total density was over 13,000 organism/m^2 and richness was high (48 taxa/site). The benthic invertebrate community in the Winefred River is representative of a lotic-erosional habitat.

Table 34 Benthic Invertebrate Community Structure in a Waterbody (Winefred Lake) in the Aquatic Resources Local Study Area, Fall 1966 and 2007

Variable	Winefred Lake (1966)	Winefred Lake (WB-WL) 2007
Density and Richness		
mean total density [± 1 SE, no./m^2]	534	8,918 ± 2,340
total richness	-	26
Composition [(a)]		
Nematoda	-	0
Hirudinea (leeches)	1.5	-
Oligochaeta	7.0	6.2
Pelecypoda	1.5	6.4
Gastropoda	1.0	4.2
Ostracoda		8.6
Amphipoda	2.6	42.0
EPT[(b)]	-	0.5
Chironomidae (all taxa combined) [(c)]	85.7	26.8
Chironominae [(c)]	-	17.2
Tanypodinae [(c)]	-	5.1
Tanytarsini [(c)]	-	3.3
Orthocladiinae [(c)]	-	1.3
other Diptera	-	0
other taxa	0.6	7.4

(a) Percent composition of major groups is shown as percent contribution to mean total density.

(b) EPT = Ephemeroptera, Plecoptera and Trichoptera combined.

(c) % composition values presented by subfamily are those that contributed to the % composition of all Chironomidae taxa combined.

- = data not available

Note: Data from McDonald (1967) and MEG (2008).

Table 35 Composition of Benthic Invertebrate Samples Collected from the Winefred River, 1973 and 1975

Taxonomic Group	Presence of Benthic Invertebrate Groups		
	Winefred River Station #1 (August 2, 1973)[a]	Winefred River Station #2 (July 20, 1975)[b]	Winefred River Station #3 (August 2, 1973)[a]
Ephemeroptera			
Baetis sp.	+	-	+
Heptagenia sp.	+	-	-
Tricorythodes sp.	+	-	+
Plecoptera			
Perlidae	-	2	-
Isogenus elongatus	-	-	+
Pteronarcys dorsata	-	-	+
Arcynopteryx curvata or *parallela*	-	-	+
Trichoptera			
Brachycentridae	-	98	-
Hydropsychidae	-	1	-
Helicopsychidae	-	2	-
Leptoceridae	-	2	-
Hydropsyche sp.	+	-	+
Brachycentrus sp.	+	-	+
Glossosoma sp.	+	-	+
Lepidostoma sp.	+	-	+
Arctopsyche ladogensis	-	-	+
Odonata			
Gomphidae	-	1	-
Ophiogomphus sp.	+	-	+
Diptera			
Simuliidae	+	-	-
Polypedilum sp.	+	-	-
Micropsectra sp.	+	-	+
Metriocnemus sp.	+	-	+
Microtendipes sp.	+	-	+
Hexatoma sp.	-	-	+
Rheotanytarsus sp.	-	-	+
Cladotanytarsus sp.	-	-	+
Coleoptera			
Optioservus sp.	+	-	+
Mollusca			
Gastropoda	-	1	-
Pelecypoda	-	13	-
Sphaerium sp.	+	-	+
Pisidium sp.	+	-	+
Helisoma sp.	+	-	-
Nematoda	+	-	-
Hirudinea	+	-	-

[a] + = present in sample; - = not present in sample or not identified to specific taxonomic level.

[b] Actual number of organisms counted from three samples (data were pooled).

Source: Rhude (1976).

Table 36 Benthic Invertebrate Community Structure in Watercourses, August 2007

Variable	Winefred River (WC 5-07) 2007
Density and Richness	
mean total density [± 1 SE, no./m^2]	13,875 ± 4,484
total richness	48
Percent Composition by Major Group [(a)]	
Nematoda	0.1
Oligochaeta	5.3
Hirudinea	0.2
Pelecypoda	2.3
Gastropoda	0.1
Ostracoda	2.7
EPT [(b)]	40.0
Chironomidae (all taxa combined)[(c)]	33.4
Tanytarsini[(c)]	0.5
Tanypodinae[(c)]	4.3
Chironominae[(c)]	14.9
Orthocladiinae[(c)]	13.6
other Diptera	9.8
other taxa	5.7

(a) Percent composition of major groups is shown as percent contribution to mean total density.

(b) EPT = Ephemeroptera, Plecoptera and Trichoptera combined.

(c) % composition values presented by subfamily are those that contributed to the % composition of all Chironomidae taxa combined.

Note: Data from MEG (2008).

4.1.2.1 Local Study Area

Christina River at Chard Sub-Basin Watercourses

Unnamed Tributaries to Christina Lake

Benthic invertebrate data for tributaries in the LSA are available from the Jackfish 2 Project (Devon 2006), Rio Alto (2002), and EnCana (2009) within the LSA. Both studies used an Ekman grab and samples were sieved through a 500 µm mesh screen. Mean benthic invertebrate density and total richness at all three sampling locations in Sunday Creek were low in October 2005 (Devon 2006) (Table 37). The benthic invertebrate community in Sunday Creek was dominated by the midges at all three sites. Unnamed Creek (UC2) also had low mean density and total richness in 2005 and the benthic invertebrate community was dominated by the midges.

Table 37 Benthic Invertebrate Summary Variables for Sunday Creek and Unnamed Creek, October 2005

Variable	Sunday Creek			Unnamed Creek
	SU1	SU3	SU4	UC2
Density and Richness				
mean density (no./m²)	2,130	2,309	986	1,797
mean richness	8	15	7	17
Percent Composition [(a)]				
% EPT [(b)]	1	2	2	13
% Chironomidae	67	53	73	60
% other Diptera	10	27	5	10
% other taxa	22	18	20	17
Total	**100**	**100**	**100**	**100**

(a) Percent composition of major groups is shown as percent contribution to mean total density;

(b) EPT = Ephemeroptera, Plecoptera and Trichoptera combined.

Note: Data from Devon (2006).

The lower mean abundances observed in the Devon study (2006) compared to the NAOSC study (2007) likely resulted from the use of 500 µm mesh which doesn't retain as many organisms compared to the 250 µm mesh used in the NAOSC study (2006). The resulting lower abundances also likely lead to lower total richness values for the tributaries in the Christina River sub basin. In both studies, the overall benthic invertebrate community composition was typical of small streams in the Athabasca Oil Sands Region.

A small study was completed on behalf of Rio Alto (2002, Table 38). Two depositional sites (ST1 and ST2) were sampled from unnamed tributaries draining Wiau Lake. The mean benthic density and richness was low at both sites ranging from, 1,280 to 1,742 organisms/m² and 8 to 12 taxa/site, respectively. Midges and aquatic worms were the dominant organisms.

Table 38 Summary of Benthic Invertebrate Data for Streams Draining Wiau Lake

Variable	Unnamed Tributary	
	ST1	ST2
mean density (no./m²)	1,280	1,742
total richness	19	18
Oligochaeta	10	45
Ephemeroptera	2	<1
Plecoptera	0	0
Trichoptera	0	0
Chironomidae	45	23
Other	42	32
total	**100**	**100**

(a) Percent composition of major groups is shown as percent contribution to mean total density.

(b) EPT = Ephemeroptera, Plecoptera and Trichoptera combined.

Notes: Data from Rio Alto (2002).

A small study was completed on behalf of EnCana (2009, Table 39). One depositional site (SC-1) was sampled from Sunday Creek. Mean total benthic density was low at just over 5,000 no/m². The depositional benthic community was dominated by chironomids which account for more than half of the total density and the second most abundant organisms was a mayfly. In Sunday Creek, depositional communities consisted mostly of midges (Chicronomidae), mayflys (Ephemeroptera), and various midges (Table 39).

Table 39 Benthic Invertebrate Summary Variables for Sunday Creek, September 2006

Variable	Sunday Creek (SC-1)
Density and Richness	
mean total density [± 1 SE, no./m^2]	5,322
total richness	22
Percent Composition[(a)]	
Nematoda	4.2
Oligochaeta	0.6
Pelecypoda	1.1
Ostracoda	0.0
Ephemeroptera	18.2
Chironomidae (all taxa combined)[(b)]	58.1
other Diptera	17.3
other taxa	0.5

(a) Percent composition of major groups is shown as percent contribution to mean total density;

(b) % composition values presented by subfamily are those that contributed to the % composition of all Chironomidae taxa combined.

Note: Data from EnCana (2009).

4.1.3 Field Surveys

Benthic invertebrate data collected during the baseline field surveys in September 2011 was not available at the time of submission. The delivery date of the benthic invertebrate samples data are April 2012. After the results are available, the data will be summarized in a supplemental document.

5 DIVERSITY OF FISH AND FISH HABITAT

5.1 RESULTS

The results of the assessment of fish and fish habitat diversity for the watercourses and waterbodies assessed as part of the current field studies within the LSA are provided in the following sections. The assessment was based on indicators of fish species diversity, habitat diversity and ecosystem diversity.

5.1.1 Fish Species Diversity

The results of the fish species diversity assessment for the watercourses and waterbodies representing aquatic resources potentially affected by the Project are presented in Table 40 for the three species diversity indicators: species richness, species overlap and listed species. A numerical rank (from 1 to 4) was determined for each of these three indicators and a general rank for each watercourse or waterbody was assigned based on the value obtained by multiplying the three individual ranks.

Fish species diversity was ranked very low for all waterbodies and watercourses within the LSA that were assessed for the current field program. Species richness was ranked as very low in Wiau Lake, all unnamed waterbodies, and in all unnamed watercourses. All the waterbodies and watercourses, except unnamed watercourse UNT-1 had less than four species present compared to the larger rivers and lakes within the RSA that typically have up to 10 species and no unique species were identified. The selected waterbodies and watercourses did not contain any listed species.

Table 40 Ranking of Watercourses and Waterbodies According to Fish Species-Level Indicators of Diversity

Watercourse or Waterbody	Fish Species Richness		Fish Species Overlap		Listed Fish Species		Fish Species Diversity Ranking and Score
	Number of Species and % of Potential Species	Ranking	Number of Unique Species and % of Overlapping Species	Ranking	Listed Species	Ranking	
Waterbody							
Wiau Lake (WL-1)	2 of 26 potential species – 7.7%	1	no unique species, 100% overlap	1	none	1	1 – very low (score = 1)
Unnamed Waterbody (WB-1)	1 of 26 potential species – 3.8%	1	no unique species, 100% overlap	1	none	1	1 – very low (score = 1)
Unnamed Waterbody (WB-2)	1 of 26 potential species – 3.8%	1	no unique species, 100% overlap	1	none	1	1 – very low (score = 1)
Unnamed Waterbody (WB-3)	1 of 26 potential species – 3.8%	1	no unique species, 100% overlap	1	none	1	1 – very low (score = 1)
Unnamed Waterbody (WB-4)	1 of 26 potential species – 3.8%	1	no unique species, 100% overlap	1	none	1	1 – very low (score = 1)
Watercourse							
Unnamed Watercourse(WLT-1)	0 of 26 potential species – 0%	1	no fish detected	1	none	1	1 – very low (score = 1)
Unnamed Watercourse(WLT-2)	1 of 26 potential species – 3.8%	1	no unique species, 100% overlap	1	none	1	1 – very low (score = 1)
Unnamed Watercourse(SCT-1)	1 of 26 potential species – 3.8%	1	no unique species, 100% overlap	1	none	1	1 – very low (score = 1)
Unnamed Watercourse(SCT-2)	1 of 26 potential species – 3.8%	1	no unique species, 100% overlap	1	none	1	1 – very low (score = 1)
Unnamed Watercourse(SCT-3)	3 of 26 potential species – 11.5%	1	no unique species, 100% overlap	1	none	1	1 – very low (score = 1)
Unnamed Watercourse(UNT-1)	5 of 26 potential species – 19.2%	1	no unique species, 100% overlap	1	none	1	1 – very low (score = 1)

5.1.2 Fish Habitat Diversity

The results of the habitat diversity assessment for the waterbody and watercourse sampling sites potentially affected by the Project are presented in Table 41 and Table 42, respectively. Results are presented for the assessment of the selected fish habitat diversity indicators. A numerical rank (from 1 to 4) was determined for each of these indicators and used to calculate an average rank for each watercourse or waterbody.

The overall fish and fish habitat diversity of each of the selected waterbodies and watercourses was assessed by combining the general rankings for species, habitat and ecosystem-level diversity indicators. The contribution of each waterbody or watercourse to fish and fish habitat diversity was categorized as very low, low, moderate or high based on the ranking they received in the evaluation of each of the species, habitat and ecosystem indicators.

Overall, habitat diversity was ranked as moderate for Wiau Lake and UNT-1. Habitat diversity was ranked low for WLT-2 and SCT-1. The remaining unnamed waterbodies and watercourses had a very low habitat diversity ranking. Most of the unnamed waterbodies and watercourses were small and shallow, with low habitat variation (number of habitats) and habitat composition (type of habitats).

5.1.3 Ecosystem-Level Indicators of Diversity

Ecosystem diversity was assessed for each of the selected watercourses and waterbodies based on the ratio of predator species to prey species. The number of predator (piscivorous) species and prey (forage fish) species at each of the watercourse and waterbody sampling sites along with the ecosystem diversity ranking are presented in Table 43.

The ecosystem diversity for Wiau Lake was rated as high. Two predator fish species have been documented at this site, and while no prey species have been captured in recent sampling, they are assumed to be present to support the predator population in the lake. All other waterbodies and watercourses were rated as having very low ecosystem diversity. With the exception of WLT-2, SCT-3 and UNT-1 that contained two or more prey species, the remaining waterbodies and watercourses all contained one prey species and all lacked predator species.

Table 41 Ranking of Waterbodies According to Indicators of Fish Habitat Diversity

Waterbody	Waterbody Habitat Diversity Index			Waterbody Size			Fish Habitat Diversity Ranking
	Number of Habitat Types	Habitat Diversity	Ranking	Area [ha]	Maximum Depth [m]	Ranking	
Wiau Lake (WL-1)	12	3.8	3 – moderate	2,644.5	3.0	3 – moderate	3 – moderate (score = 9)
Unnamed Waterbody (WB-1)	6	0.93	1 – very low	57.3	1.2	2 – low	1 – very low (score = 2)
Unnamed Waterbody (WB-2)	6	0.9	1 – very low	16.8	2.2	2 – low	1 – very low (score = 2)
Unnamed Waterbody (WB-3)	6	0.9	1 – very low	5.8	1.7	1 – very low	1 – very low (score = 1)
Unnamed Waterbody (WB-4)	6	0.84	1 – very low	43.3	1.7	2 – low	1 – very low (score = 2)

Table 42 Ranking of Watercourses According to Indicators of Fish Habitat Diversity

Watercourse	Watercourse Habitat Unit Diversity Index				Stream Order at Mouth		Fish Habitat Diversity Ranking
	Number of Habitat Units per 100 m	Number of Habitat Types	Habitat Unit Diversity	Ranking	Stream Order	Ranking	
Unnamed Watercourse(WLT-1)	0.5	1	0.029	1 – very low	1	1 – very low	1 – very low (score = 1)
Unnamed Watercourse(WLT-2	2.4	3	0.424	2 – low	2	2 – low	2 – low (score = 4)
Unnamed Watercourse(SCT-1)	5	4	1.176	3 – moderate	1	1 – very low	2 – low (score = 3)
Unnamed Watercourse(SCT-2)	1	1	0.059	1 – very low	1	1 – very low	1 – very low (score = 1)
Unnamed Watercourse(SCT-3)	2.5	2	0.294	2 – low	1	1 – very low	1 – very low (score = 2)
Unnamed Watercourse(UNT-1)	4.9	4	1.148	3 – moderate	2	2 – very low	3 - moderate (score = 6)

Table 43 Ranking of Waterbodies and Watercourses for Predator to Prey Species Ratios

Watercourse or Waterbody	Predator to Prey (Forage Guild) Ratio	
	Number of Predator / Prey Species	Ranking
Waterbody		
Wiau Lake (WL-1)	2 predator/0 prey[(a)]	4 – high
Unnamed Waterbody (WB-1)	0 predator/1 prey	1 – very low
Unnamed Waterbody (WB-2)	0 predator/1 prey	1 – very low
Unnamed Waterbody (WB-3)	0 predator/1 prey	1 – very low
Unnamed Waterbody (WB-4)	0 predator/1 prey	1 – very low
Watercourse		
Unnamed Watercourse(WLT-1)	0 predator/0 prey	1 – very low
Unnamed Watercourse(WLT-2)	0 predator/2 prey	1 – very low
Unnamed Watercourse(SCT-1)	0 predator/1 prey	1 – very low
Unnamed Watercourse(SCT-2)	0 predator/1 prey	1 – very low
Unnamed Watercourse(SCT-3)	0 predator/3 prey	1 – very low
Unnamed Watercourse(UNT-1)	0 predator/5 prey	1 – very low

(a) Although no prey species have been captured in Wiau Lake, the presence of two predator species would indicate prey species are present.

5.1.4 Summary

The overall fish and fish habitat diversity of each of the selected waterbodies and watercourses was assessed by combining the general rankings for species, habitat and ecosystem level diversity indicators (Table 44). The contribution of each waterbody or watercourse to fish and fish habitat diversity was categorized as very low, low, moderate or high based on the ranking they received in the evaluation of each of the species, habitat and ecosystem indicators.

Table 44 Summary of Diversity Rankings for Watercourses and Waterbodies

Watercourse or Waterbody	Ranking			
	Species Diversity	Habitat Diversity	Ecosystem Diversity	Overall Diversity
Waterbody				
Wiau Lake (WL-1)	very low	moderate	high	moderate
Unnamed Waterbody (WB-1)	very low	very low	very low	very low
Unnamed Waterbody (WB-2)	very low	very low	very low	very low
Unnamed Waterbody (WB-3)	very low	very low	very low	very low
Unnamed Waterbody (WB-4)	very low	very low	very low	very low
Watercourse				
Unnamed Watercourse(WLT-1)	very low	very low	very low	very low
Unnamed Watercourse(WLT-2)	very low	low	very low	very low
Unnamed Watercourse(SCT-1)	very low	low	very low	very low
Unnamed Watercourse(SCT-2)	very low	very low	very low	very low
Unnamed Watercourse(SCT-3)	very low	very low	very low	very low
Unnamed Watercourse(UNT-1)	very low	moderate	very low	very low

Wiau Lake was rated as having moderate overall diversity. All the remaining unnamed waterbodies and watercourses were all rated as having a very low overall diversity.

Species, habitat and ecosystem diversity was also assessed as part of the KS1 (Canadian Natural 2007) and Kirby North 2010 (Enermark 2008) projects. The major unnamed tributary to Wiau Lake and the large unnamed waterbody directly connected to the tributary both ranked as having moderate overall diversity, similar to Wiau Lake (Canadian Natural 2007). One additional unnamed waterbody in the Wiau Lake watershed was assessed as having low overall diversity (Canadian Natural 2007). Edwards Lake, Glover Lake, Birch Creek and Sunday Creek ranked as having moderate habitat potential (Enermark 2008). The other watercourses and waterbodies assessed within the LSA as part of KS1 and Kirby North 2010 were evaluated as having very low overall diversity.

6 SUMMARY

6.1 INTRODUCTION

The fish and fish habitat information presented in this report for the RSA and LSA, including literature information and data collected during field surveys for the Project is summarized in the following sections.

Field investigations were undertaken at several waterbody and watercourse sites within the LSA. This report presented the results of these field investigations, conducted during winter and summer 2011, together with the results of other baseline surveys conducted within the LSA in recent years (Table 45). In addition, other relevant historical information obtained from the literature was reviewed.

Table 45 Summary of the Number of Sampling Sites Within each of the Local Study Area Baseline Surveys

Baseline Surveys	Number of Sampling Sites			
	Fisheries		Benthic Invertebrates	
	Waterbodies	Watercourses	Waterbodies	Watercourses
Kirby South 2001	13	6	5	2
Kirby South 2006	6	6	4	3
Kirby North 2008	5	7	4	3
Kirby Expansion Project 2011	5	6	3	6

Waterbodies and watercourses discussed in this baseline report included Wiau Lake, four unnamed waterbodies, and six unnamed watercourses.

Field sampling and assessments for these sites included:

- documented use of the available habitats for spawning, nursery, rearing, feeding and overwintering by indigenous fish species;
- the seasonal presence, relative abundance and distribution of fish; and
- the diversity of fish and fish habitat.

In addition, benthic invertebrate sampling was undertaken at Wiau Lake, two unnamed waterbodies, and at all six unnamed watercourses.

6.2 FISH HABITAT AND FISH COMMUNITIES

6.2.1 Regional Study Area

6.2.1.1 Christina River at Chard Sub-Basin

Waterbodies

Christina Lake is the largest lake within the Christina River at Chard sub-basin. The lake provides suitable fish habitat during both the winter and the open-water period. Kirby Lake provides suitable habitat for sport fish species as it supports a recreational fishery. Historical information indicates that the numerous unnamed waterbodies within the Christina River at Chard sub-basin provide limited habitat potential as they are shallow and have DO concentration limitations during the overwintering period.

Waterbodies within the Christina River at Chard sub-basin are known to contain seven sport fish and two non-sport fish species, including Arctic grayling, burbot, cisco, lake whitefish, northern pike, walleye, yellow perch, longnose sucker and white sucker. Five forage fish species are also known to occur in the waterbodies.

Watercourses

Christina River at Chard sub-basin includes the headwaters of the Christina River, Wadell Creek, May River, Goose River and Jackfish River. These watercourses provide suitable habitat potential for large-bodied fish and forage fish. Several unnamed Christina River tributaries and unnamed watercourses within the Christina River at Chard sub-basin are small and the habitat potential for these watercourses was generally rated as nil to low for overwintering but suitable for open-water seasons.

Watercourses within the Christina River at Chard sub-basin are known to contain six sport fish and two non-sport fish species, including Arctic grayling, burbot, goldeye, lake whitefish, northern pike, walleye, longnose sucker and white sucker. Seven forage fish species are also known to occur in the waterbodies.

6.2.1.2 Pony Creek and Kettle River Sub-Basin

Waterbodies

The small, unnamed waterbodies located in the Pony Creek and Kettle River sub-basin have been examined for fish and fish habitat conditions. These waterbodies are small and shallow with limited habitat potential for fish species. No fish have been documented to occur in these waterbodies.

Watercourses

The Pony Creek and Kettle River sub-basin is mainly of the two river systems, Pony Creek and Kettle River, including the downstream portion of the Christina River. The Christina River and lower sections of Kettle River and Pony Creek provide suitable habitat potential for a number of large-bodied fish and forage fish species. Upstream reaches of Kettle River and Pony Creek provide limited habitat potential, particularly during the winter.

Watercourses within the Pony Creek and Kettle River sub-basin are known to contain two sport fish and two non-sport fish species, including Arctic grayling, burbot, longnose sucker and white sucker. Eight forage fish species are also known to occur in the watercourses.

6.2.1.3 Winefred River Sub-Basin

Waterbodies

Winefred Lake is the largest lake within the Winefred River sub-basin. The lake provides suitable fish habitat during both the winter and the open-water period. Other waterbodies within the sub-basin include Bohn Lake, Cowper Lake, Glover Lake, Grist Lake, Jumbo Lake and Watchusk Lake. All these lakes drain directly or through tributaries into the Winefred River. Several unnamed waterbodies have been surveyed within the Winefred River sub-basin. These waterbodies provided limited suitable overwintering habitat, but open-water conditions were suitable for sport and non-sport fish species.

Waterbodies within the Winefred River sub-basin are known to contain eight sport fish and one non-sport fish species, including Arctic grayling, burbot, cisco, lake trout, lake whitefish, northern pike, walleye, yellow perch and white sucker. Seven forage fish species are documented to occur in the waterbodies.

Watercourses

The Winefred River sub-basin includes the Winefred River and the Landels River. These watercourses provide suitable habitat potential for use by a variety of sport, non-sport and forage fish species. Overwintering potential is limited in some locations. Winefred River sub-basin contains several small unnamed tributaries. Habitat conditions in the tributary watercourses that have been examined are somewhat variable, but are generally limited by small size, low flows, and poor fish passage due to sections of undefined channel and extensive beaver activity. Overwintering potential is particularly limited.

Watercourses within the Winefred River sub-basin are known to contain five sport fish and two non-sport fish species, including Arctic grayling, burbot, northern pike, walleye, yellow perch, longnose sucker and white sucker. Seven forage fish species are documented to occur in the watercourses.

6.2.1.4 Sand River Sub-Basin

Waterbodies

The Sand River sub-basin contains a number of large waterbodies including Ipiatik Lake, Siebert Lake, Pinehurst Lake, Wolf Lake and Touchwood Lake. These lakes provide suitable habitat for a variety of large-bodied and forage fish species. Several unnamed waterbodies have been surveyed within the Sand River sub-basin. These waterbodies provided limited suitable overwintering habitat, but open-water conditions were suitable for sport and non-sport fish species.

Waterbodies within the Sand River sub-basin are known to contain six sport fish and two non-sport fish species, including burbot, cisco, lake whitefish, northern pike, walleye, yellow perch, longnose sucker and white sucker. Six forage fish species are documented to occur in the waterbodies.

Watercourses

The Sand River sub-basin includes the Sand River and Wolf River. The Sand River is largely contained within the Cold Lake Air Weapons Range and is a tributary of the Beaver River. Existing information for these watercourses is limited but historical catch information indicates the watercourses provide suitable habitat potential. Several unnamed watercourses have been surveyed within the Sand River sub-basin. These watercourses provide limited suitable overwintering habitat, but open-water conditions were suitable for sport and non-sport fish species.

Watercourses within the Sand River sub-basin are known to contain five sport fish and two non-sport fish species, including cisco, lake whitefish, northern pike, walleye, yellow perch, longnose sucker and white sucker. Ten forage fish species are documented to occur in the watercourses.

6.2.1.5 Lac la Biche Sub-Basin

Waterbodies

Lac la Biche is the largest lake within the Lac la Biche sub-basin. Lac la Biche provides high habitat potential for large-bodied and forage fish species. Heart Lake also provides suitable habitat for a variety of fish species. Numerous named and unnamed waterbodies are within the Lac la Biche sub-basin. The medium sized lakes provided moderate habitat potential but limited capacity for overwintering due to low levels of DO during the winter. Most of the smaller unnamed waterbodies were all shallow and had significant oxygen depletion under ice or limited water depth during winter.

Waterbodies within the Lac la Biche sub-basin are known to contain six sport fish and two non-sport fish species, including burbot, cisco, lake whitefish, northern pike, walleye, yellow perch, longnose sucker and white sucker. Five forage fish species are documented to occur in the waterbodies.

Watercourses

Information on the watercourses within the Lac la Biche sub-basin, outside of the LSA is limited. The Owl River is the largest river in the sub-basin and drains into Lac la Biche. Historical catch information indicates the Owl River provides suitable habitat potential.

Watercourses within the Lac la Biche sub-basin are known to contain four sport fish and one non-sport fish species, including cisco, northern pike, walleye, yellow perch and white sucker. Six forage fish species are documented to occur in the watercourses.

6.2.2 Local Study Area

6.2.2.1 Christina River at Chard Sub-Basin

A major portion of the LSA is contained within the Christina River at Chard sub-basin.

Waterbodies

Edwards Lake is located in the headwaters of Sunday Creek and provides suitable habitat for sport fish, non-sport fish and forage fish species. The lake provides spawning habitat and dissolved oxygen levels in the winter were relatively high, providing suitable overwintering habitat for most sport, non-sport and forage fish species. Fish species captured in Edwards Lake include northern pike and Iowa darter. Fishing regulations indicate lake whitefish and burbot are also present in the lake.

Glover Lake is located in the headwaters of Birch Creek. The lake provides suitable habitat for sport fish, non-sport fish and forage fish species. Dissolved oxygen levels in the winter were relatively high, providing suitable overwintering habitat for sport, non-sport and forage fish species. Fishing regulations indicate lake whitefish and burbot are also present in the lake.

Several unnamed waterbodies within the LSA in the Christina River at Chard sub-basin have been evaluated. Fish species previously recorded include northern pike, white sucker, longnose sucker, lake chub and brook stickleback.

Kirby North 2010

Unnamed Waterbody 7 (WB-7) is an isolated waterbody located within the Christina River at Chard sub-basin. Unnamed Waterbody WB-7 was considered to have suitable habitat for forage fish, providing rearing, feeding and spawning habitat. However, the habitat suitability for sport fish (northern pike) and non-sport fish (suckers) may be limited by the lack of connectivity to streams in the area restricting migration into and out of the waterbody and low winter dissolved oxygen concentrations. Although this waterbody may provide suitable rearing and feeding habitat during open-water seasons, the overwintering conditions would be severely limited for most sport or non-sport fish due to low dissolved oxygen concentrations. No fish were captured in WB-7.

Unnamed Waterbody 22 (WB-22) is a headwater lake of Sunday Creek, a tributary of Christina Lake. Unnamed Waterbody WB-22 provides suitable habitat for sport, non-sport and forage fish species. Dissolved oxygen levels in the winter were relatively high, providing suitable overwintering habitat for sport, non-sport and forage fish species. Yellow perch and unidentified forage fish were observed in the lake.

Other unnamed waterbodies evaluated were all shallow. The maximum depths for most of the lakes ranged between 1.6 m and 3.7 m, with some lakes having depths of less than 1.5 m. Most of these small lakes have significant oxygen

depletion under ice or limited water depth during winter. Fish assemblages at these lakes consist primarily of brook stickleback and/or limited numbers of lake chub.

Kirby Expansion Project

Unnamed Waterbody WB-1 is located in the centre of the LSA and is a headwater lake of Birch Creek. Unnamed Waterbody WB-1 provides suitable habitat for forage fish. Brook stickleback were the only species captured during the survey. Habitat suitability for sport and non-sport fish species is limited due to the shallow depth and lack of a defined outlet channel. Overwintering habitat is not available for sport and non-sport fish species.

Unnamed Waterbody WB-2 is a headwater lake of Sunday Creek. Unnamed Waterbody WB-2 provides suitable habitat for forage fish. Brook stickleback were the only species captured during the survey. Habitat suitability for sport and non-sport fish species is suitable during the open-water season. Over-wintering habitat is limited for sport and non-sport fish species due to the low DO concentrations measured.

Unnamed Waterbody WB-3 is a headwater lake of Sunday Creek. Unnamed Waterbody WB-3 provides suitable habitat for forage fish. Brook stickleback were the only species captured during the survey. Habitat suitability for sport and non-sport fish species is suitable during the open-water season. Over-wintering habitat is limited for sport and non-sport fish species due to the shallow depth of the lake.

Unnamed Waterbody WB-4 is a headwater lake of Sunday Creek. Unnamed Waterbody WB-4 provides suitable habitat for forage fish. Brook stickleback were the only species captured during the survey. Habitat suitability for sport and non-sport fish species is suitable during the open-water season. Over-wintering habitat is limited for sport and non-sport fish species due to the shallow depth of the lake.

Watercourses

Birch Creek is a tributary to Christina Lake. Habitat in Birch Creek was dominated by runs with occasional pools and riffles. Channel width was measured to be between 8.3 m and 12.0 m, with maximum water depths ranging from 0.2 to 0.4 m. Substrate was composed of fines and sand with occasional rubble and boulders. Fish species captured in Birch Creek include northern pike, brook stickleback and slimy sculpin.

Sunday Creek is a tributary to Christina Lake, and is characterized by run habitat and some pools and riffles. The substrate is composed of fines, sand, gravel, cobble and boulders. Fish species captured in Sunday Creek include Arctic grayling, northern pike, lake whitefish, walleye, white sucker, brook stickleback, lake chub, slimy sculpin and spoonhead sculpin.

Kirby North 2010

Birch Creek was surveyed at two locations, BC-1 and BC-2. The habitat-use potential in Birch Creek was low to moderate for all reaches, which consisted of mostly shallow runs. Although dissolved oxygen levels in winter were suitable to support overwintering for sport fish and non-sport fish species, shallow winter depths may be limiting. Fish species captured included longnose sucker, finescale dace, brook stickleback and slimy sculpin.

Sunday Creek was surveyed at two locations, SC-1 and SC-2. The habitat-use potential in Sunday Creek was low to moderate for all reaches, which consisted primarily of shallow run habitat, and was accessible to fish from Christina Lake. Relatively high winter dissolved oxygen levels would provide potential for overwintering, although much of Sunday Creek in the surveyed areas consisted of shallow run areas that could freeze to the bottom during winter. Fish species captured included northern pike, white sucker, spottail shiner and Iowa darter.

Unnamed Watercourse 12 (WC-12) is a tributary to Edwards Lake. The watercourse was observed to be dry in the fall but water was observed in the spring. Habitat use-potential for sport, non-sport and forage fish is nil to low. Overwintering habitat use potential is unlikely due to the dry conditions observed in the fall. However, farther downstream near Edwards Lake, it is likely impounded areas could provide overwintering habitat use potential for forage fish. Brook stickleback were captured.

Unnamed Watercourse 13 (WC-13) is a tributary to Glover Lake. Beaver impoundments were observed in the watercourse downstream of the site. Habitat use-potential for sport, non-sport and forage fish is nil to low. No fish were captured.

Kirby Expansion Project

Unnamed Watercourse SCT-1 is tributary of Sunday Creek. The habitat use potential at SCT-1 was considered low to moderate. The site was comprised of riffle, run and pool habitat that provided habitat for different fish guilds. Suitable spawning habitat was present for species that require swift flow and rocky substrates, as well as for those species that prefer low-velocity areas with

submerged vegetation. The presence of large woody debris jams could provide an impediment to migration of large-bodied fish. Dissolved oxygen concentrations were suitable for overwintering for some large-bodied and small-bodied fish species such as northern pike, slimy sculpin, and brook stickleback. However, overwintering habitat for large-bodied fish would be limited by the shallow water depth and intermittent areas of flowing water with many areas found frozen to the bottom. Slimy sculpin were the only species captured.

Unnamed Watercourse SCT-2 is tributary of Sunday Creek. The habitat use potential for site SCT-2 was considered low. The surveyed reach was comprised of a shallow run habitat. Suitable spawning habitat was absent for species that require swift flow and rocky substrates, but was present in small amounts for species that prefer low-velocity areas with submerged vegetation. Dissolved oxygen concentrations were suitable to provide overwintering habitat for lower DO concentration tolerant large-bodied and small-bodied fish species, but shallow water depth would limit available habitat. Brook stickleback were the only species captured.

Unnamed Watercourse SCT-3 is tributary of Sunday Creek. The habitat use potential for unnamed watercourse SCT-3 was considered low for overwintering potential. Suitable spawning habitat was absent for species that require swift flow and rocky substrates, but was present in small amounts for species that prefer low-velocity areas with submerged vegetation. The surveyed reach was comprised of run and impounded habitat. Beaver dams provided impediments to fish migration but provide potential overwintering habitat. Dissolved oxygen concentrations were suitable to provide overwintering habitat for lower DO concentration tolerant large-bodied and small-bodied fish species, but shallow water depth would limit available habitat. Brook stickleback were the only species captured.

6.2.2.2 Winefred River Sub-Basin

The Winefred River sub-basin comprises only a small portion of the southeast corner of the LSA.

Watercourses

Kirby Expansion Project

Unnamed Watercourse (UNT-1) is a tributary of Winefred Lake. The habitat use potential at UNT-1 was considered to be low to moderate. The site was comprised of riffle, run and pool habitat that provided habitat for various fish

species. Suitable spawning habitat was present for species that require swift flow and rocky substrates, as well as for those species that prefer low-velocity areas with submerged vegetation. Dissolved oxygen concentrations were suitable for overwintering for some large-bodied and small-bodied fish species such as northern pike, white sucker, lake chub, and brook stickleback. However, overwintering habitat for large-bodied fish may be limited by the shallow water depth. White sucker, northern redbelly dace, brook stickleback, finescale dace and lake chub were the species captured.

6.2.2.3 Lac la Biche Sub-Basin

The Lac la Biche sub-basin comprises waterbodies and watercourses, including Waiu Lake, within the southwestern portion of the LSA.

Waterbodies

Wiau Lake is a large, shallow lake consisting of two large bays (north and south) separated by a long narrow channel. Fish habitats have been described as being adequate. Although there may be limitations on overwintering capacity, Wiau Lake has been found to provide adequate overwintering habitat for northern pike and yellow perch. The abundance of aquatic vegetation provides suitable habitat for spawning, rearing and feeding for resident fish populations, particularly northern pike. Northern pike and yellow perch are the two sport fish species that have been documented to occur in Wiau Lake.

Kirby South 2010

Numerous unnamed waterbodies within the Lac la Biche sub-basin are located within the LSA, all of which are contained within the smaller Wiau Lake watershed.

Unnamed Lake 1 (UL-1) is a large lake located within the LSA. Unnamed Lake 1 has moderate overwintering potential for fish. Water depths range from 1.5 to 2.0 m with a maximum depth measured at 4.8 m along the east shoreline. Substrate throughout the lake consists of silt and sand, with silt, sand and occasional small gravel near the shoreline. Habitat quality for spawning, rearing and feeding of the resident northern pike, white sucker and minnow populations is considered moderate. Northern pike, white sucker, lake chub and brook stickleback have been captured in Unnamed Lake 1. Given the depth and the presence of potential barriers to migration upstream and downstream of the lake, the fish species captured are likely resident and overwinter in Unnamed Lake 1. The margins of the lake, as well as inlet and outlet streams also appear to provide spawning substrates for white sucker and northern pike.

Unnamed Lake 2 (UL-2) is a small, shallow lake unlikely to provide significant overwintering habitat for fish. Substrate throughout the lake consists of silt and detritus. Habitat quality in the lake for spawning, rearing and feeding is considered low and suitable for only minnow species. Downstream of the lake, the stream would provide only approximately 100 m of habitat for resident lake fish before extensive beaver dams result in barriers to movement. Upstream of the lake, the channel is undefined and ponded, limiting fish potential. Only brook stickleback have been captured in the lake.

Unnamed Lake 3 (UL-3) is located at the headwaters of the unnamed tributary flowing through the LSA. Overwintering potential for fish populations is considered low due to low DO concentrations and shallow depth. Substrate throughout the lake consists of fine sediments and detritus. Habitat quality for spawning, rearing and feeding is low to moderate for resident minnow species. No inlet streams are present and there is no defined outlet channel to the lake. At the northeast point of the lake, there is a wet, vegetated swale, with no channelization, preventing fish migration between the lake and the stream system. Brook stickleback and lake chub have been captured.

Unnamed Lake 4 (UL-4) is located within the LSA, northeast of Unnamed Lake 3. Overwintering potential is considered to be low for sport fish and moderate for forage fish. The substrate throughout the lake is primarily comprised of silt, fine sand and detritus. Unnamed Lake 4 is one of the deeper of the small lakes in the Lease Area. Most of the lake is less than 2.2 m in depth; however, a few small deep holes have been recorded with depths of 3.7 m. Unnamed Lake 4 is isolated, with no inlet or outlet streams present at the lake. Numerous brook sticklebacks have been captured in the lake but no other fish species have been recorded during baseline surveys.

Unnamed Lake 7 (UL-7) is a small, shallow lake to the south of Unnamed Lake 1 with limited overwintering potential for fish populations. The lake is flat-bottomed and shallow with a maximum depth of 1.1 m. Substrate is primarily soft silt and sand. Spring DO levels are fairly low, but levels of 11 mg/L have been measured during the summer. Unnamed Lake 7 is isolated, with no inlet or outlet streams. Only brook stickleback have been captured in Unnamed Lake 7.

The same waterbody was surveyed and called Unnamed Lake 11 (UL-11) for KS1 and Unnamed Waterbody 21 for the Kirby North 2010. UL-11/WB-21 is located to the northeast of Wiau Lake and drains into the unnamed tributary to Wiau Lake. The waterbody is shallow with a maximum depth of about 1.6 m with a large littoral zone. The waterbody was considered to have suitable habitat for forage fish, providing rearing, feeding and spawning habitat. However, the

habitat suitability for sport fish (northern pike) and non-sport fish (suckers) may be limited by shallow depth and low winter dissolved oxygen. No fish have been captured although numerous forage fish were observed in the lake during surveys.

Unnamed Lake 12 (UL-12) is a small lake between Unnamed Lake 2 and Unnamed Lake 7. The lake is shallow, with most of the lake less than 2.0 m in depth, and a maximum depth of 2.5 m. Substrate is comprised primarily of silt and sand. Habitat for spawning, rearing and feeding is considered low to moderate for minnow species. Unnamed Lake 12 is isolated with no inlet or outlet streams. Brook stickleback is the only fish species that has been captured.

Unnamed Lake 13 (UL-13) is a small lake to the west of Unnamed Lake 1. The lake is shallow, with a maximum depth of 1.2 m. Substrate consists of fine silt and sand. Spawning, rearing and feeding habitat quality is considered to be low for all fish species. Unnamed Lake 13 is isolated, with no inlet or outlet streams. No fish have been captured.

Watercourses

Kirby South 2010

Fish and fish habitat surveys have been conducted for several unnamed watercourses that drain into Wiau Lake.

The major unnamed tributary of Wiau Lake, labelled as Tributary #5 (Trib-5), was assessed at multiple locations from its headwaters to the confluence with Wiau Lake. Near the confluence with Wiau Lake, the watercourse is a low gradient (less than 0.5%), wide, flooded channel flowing through sedge/willow wetlands. The wetted width ranged from approximately 10 to 15 m during previous spring surveys. The habitat is composed entirely of low to moderate quality runs (R3, R2), with silt substrate and depths of 0.5 to 1.0 m in depth. The tributary provides sufficient depth for fish to overwinter, however low DO in winter may preclude some fish species from utilizing the survey area. Also, it is likely that most fish would move into Wiau Lake to overwinter, if accessible. Spring DO levels have been found to be adequate for sport fish. Overall, this tributary to Wiau Lake would provide moderate to good rearing and feeding habitat for resident Wiau Lake fish, as well as suitable northern pike spawning habitat in the spring.

Most of the tributary to Wiau Lake is extensively influenced by beaver activity with low-quality runs (R3), beaver impoundments and limited riffle sections. Boulder/cobble riffle habitat is present downstream of Unnamed Lake 1. A spring

survey conducted in 2007 indicated sufficient water levels and DO for fish with suitable spawning and rearing habitat.

Seven fish species have previously been captured during baseline sampling in the major tributary to Wiau Lake. Northern pike, yellow perch, white sucker, finescale dace, brook stickleback, lake chub and fathead minnow have been captured in this tributary.

Surveys have previously been completed for two secondary tributaries to the unnamed stream to Wiau Lake labelled as Tributary 1 (Trib-1) and Tributary 2 (Trib-2). These watercourses are small and may provide rearing habitat for juvenile lake resident fish species. The substrate is primarily silt with limited cover provided by sedge vegetation at the margins. The presence of multiple small woody debris jams and beaver dams restrict fish migration. Water depth and flow is limited in these tributaries with most having no defined channels. Only brook stickleback have been captured in these watercourses.

Kirby North 2010

Unnamed Watercourse 11 (WC-11) is a tributary to Wiau Lake within the Lac la Biche sub-basin. Unnamed Waterbody WC-11 consisted mainly of deeper runs accessible to fish from Wiau Lake, and has low to moderate habitat potential for sport and non-sport fish species. Habitat potential for forage fish is moderate to high. Although dissolved oxygen levels in winter were suitable for sport fish and sucker overwintering, shallow winter depths may be limiting for these species. Fish captured included northern pike, yellow perch, white sucker, lake chub, brook stickleback, fathead minnow and logperch.

Kirby Expansion Project

Unnamed Watercourse WLT-1 is a small, low-gradient watercourse that flows into Wiau Lake. The habitat use potential in WLT-1 was considered to be nil to low. The watercourse lacked a define channel in most areas therefore impeding fish migration. Suitable spawning habitat was absent at this location for species that require swift flow and rocky substrates, but was present in small amounts for species that prefer low-velocity flow with submerged vegetation. Dissolved oxygen concentrations were suitable for fish in the summer. Overwintering habitat for all fish was absent during winter because the watercourse was frozen to the bottom within the surveyed reach. No fish were captured.

Unnamed Watercourse WLT-2 is a narrow, low-gradient watercourse and is a tributary of Wiau Lake. The habitat use potential in unnamed watercourse WLT-2 was considered to be low. The sampled reach consisted of run and pool

habitat. Beaver dams that might impede fish migration were present in the channel. Suitable spawning habitat was absent at this location for species that require swift flow and rocky substrates, but was present in small amounts for species that prefer low-velocity flow with submerged vegetation. Water quality sampling during the winter survey indicated that low dissolved oxygen concentrations reduce the potential to provide suitable overwintering habitat for large-bodied fish species, but would be suitable for forage fish species that can tolerate low dissolved oxygen concentrations. Brook stickleback were captured.

6.2.3 Fish Species Distribution

A list of fish species documented to occur in the RSA was compiled from the available literature as well as data collected during the baseline study (Table 16). The distribution of fish species is shown with respect to the main sub-basins in the RSA, as well as the named and unnamed tributaries and waterbodies located within these basins. Also shown for each sub-basin are the species documented to occur in or near the LSA.

In total, 26 fish species have been recorded within the RSA, including nine sport species, two non-sport (i.e., sucker) species and 15 small-bodied forage fish species. Sport fish distribution has so far been found to be primarily limited to the mainstems of the larger rivers larger rivers in the RSA (i.e., Christina, Winefred, Kettle, and Landels rivers), and to the large named lakes. Northern pike and Arctic grayling were also found in tributaries of the major rivers. The two sucker species occur in many areas in the RSA and LSA, including the named and unnamed watercourses and waterbodies. However, fish communities in the LSA are dominated by forage fish species, with the most widely distributed species being brook stickleback, lake chub, pearl dace and slimy sculpin.

No fish species recorded within the RSA are listed under the Canadian *Species at Risk Act* (SARA 2011) or by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2011), which constitutes the federal lists of endangered species, threatened species and species of special concern.

One fish species reported from the RSA are listed as having special status in Alberta, based the most current general status report (ASRD 2010). Arctic grayling is currently designated as a ‘species of special concern’ (ASRD 2010) in Alberta.

Arctic grayling have been recorded in the mainstem of the Christina, Kettle, and Winefred rivers in RSA. This species has also been recorded in Christina and Winefred lakes near the LSA. Northern redbelly dace have been documented to occur in the LSA but have been recorded in low numbers at a few locations. Spoonhead sculpin and lake trout have been recorded in the mainstem of the Christina River in downstream in RSA.

6.2.4 Fishing Pressure and Fish Harvest

Aquatic resources in the LSA that provide exploitable fish populations of importance to sport or traditional fisheries are limited. Key resources are the mainstem of the Christina Lake, which supports key species such as Arctic grayling, burbot, northern pike and walleye, and the mainstem of Christina River, which supports northern pike and walleye.

In the portion of the RSA outside the LSA, key resources with exploitable fish populations include the mainstem of the Christina River, the mainstem of the Winefred River, Christina Lake and Winefred Lake. Christina and Winefred lakes both provide important sport fisheries. Sport fishing lodges or camps operate on Christina and Winefred lakes that target species such as Arctic grayling, northern pike and walleye.

The LSA does not have any potential for commercial fisheries, and the potential for the RSA is limited to the larger waterbodies in the Christina River, Sand River, Lac la Biche and Winefred River sub-basins. These lakes were investigated as potential commercial fisheries and it was concluded that commercial fishing for key species such as lake trout, northern pike or walleye would detract from the value of the lakes as sport fisheries. The commercial potential of other species (i.e., cisco, lake whitefish) was considered low based on such factors as small fish size. In the past, Winefred Lake supported a commercial fishery for walleye, northern pike and whitefish although the fishery was officially closed in 1986.

6.3 DIVERSITY OF FISH AND FISH HABITAT

Aquatic ecosystem diversity was addressed as part of the baseline study through the assessment of the diversity of the fish communities and fish habitats present in the surveyed waterbodies and watercourses in the LSA. Fish and fish habitat diversity was assessed through an examination of:

- fish species diversity;
- fish habitat diversity; and
- ecosystem diversity, as represented by trophic level complexity.

Fish and fish habitat diversity was assessed for the waterbody and watercourse sampling sites that were examined during the Project baseline study. The contribution of each waterbody or watercourse to fish and fish habitat diversity was categorized as very low, low, moderate or high based on the ranking they received in the evaluation of each of the species, habitat and ecosystem indicators.

Based on the ranking system used for this assessment, Wiau Lake provides the highest contribution to fish and fish habitat diversity in the LSA, with an overall diversity ranking of moderate. Wiau Lake has moderate species diversity due to the presence of predator species. All remaining waterbody and watercourse sites were ranked as very low for overall diversity.

Diversity was also assessed for the Kirby South and Kirby North projects. The major tributary to Wiau Lake, Birch Creek, Sunday Creek, Edwards Lake and Glover Lake were assessed as having moderate overall diversity. All other waterbodies and watercourses were assessed as having either low or very low overall diversity.

7 CLOSURE

We trust the above meets your present requirements. If you have any questions or require additional details, please contact the undersigned.

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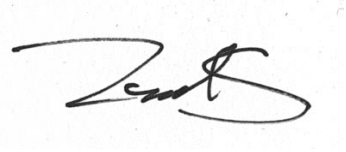

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9 ABBREVIATIONS

°C	Degrees Celsius
%	Percent
<	Less than
>	Greater than
±	Plus or minus
AENV	Alberta Environment
AEW	Alberta Environment and Water
ASRD	Alberta Sustainable Resource Development
bbl/d	Barrels of bitumen per day
Canadian Natural	Canadian Natural Resources Limited
CEMA	Cumulative Environmental Management Association
cm	Centimetre
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CPUE	Catch per unit of effort
DO	Dissolved Oxygen
e.g.	For example
et al.	And others
FRM	FRM Environmental Consulting Ltd.
FWMIS	Fish and Wildlife Management Information System
g	Grams
h or hr	Hour
ha	Hectare
ID	Interim Directive
i.e.	That is
in	Inches
IR	Indian Reserve
kg	kilogram
km	Kilometre
km^2	Square kilometre
LSA	Local Study Area
m	Metre
m^2	Square metres
masl	Metres above sea level

mg/L	Milligrams per litre
mm	Millimetre
m^3/s	Cubic metres per second
NAD	North American Datum
No.	Number
no/m^2	Number per square metre
NTU	Nephelometric Turbidity Units
Oz.	ounce
RAMP	Regional Aquatics Monitoring Program
RAP	Restricted Activity Period
Rg	Range
ROW	Rights-of-way
RSA	Regional Study Area
S	Second
SAGD	Steam Assisted Gravity Drainage
SARA	*Species at Risk Act*
The Project	Kirby In Situ Oil Sands Expansion Project
Tp	township
UTM	Universal Transverse Mercator
W4M	West of the Fourth Meridian
WSC	Water Survey of Canada
µm	Micron or Micrometre
µS/cm	Microsiemens per centimetre

10 GLOSSARY

Abiotic	Non-living factors that influence an ecosystem, such as climate, geology and soil characteristics.
Anoxia	Little to no dissolved oxygen in the water sample. Waters with less than 2 mg/L of dissolved oxygen experience anoxia.
Baseline	A surveyed or predicted condition that serves as a reference point to which later surveys are coordinated or correlated.
Baseline Case	The EIA assessment case that includes existing environmental conditions as well as existing and approved projects or activities.
Basin	A geographic area drained by a single major stream; consists of a drainage system comprised of streams and often natural or artificial (constructed) lakes.
Bathymetry	Measurement of the depth of an ocean or large waterbody.
Benthic Invertebrates	Invertebrate organisms living at, in or in association with the bottom (benthic) substrate of lakes, ponds and streams. Examples of benthic invertebrates include some aquatic insect species (such as caddisfly larvae) that spend at least part of their life stages dwelling on bottom sediments in the waterbody. These organisms play several important roles in the aquatic community. They are involved in the mineralization and recycling of organic matter produced in the water above, or brought in from external sources, and they are important second and third links in the trophic sequence of aquatic communities. Many benthic invertebrates are major food sources for fish.
Biotic	The living organisms in an ecosystem.
Bitumen	A highly viscous, tarry, black hydrocarbon material having an API gravity of about 9 (specific gravity about 1.0). It is a complex mixture of organic compounds. Carbon accounts for 80 to 85% of the elemental composition of bitumen, hydrogen 10%, sulphur 5%, and nitrogen, oxygen and trace elements form the remainder.
Boreal Forest	The northern hemisphere, circumpolar, tundra forest type consisting primarily of black spruce and white spruce with balsam fir, birch and aspen.

Channel	The bed of a stream or river.
Channel Unit	Distinct channel sections with specific characteristics of water depth, velocity and cover for fish.
Channel Width	The horizontal distance along a transect line from stream bank to stream bank (rooted vegetation to rooted vegetation) at the normal high water marks measured at right angles to the direction of flow.
Community	Plant or animal species living in close association or interacting as a unit.
Conductivity	A measure of the capacity of water to conduct an electrical current. It is the reciprocal of resistance. This measurement provides an estimate of the total concentration of dissolved ions in the water.
Coniferous	Bearing cones or strobili (a cone-like cluster).
Creel Survey	Catch assessment surveys undertaken to estimate the catches made by small scale or recreational fishermen, usually through a sampling program involving interviews and inspection of individual catches in the identified fishing and landing places.
Critical Habitat	Critical fish habitat is that used by species at risk or is habitat critical to sustaining local populations of a fish species, because of its rareness, high productive capacity, or sensitivity of the life stages it supports.
Deciduous	Tree species that lose their leaves at the end of the growing season.
Depositional	Gentle slope with fines.
Dissolved Oxygen (DO)	Measurement of the concentration of dissolved (gaseous) oxygen in the water, usually expressed in milligrams per litre (mg/L).
Diversity	The variety, distribution and abundance of different plant and animal communities and species within an area.
Drainage Basin	A region of land that eventually contributes water to a river or lake.
Ecosystem	An integrated and stable association of living and non-living resources functioning within a defined physical location. A community of organisms and its environment functioning as an ecological unit. For the purposes of assessment, the ecosystem must be defined according to a particular unit and scale.

Ekman Grab	Cube-shaped mechanical device with a spring-loaded opening that is lowered to the bottom of a waterbody and triggered to close as to collect a sample of the bottom substrate.
Electrofishing	A 'live' fish capture technique in which negative (anode) and positive (cathode) electrodes are placed in the water and an electrical current is passed between the electrodes. Fish are attracted (galvano-taxis) to the anode and become stunned (galvano-narcosis) by the current, allowing fish to be collected, measured and released.
Elutriate	To purify or separate by washing and straining.
Emergent Vegetation	Aquatic plants which root in shallow water but grow primarily above the water e.g., cattails and bulrushes.
Environmental Impact Assessment (EIA)	A review of the effects that a proposed development will have on the local and regional environment.
Evenness	The relative abundance of species; measured using the Shannon Weiner Index.
Extinct	A species that no longer exists.
Extirpated	A species no longer existing in the wild in Canada, but exists elsewhere in the world.
Fines	Silt and clay particles.
Floating-leaved Vegetation	Aquatic plants which root and grow under the water but have large leaves that float at the surface, e.g., pond lily.
Forage Fish	Small fish that provide food for larger fish (e.g., longnose sucker, fathead minnow).
Forb	A broad-leaved herb that is not a grass.
Fork Length	The length of a fish measured from the most anterior portion of the head to the tip of the shortest rays in the caudal fin (i.e., to the fork in the tail).
Fry	The early stage of development for the fish from hatching until it is one year old.
Generalist	Organism which can survive under a wide variety of conditions, and does not specialize to live under any particular set of circumstances.

Genus	A low-level taxonomic rank used in the classification of living and fossil organisms.
Groundwater	That part of the subsurface water that occurs beneath the water table, in soils and geologic formations that are fully saturated.
Guild	A set of co-existing species that share a common resource.
Habitat	The place or environment where a plant or animal naturally or normally lives or occurs.
Habitat Unit (HU)	Generally, used in Habitat Suitability Index models. A habitat is ranked in regards to its suitability for a particular wildlife species. This ranking is then multiplied by the area (hectares) of the particular habitat type to give the number of habitat units (HU) available to the wildlife species in question.
Headwater(s)	The source and upper reaches of a stream; also the upper reaches of a reservoir. The water upstream from a structure or point on a stream. The small streams that come together to form a river. Also may be thought of as any and all parts of a river basin except the mainstem river and main tributaries.
In Situ	Also known as “in place”. Refers to methods of extracting deep deposits of oil sands without removing the groundcover. The in situ technology in oil sands uses underground wells to recover the resources with less impact to the land, air and water than for oil sands mining.
Instar	A development stage of arthropods, such as insects, between each moult (ecdysis), until sexual maturity is reached.
Littoral Zone	The zone in a lake that is closest to the shore. It includes the part of the lake bottom, and its overlying water, between the highest water level and the depth where there is enough light (about 1% of the surface light) for rooted aquatic plants and algae to colonize the bottom sediments.
Local Study Area (LSA)	Defines the spatial extent directly or indirectly affected by the Project.
Macrophytes	Plants large enough to be seen by the unaided eye. Aquatic macrophytes are plants that live in or in close proximity to water.
Mainstem	The main portion of a watercourse extending continuously upstream from its mouth, but not including any tributary watercourses.

Mixedwood	A terrestrial forest type that is an assemblage of both deciduous and coniferous tree species.
Morphology	Morphology or fluvial geomorphology is the term used in the description of closure drainage designs that replicate natural analogues. It describes the process and the structure of natural systems that are to be replicated in constructed drainage channels, including regime relationships for various channel parameters such as width, depth, width/depth ratio, meander wavelength, sinuosity, bed material, gradient and bank slope.
Muskeg	A soil type comprised primarily of organic matter. Also known as bog peat.
Niche	The function or position of an organism or population within an ecological community.
Non-Sport Fish	Large fish that is not caught for food or sport (e.g., longnose sucker, white sucker).
Oil Sands	A sand deposit containing a heavy hydrocarbon (bitumen) in the intergranular pore space of sands and fine grained particles. Typical oil sands comprise approximately 10 wt% bitumen, 85% coarse sand (>44 µm) and a fines (<44 µm) fraction, consisting of silts and clays.
Oil Sands Region	The Oil Sands Region includes the Fort McMurray – Athabasca Oil Sands Subregional Integrated Resource Plan (IRP), the Lakeland Subregional IRP and the Cold Lake – Beaver River Subregional IRP.
Overwintering Habitat	Habitat used during the winter as a refuge and for feeding.
Pelagic	Inhabiting open water, typically well off the bottom. Sometimes used synonymously with limnetic to describe the open water zone (e.g., large lake environments).
pH	The degree of acidity (or alkalinity) of soil or solution. The pH scale is generally presented from 1 (most acidic) to 14 (most alkaline). A difference of one pH unit represents a ten-fold change in hydrogen ion concentration.
Piscivorous Diet	Feeding on fish.

Planned Development Case (PDC)	The Planned Development Case includes the Application Case components and planned developments that have been publicly disclosed at least six months prior to submission of the Environmental Impact Assessment.
Reach	A comparatively short length of river, stream channel or shore. The length of the reach is defined by the purpose of the study.
Regional Aquatics Monitoring Program (RAMP)	RAMP was established to determine, evaluate and communicate the state of the aquatic environment in the Athabasca Oil Sands Region.
Regional Study Area (RSA)	Defines the spatial extent related to the cumulative effects resulting from the Project and other regional developments.
Richness	The number of species in a biological community (e.g., habitat).
Riffle Habitat	Shallow rapids where the water flows swiftly over completely or partially submerged materials to produce surface agitation.
Riffle-Run-Pool	A mixture of flows and depth and providing a variety of habitats. Pools are deep with slow water. Riffles are shallow with fast, turbulent water running over rocks. Runs are deep with fast water and little or no turbulence.
Riparian	Refers to terrain, vegetation or simply a position next to or associated with a stream, floodplain or standing waterbody.
Rubble	Broken stone, or irregular size, shape and texture.
Sediment	Solid material that is transported by, suspended in, or deposited from water. It originates mostly from disintegrated rocks; it also includes chemical and biochemical precipitates and decomposed organic material, such as humus. The quantity, characteristics and cause of the occurrence of sediment in streams are influenced by environmental factors. Some major factors are degree of slope, length of slope soil characteristics, land usage and quantity and intensity of precipitation.
Sedge	Any plant of the genus *Carex*, perennial herbs, often growing in dense tufts in marshy places. They have triangular jointless stems, a spiked inflorescence and long grass-like leaves which are usually rough on the margins and midrib. There are several hundred species.

Seepage	Slow water movement in subsurface. Flow of water from constructed retaining structures. A spot or zone, where water oozes from the ground, often forming the source of a small spring.
Simpson's Diversity	Also know as species diversity index. Simpson's Diversity is one of a number of diversity indices, used to measure of diversity. In ecology, it is often used to quantify the biodiversity of a habitat. It takes into account the number of species present, as well as the relative abundance of each species. The Simpson index represents the probability that two randomly selected individuals in the habitat will not belong to the same species.
Spawning	The reproductive stage of adult fish that includes fertilization and deposition of eggs.
Species	A group of organisms that actually or potentially interbreed and are reproductively isolated from all other such groups; a taxonomic grouping of genetically and morphologically similar individuals; the category below genus.
Species Diversity	A description of a biological community that includes both the number of different species and their relative abundance. Provides a measure of the variation in number of species in a region. This variation depends partly on the variety of habitats and the variety of resources within habitats and, in part, on the degree of specialization to particular habitats and resources.
Species Richness	The number of different species occupying a given area.
Sport / Game Fish	Large fish caught for food or sport (e.g., northern pike, Arctic grayling).
Stratify	Layering of lakes into two or more non-mixing layers; in summer, typically a layer of warmer, less dense water lies on a cooler, denser layer; in winter, typically a layer of very cold (less than 4°C), less dense water overlies warmer, denser water (approximately 4°C).
Steam Assisted Gravity Drainage (SAGD)	An in situ oil sands recovery technique that involves the use of two horizontal wells, one to inject steam and a second to produce the bitumen.
Stream Order	A simple hydrology algorithm used to define stream size based on a hierarchy of its tributaries.
Submergent Vegetation	Aquatic vegetation completely below the surface.

Substrate	Material in the stream bed. The assemblage of material sizes include: • Organic/Silt: organic material or fine material less than 0.006 mm diameter; • Sand: material 0.06 to 2.0 mm diameter; • Small Gravel: material 2 to 8 mm diameter; • Large Gravel: material 8 to 32 mm diameter; • Pebble: material 32 to 64 mm diameter; • Cobble: material 64 to 256 mm diameter; and • Boulder: material >256 mm diameter.
Swale	A natural depression or wide shallow ditch used to convey runoff.
Taxa	A group of organisms of any taxonomic rank (e.g., family, genus, or species).
Thermocline	A layer within a waterbody where the temperature changes rapidly with depth.
Transect	A method of sampling vegetation, along a path or fixed line.
Trophic	Pertaining to part of a food chain, for example, the primary producers are a trophic level just as tertiary consumers are another trophic level.
Turbidity	An indirect measure of suspended particles, such as silt, clay, organic matter, plankton and microscopic organisms, in water.
Waterbody	A general term that refers to ponds, bays, lakes, estuaries and marine areas.
Watercourse	A general term that refers to riverine systems such as creeks, brooks, streams and rivers.
Watershed	The area of land bounded by topographic features that drains water to a larger waterbody such as a river, wetlands or lake. Watershed can range in size from a few hectares to thousands of kilometres.
Wetlands	Wetlands are land where the water table is at, near or above the surface or which is saturated for a long enough period to promote such features as wet-altered soils and water tolerant vegetation. Wetlands include organic wetlands or “peatlands,” and mineral wetlands or mineral soil areas that are influenced by excess water but produce little or no peat.

Wetted Width	The width of the water surface measured at right angles to the direction of flow. Multiple channel widths are summed to obtain total wetted width.
Young of the Year (YOY)	Fish at age 0, within the first year after hatching.

ATTACHMENT A

SUBSTRATE PARTICLE SIZE CRITERIA FOR HABITAT MAPPING

Table A-1 Substrate Size Criteria for Habitat Assessment

Class Name	Abbreviation		Size Range	
	Specific	General	mm	Inches
clay/silt	Si	Si	<0.06	<0.0024
sand	Sa	Sa	0.06 to 2.0	0.0024 to 0.08
small gravel	S Gr	Gr	2 to 8	0.08 to 0.3
medium gravel	M Gr		8 to 32	0.3 to 1.3
large gravel	L Gr		32 to 64	1.3 to 2.5
small cobble	S Co	Co	64 to 128	2.5 to 5
large cobble	L Co		128 to 256	5 to 10
small boulder	S Bo	Bo	256 to 762	10 to 30
large boulder	L Bo		>762	>30
bedrock	Be	Be	-	-

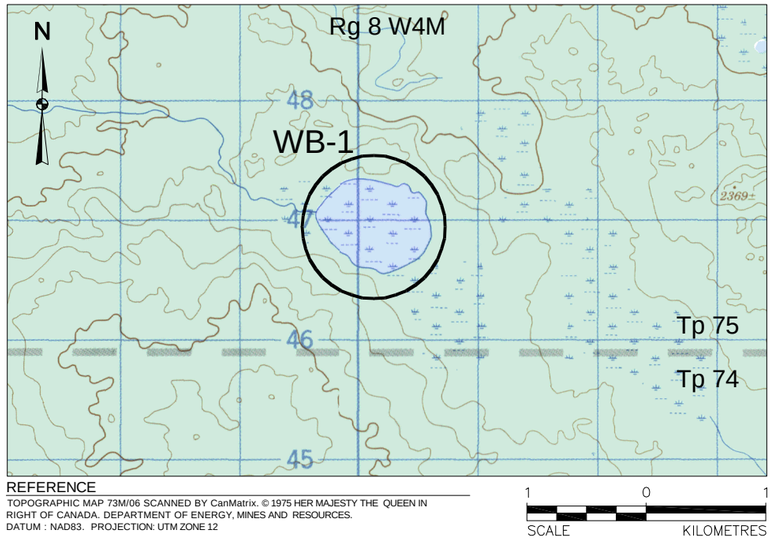
- = Not applicable.

ATTACHMENT B

HABITAT MAPS FOR WATERBODY AND WATERCOURSE FIELD SAMPLING SITES

Photo 1 - Aerial view of unnamed waterbody, looking north (September 2011).

Photo 2 - Aerial view of unnamed waterbody, looking south (September 2011).



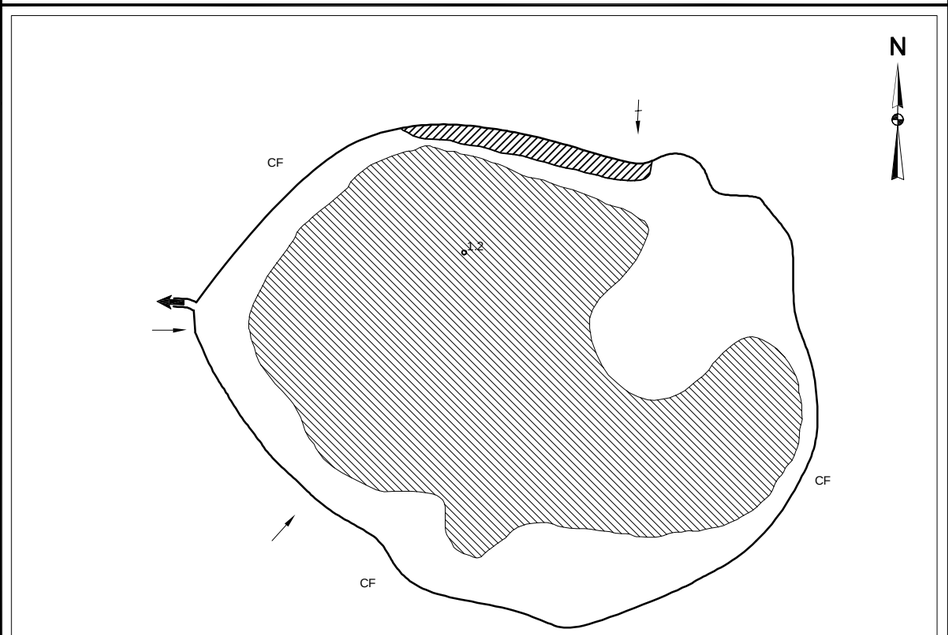


Photo 3 - Shoreline habitat on southern edge of waterbody (September 2011).

Photo 4 - Shoreline habitat on northern edge of waterbody (September 2011).

LEGEND - LAKE HABITAT MAPPING SYSTEM

- 0.61 m — Indicates Depth
- Direction of Flow
- BL — Beaverlodge
- Exposed Bar - Fine
- Exposed Bar - Coarse
- Island
- Woody Debris Pile
- Overhead Cover, High Quality
- Overhanging Vegetation
- Tree, Shrub, Grass

Substrate Particle Size:

Or	Organic Material	
Si	Silt	(<0.06 mm)
Sa	Sand	(0.06 to 2 mm)
Gr	Gravel	(2 to 64 mm)
Co	Cobble	(64 to 256 mm)
Bo	Boulder	(>256 mm)
Be	Bedrock	

Shore / Bottom Slope

Shallow Slope	(0 to 5%)
Intermediate Slope	(6 to 30%)
Steep Slope	(31 to 70%)
Very Steep Slope	(>70%)

Upland Vegetation Type:

BA	Bare
OT	Open Tundra
MU	Muskeg/Bog
GF	Grass/Forbs
SE	Sedges
SH	Shrub
DF	Deciduous Forest
CF	Coniferous Forest
MW	Mixedwood Forest

Aquatic Macrophyte Distribution

- Emergent Vegetation
- Submergent or Floating-Leaved Vegetation
- Inundated Terrestrial Vegetation

PROJECT

Canadian Natural

KIRBY IN SITU OIL SANDS EXPANSION PROJECT

TITLE

HABITAT MAP FOR UNNAMED WATERBODY (WB-1)

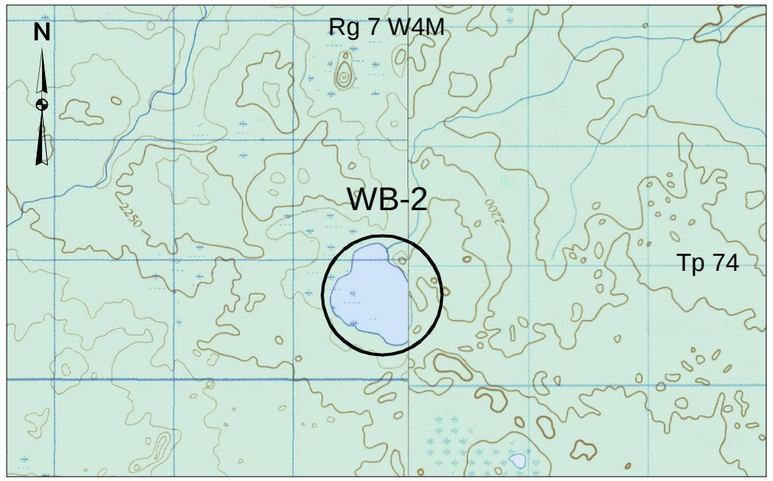
Golder Associates Calgary, Alberta

PROJECT	10.1346.0052.6100		FILE No.	101346005261 00A008	
DESIGN	DA	12/10/11	SCALE	AS SHOWN	REV. 0
CADD	IPG	13/10/11			
CHECK	MD	07/12/11			
REVIEW	KC	08/12/11			

FIGURE:B-1

L:\2010\1346\10-1346-0052\6100\Report A (6110)\FigB-1_101346005261 00A008 WB-1.dwg Dec 08, 2011 - 12:23pm

Photo 1 - Aerial view of unnamed waterbody, looking east (June 2011).



REFERENCE

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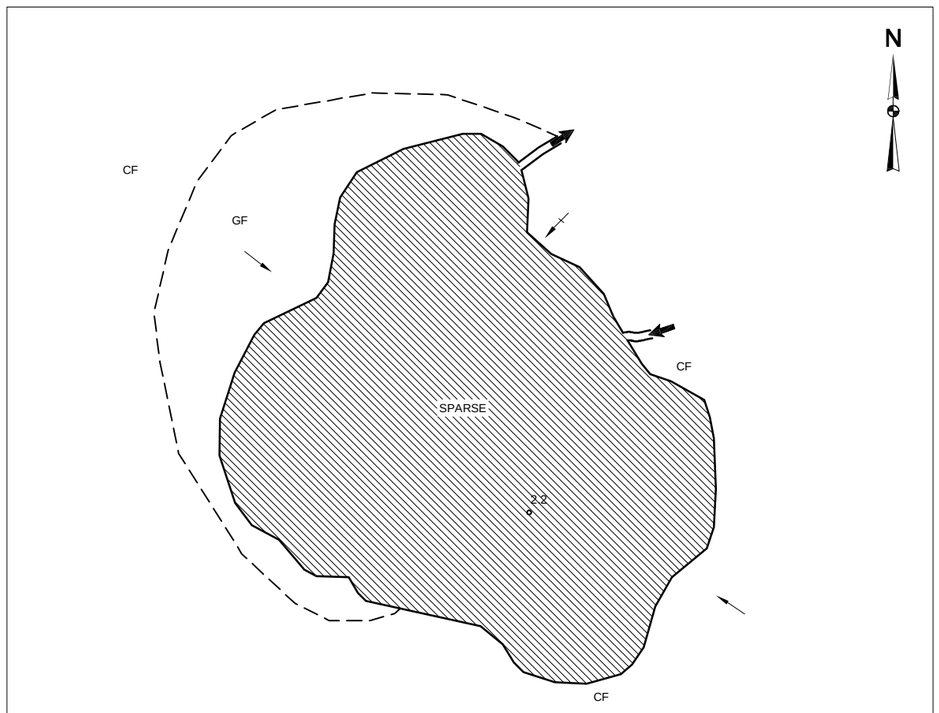
DATUM : NAD83. PROJECTION: UTM ZONE 12

1 0 1
SCALE KILOMETRES

Photo 3 - West shoreline of unnamed waterbody (September 2011).

Photo 2 - Nearshore habitat and location of minnow trap sets on the unnamed waterbody (September 2011).



SCHEMATIC ONLY, NOT TO SCALE

Photo 4 - West shoreline of unnamed waterbody (September 2011).

LEGEND - LAKE HABITAT MAPPING SYSTEM

- 0.61 m — Indicates Depth
- Direction of Flow
- BL — Beaverlodge
- Exposed Bar - Fine
- Exposed Bar - Coarse
- Island
- Woody Debris Pile
- Overhead Cover, High Quality
- Overhanging Vegetation
- Tree, Shrub, Grass

Substrate Particle Size:

Or	Organic Material	
Si	Silt	(<0.06 mm)
Sa	Sand	(0.06 to 2 mm)
Gr	Gravel	(2 to 64 mm)
Co	Cobble	(64 to 256 mm)
Bo	Boulder	(>256 mm)
Be	Bedrock	

Shore / Bottom Slope

Shallow Slope	(0 to 5%)
Intermediate Slope	(6 to 30%)
Steep Slope	(31 to 70%)
Very Steep Slope	(>70%)

Upland Vegetation Type:

BA	Bare
OT	Open Tundra
MU	Muskeg/Bog
GF	Grass/Forbs
SE	Sedges
SH	Shrub
DF	Deciduous Forest
CF	Coniferous Forest
MW	Mixedwood Forest

Aquatic Macrophyte Distribution

- Emergent Vegetation
- Submergent or Floating-Leaved Vegetation
- Inundated Terrestrial Vegetation

PROJECT

Canadian Natural

KIRBY IN SITU OIL SANDS EXPANSION PROJECT

TITLE

HABITAT MAP FOR UNNAMED WATERBODY (WB-2)

Golder Associates Calgary, Alberta

PROJECT	10.1346.0052.6100		FILE No.	10134600526100A009
DESIGN	DA	12/10/11	SCALE	AS SHOWN REV. 0
CADD	IPG	13/10/11		
CHECK	MD	07/12/11		
REVIEW	KC	08/12/11		

FIGURE:B-2

L:\2010\1346\10-1346-0052\6100\Report A (6110)\FigB-2_10134600526100A009 WB-2.dwg Dec 08, 2011 - 12:23pm

Photo 1 - Aerial view of unnamed waterbody looking northeast (September 2011).

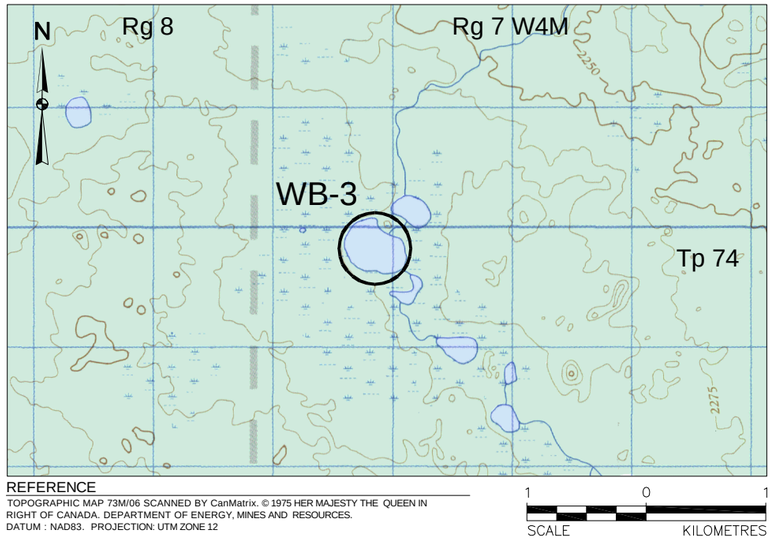
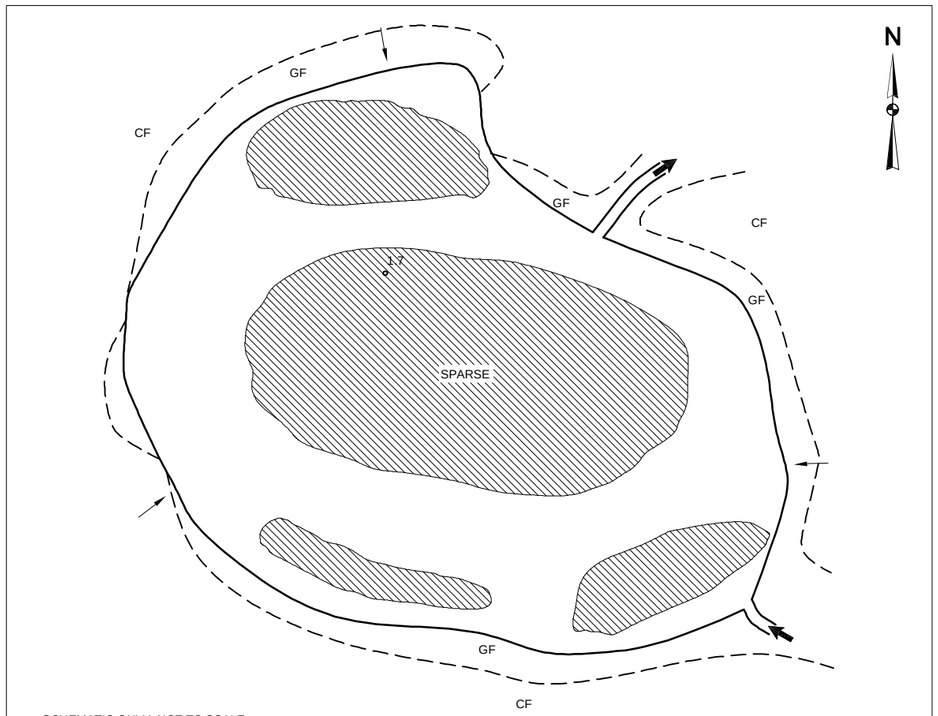


Photo 3 - Location of minnow traps on east shoreline (September 2011).

Photo 2 - Inlet of unnamed waterbody (September 2011).



SCHEMATIC ONLY, NOT TO SCALE

Photo 4 - View across unnamed waterbody (September 2011).

LEGEND - LAKE HABITAT MAPPING SYSTEM

- 0.61 m — Indicates Depth
- Direction of Flow
- BL — Beaverlodge
- Exposed Bar - Fine
- Exposed Bar - Coarse
- Island
- Woody Debris Pile
- Overhead Cover, High Quality
- Overhanging Vegetation
- Tree, Shrub, Grass

Substrate Particle Size:

Or	Organic Material	
Si	Silt	(<0.06 mm)
Sa	Sand	(0.06 to 2 mm)
Gr	Gravel	(2 to 64 mm)
Co	Cobble	(64 to 256 mm)
Bo	Boulder	(>256 mm)
Be	Bedrock	

Shore / Bottom Slope

Shallow Slope	(0 to 5%)
Intermediate Slope	(6 to 30%)
Steep Slope	(31 to 70%)
Very Steep Slope	(>70%)

Upland Vegetation Type:

BA	Bare
OT	Open Tundra
MU	Muskeg/Bog
GF	Grass/Forbs
SE	Sedges
SH	Shrub
DF	Deciduous Forest
CF	Coniferous Forest
MW	Mixedwood Forest

Aquatic Macrophyte Distribution

- Emergent Vegetation
- Submergent or Floating-Leaved Vegetation
- Inundated Terrestrial Vegetation

PROJECT
Canadian Natural

KIRBY IN SITU OIL SANDS EXPANSION PROJECT

TITLE

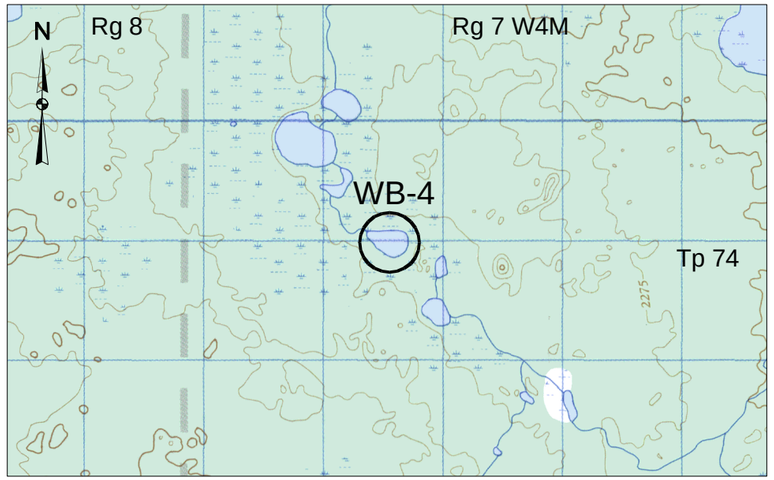
HABITAT MAP FOR UNNAMED WATERBODY (WB-3)

Golder Associates
Calgary, Alberta

PROJECT 10.1346.0052.6100			FILE No. 10134600526100A010	
DESIGN	DA	12/10/11	SCALE AS SHOWN	REV. 0
CADD	IPG	18/10/11		
CHECK	MD	07/12/11	FIGURE:B-3	
REVIEW	KC	08/12/11		

L:\2010\1346\10-1346-0052\6100\Report A (6110)\FigB-3_10134600526100A010 WB-3.dwg Dec 08, 2011 - 12:23pm

Photo 1 - Aerial view of unnamed waterbody, facing east (September 2011).



REFERENCE

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DATUM : NAD83. PROJECTION: UTM ZONE 12

1 0 1
SCALE KILOMETRES

Photo 3 - Aerial view of unnamed waterbody, facing north (September 2011).

Photo 2 - Aerial view of unnamed waterbody, facing east (September 2011).

SCHEMATIC ONLY, NOT TO SCALE

Photo 4 - Helicopter with sampling gear landing on the shore of unnamed waterbody (September 2011).

LEGEND - LAKE HABITAT MAPPING SYSTEM

- 0.61 m — Indicates Depth
- Direction of Flow
- BL — Beaverlodge
- Exposed Bar - Fine
- Exposed Bar - Coarse
- Island
- Woody Debris Pile
- Overhead Cover, High Quality
- Overhanging Vegetation
- Tree, Shrub, Grass

Substrate Particle Size:

Or	Organic Material	
Si	Silt	(<0.06 mm)
Sa	Sand	(0.06 to 2 mm)
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Co	Cobble	(64 to 256 mm)
Bo	Boulder	(>256 mm)
Be	Bedrock	

Shore / Bottom Slope

Shallow Slope	(0 to 5%)
Intermediate Slope	(6 to 30%)
Steep Slope	(31 to 70%)
Very Steep Slope	(>70%)

Upland Vegetation Type:

BA	Bare
OT	Open Tundra
MU	Muskeg/Bog
GF	Grass/Forbs
SE	Sedges
SH	Shrub
DF	Deciduous Forest
CF	Coniferous Forest
MW	Mixedwood Forest

Aquatic Macrophyte Distribution

- Emergent Vegetation
- Submergent or Floating-Leaved Vegetation
- Inundated Terrestrial Vegetation

PROJECT

Canadian Natural

KIRBY IN SITU OIL SANDS EXPANSION PROJECT

TITLE

HABITAT MAP FOR UNNAMED WATERBODY (WB-4)

Golder Associates
Calgary, Alberta

PROJECT	10.1346.0052.6100		FILE No.	10134600526100A011	
DESIGN	DA	12/10/11	SCALE	AS SHOWN	REV. 0
CADD	IPG	18/10/11			
CHECK	MD	07/12/11			
REVIEW	KC	08/12/11			

FIGURE:B-4

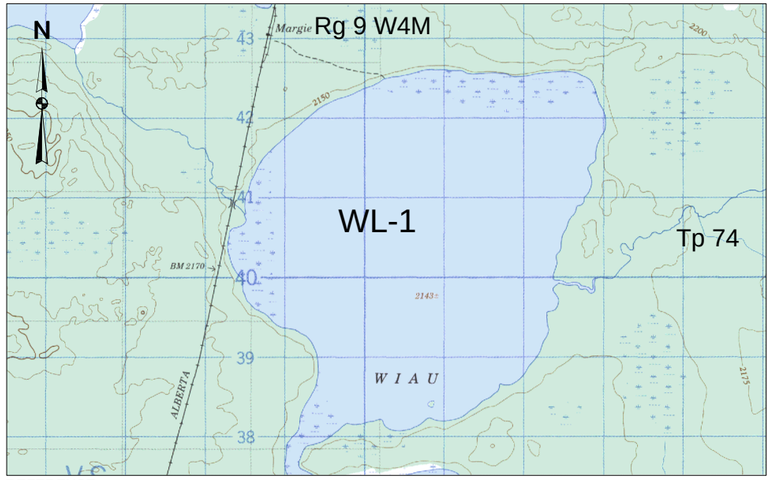
L:\2010\1346\10-1346-0052\6100\Report A (6110)\FigB-4_10134600526100A011 WB-4.dwg Dec 08, 2011 - 12:24pm

Photo 1 - Aerial view of Wiau Lake eastern shoreline (September 2011).

Photo 3 - East shoreline view of Wiau Lake (September 2011).

Photo 4 - West shoreline habitat on Wiau Lake (September 2011).

Photo 2 - Aerial view of Wiau Lake north eastern shoreline (September 2011).



REFERENCE

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DATUM : NAD83. PROJECTION: UTM ZONE 12

1.5 0 1.5
SCALE KILOMETRES

Photo 5 - West shoreline habitat on Wiau Lake (September 2011).

PROJECT

Canadian Natural

KIRBY IN SITU OIL SANDS EXPANSION PROJECT

TITLE

SITE PHOTOGRAPHS OF WIAU LAKE (WL-1)

Golder Associates
Calgary, Alberta

PROJECT 10.1346.0052.6100			FILE No. 10134600526100A007	
DESIGN	DA	12/10/11	SCALE AS SHOWN	REV. 0
CADD	IPG	13/10/11		
CHECK	MD	07/12/11	**FIGURE:B-5**	
REVIEW	KC	08/12/11		

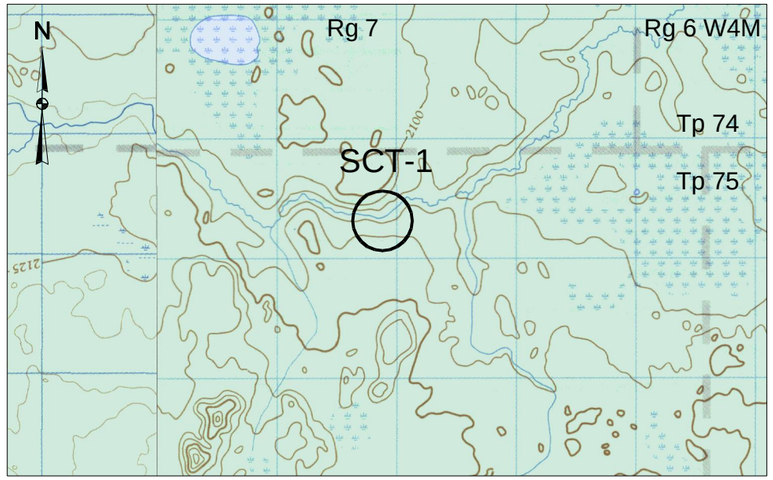
L:\2010\1346\10-1346-0052\6100\Report A (6110)\FigB-5_10134600526100A007 WL-1.dwg Dec 08, 2011 - 12:24pm

Photo 1 - Aerial view (September 2011).

Photo 3 - Downstream view of channel (September 2011).

Photo 4 - Downstream view of channel (September 2011).

Photo 2 - Upstream view of channel (September 2011).



REFERENCE

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DATUM : NAD83. PROJECTION: UTM ZONE 12

1 0 1
SCALE KILOMETRES

Photo 5 - Upstream view of channel (September 2011).

PROJECT

Canadian Natural

KIRBY IN SITU OIL SANDS EXPANSION PROJECT

TITLE

SITE PHOTOGRAPHS OF UNNAMED WATERCOURSE (SCT-1)

Golder Associates
Calgary, Alberta

PROJECT 10.1346.0052.6100			FILE No. 10134600526100A001	
DESIGN	DA	12/10/11	SCALE AS SHOWN	REV. 0
CADD	IPG	18/10/11		
CHECK	MD	07/12/11		
REVIEW	KC	08/12/11		

FIGURE:B-6

L:\2010\1346\10-1346-0052\6100\Report A (6110)\FigB-6_10134600526100A001 SCT-1.dwg Dec 08, 2011 - 12:24pm

Photo 1 - Upstream aerial view of unnamed watercourse (September 2011).

Photo 3 - Downstream view from downstream minnow trap set to old impoundment (September 2011).

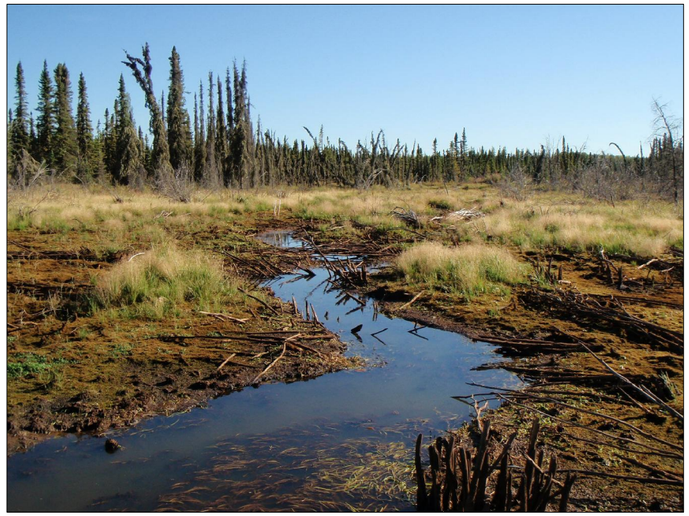
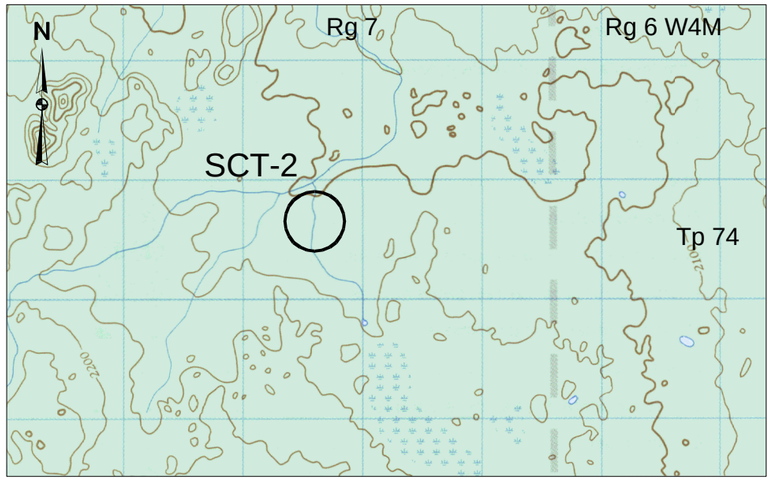


Photo 4 - Upstream view from downstream minnow trap set (September 2011).

Photo 2 - Upstream aerial view of unnamed watercourse (September 2011).



REFERENCE

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DATUM : NAD83. PROJECTION: UTM ZONE 12

1 0 1
SCALE KILOMETRES

Photo 5 - Upstream view of unnamed watercourse (September 2011).

PROJECT

Canadian Natural

KIRBY IN SITU OIL SANDS EXPANSION PROJECT

TITLE

SITE PHOTOGRAPHS OF UNNAMED WATERCOURSE (SCT-2)

Golder Associates
Calgary, Alberta

PROJECT 10.1346.0052.6100			FILE No. 10134600526100A002	
DESIGN	DA	12/10/11	SCALE AS SHOWN	REV. 0
CADD	IPG	18/10/11	**FIGURE:B-7**	
CHECK	MD	07/12/11		
REVIEW	KC	08/12/11		

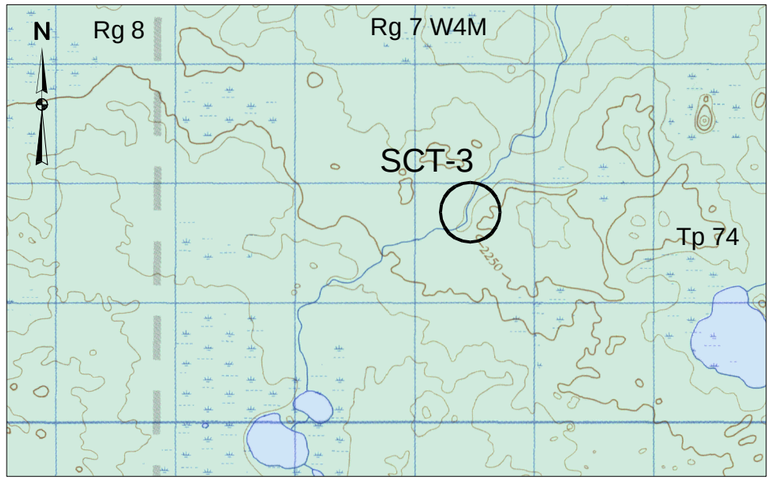
L:\2010\1346\10-1346-0052\6100\Report A (6110)\FigB-7_10134600526100A002 SCT-2.dwg Dec 08, 2011 - 12:25pm

Photo 1 - Upstream aerial view of unnamed watercourse (September 2011).

Photo 3 - Right downstream bank at beaver impoundment (September 2011).

Photo 4 - Left downstream bank at beaver impoundment (September 2011).

Photo 2 - Upstream view of confined channel (September 2011).



REFERENCE

TOPOGRAPHIC MAP 73M/06 SCANNED BY CanMatrix. © 1975 HER MAJESTY THE QUEEN IN RIGHT OF CANADA. DEPARTMENT OF ENERGY, MINES AND RESOURCES.
DATUM : NAD83. PROJECTION: UTM ZONE 12

1 0 1
SCALE KILOMETRES

Photo 5 - Upstream view of beaver impoundment (September 2011).

PROJECT

Canadian Natural

KIRBY IN SITU OIL SANDS EXPANSION PROJECT

TITLE

SITE PHOTOGRAPHS OF UNNAMED WATERCOURSE (SCT-3)

Golder Associates Calgary, Alberta

PROJECT	10.1346.0052.6100		FILE No.	10134600526100A003
DESIGN	DA	12/10/11	SCALE AS SHOWN	REV. 0
CADD	IPG	18/10/11		
CHECK	MD	07/12/11		
REVIEW	KC	08/12/11		

FIGURE:B-8

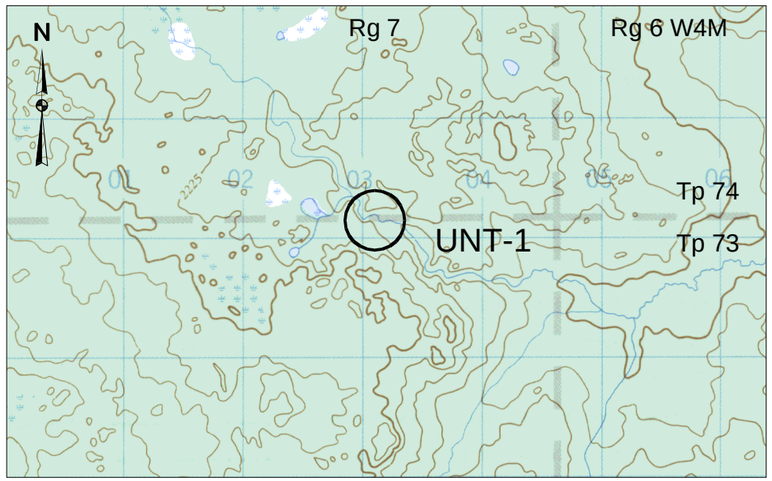
L:\2010\1346\10-1346-0052\6100\Report A (6110)\FigB-8_10134600526100A003 SCT-3.dwg Dec 08, 2011 - 12:25pm

Photo 1 - Upstream aerial view of unnamed watercourse (September 2011).

Photo 3 - Upstream view of run habitat (September 2011).

Photo 4 - Upstream view of riffle and pool habitat (September 2011).

Photo 2 - Downstream view of riffle habitat (September 2011).



REFERENCE

TOPOGRAPHIC MAP 73M/07 SCANNED BY CanMatrix. © 1975 HER MAJESTY THE QUEEN IN RIGHT OF CANADA. DEPARTMENT OF ENERGY, MINES AND RESOURCES.
DATUM : NAD83. PROJECTION: UTM ZONE 12

1 0 1
SCALE KILOMETRES

Photo 5 - Upstream view of discharge location (September 2011).

PROJECT

Canadian Natural

KIRBY IN SITU OIL SANDS EXPANSION PROJECT

TITLE

SITE PHOTOGRAPHS OF UNNAMED WATERCOURSE (UNT-1)

Golder Associates
Calgary, Alberta

PROJECT 10.1346.0052.6100			FILE No. 10134600526100A006	
DESIGN	DA	12/10/11	SCALE AS SHOWN	REV. 0
CADD	IPG	18/10/11	**FIGURE:B-9**	
CHECK	MD	07/12/11		
REVIEW	KC	08/12/11		

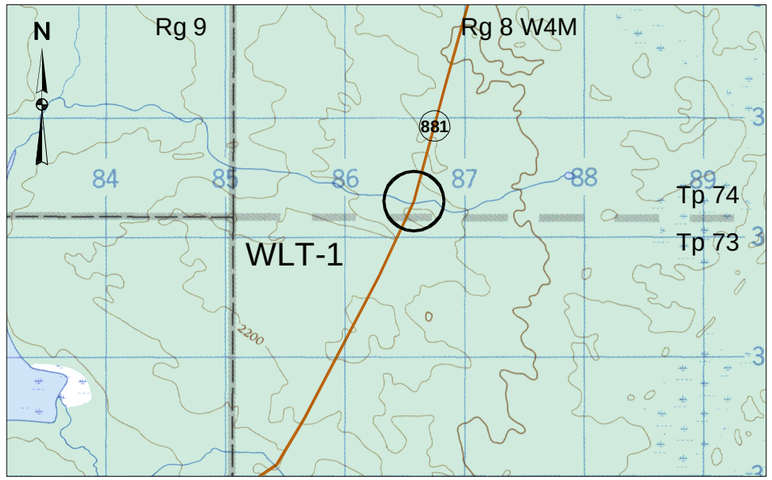
L:\2010\1346\10-1346-0052\6100\Report A (6110)\FigB-9_10134600526100A006 UNT-1.dwg Dec 08, 2011 - 12:25pm

Photo 1 - Upstream aerial view of unnamed watercourse, at Highway 881 (September 2011).

Photo 3 - View of downstream ditch with water impounded (September 2011).

Photo 4 - Upstream view of unnamed watercourse from Highway 881 (September 2011).

Photo 2 - Unconfined beaver impounded area downstream of Highway 881 (September 2011).



REFERENCE

TOPOGRAPHIC MAP 73M/06 SCANNED BY CanMatrix. © 1975 HER MAJESTY THE QUEEN IN RIGHT OF CANADA, DEPARTMENT OF ENERGY, MINES AND RESOURCES.
DATUM : NAD83. PROJECTION: UTM ZONE 12

1 0 1
SCALE KILOMETRES

Photo 5 - Downstream view of unnamed watercourse from Highway 881 (September 2011).

PROJECT

Canadian Natural

KIRBY IN SITU OIL SANDS EXPANSION PROJECT

TITLE

SITE PHOTOGRAPHS OF UNNAMED WATERCOURSE (WLT-1)

Golder Associates
Calgary, Alberta

PROJECT 10.1346.0052.6100			FILE No.10134600526100A004	
DESIGN	DA	12/10/11	SCALE AS SHOWN	REV. 0
CADD	IPG	21/10/11		
CHECK	md	07/12/11	**FIGURE:B-10**	
REVIEW	kc	08/12/11		

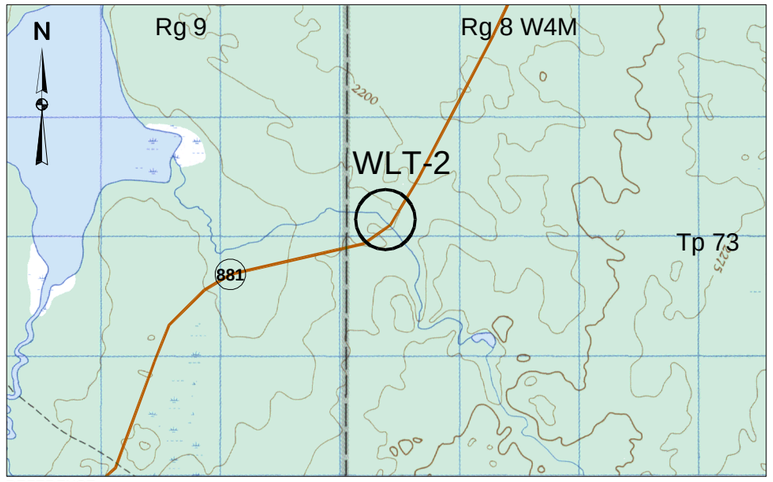
L:\2010\1346\10-1346-0052\6100\Report A (6110)\FigB-10_10134600526100A004 WLT-1.dwg Dec 08, 2011 - 12:26pm

Photo 1 - Aerial view of unnamed watercourse where it crosses Highway 881 (September 2011).

Photo 3 - Right downstream bank of unnamed watercourse (September 2011).

Photo 4 - Left downstream bank of unnamed watercourse (September 2011).

Photo 2 - Upstream aerial view of unnamed watercourse (September 2011).



REFERENCE

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DATUM : NAD83. PROJECTION: UTM ZONE 12

1 0 1
SCALE KILOMETRES

Photo 5 - Downstream view of impoundment and beaver dam (September 2011).

PROJECT

Canadian Natural

KIRBY IN SITU OIL SANDS EXPANSION PROJECT

TITLE

SITE PHOTOGRAPHS OF UNNAMED WATERCOURSE (WLT-2)

Golder Associates Calgary, Alberta

PROJECT 10.1346.0052.6100			FILE No.10134600526100A005	
DESIGN	DA	12/10/11	SCALE AS SHOWN	REV. 0
CADD	IPG	21/10/11	FIGURE:B-11	
CHECK	MD	07/12/11		
REVIEW	KC	08/12/11		

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ATTACHMENT C

FISH INVENTORY CATCH-PER-UNIT EFFORT RESULTS FOR WATERBODY AND WATERCOURSE FIELD SAMPLING SITES

Table C-1 Catch-Per-Unit-Effort for Waterbody Sampling Sites, 2011

Site ID	Season	Gill-Netting		Minnow Trapping	
		Sport Fish		Forage Fish	
		Northern Pike		Brook Stickleback	
		Number Caught	CPUE [# fish/panel-hr]	Number Caught	CPUE [# fish/trap-hr]
WL-1	winter	0	0	0	0
	summer	4	0.38	0	0
WB-1	winter	0	0	0	0
	summer	0	0	269	7.04
WB-2	winter	0	0	11	0.20
	summer	0	0	26	0.47
WB-3	winter	-	-	-	-
	summer	0	0	26	0.72
WB-4	winter	-	-	-	-
	summer	0	0	25	0.58

- = no sampling conducted.

Table C-2 Catch-Per-Unit-Effort (# fish/second) for Watercourse Sampling Baseline Sites, 2011

Site ID	Season	Non-Sport Fish (Suckers)	Forage Fish				
		White Sucker	Slimy Sculpin	Northern Redbelly Dace	Brook Stickleback	Finescale Dace	Lake Chub
Backpack [number/100 s]							
WLT-1	winter	-	-	-	-	-	-
	summer	-	-	-	-	-	-
WLT-2	winter	-	-	-	-	-	-
	summer	-	-	-	-	-	-
SCT-1	winter	-	-	-	-	-	-
	summer	-	5.6	-	-	-	-
SCT-2	winter	-	-	-	-	-	-
	summer	-	-	-	12.99	-	-
SCT-3	winter	-	-	-	-	-	-
	summer	0.2	-	-	1.98	-	-
UNT-1	winter	-	-	-	-	-	-
	summer	0.43	-	-	1.72	5.75	2.87
Minnow Trap [number/trap-hr]							
WLT-1	winter	-	-	-	-	-	-
	summer	-	-	-	-	-	-
WLT-2	winter	0	0	0	0	0	0
	summer	0	0	0	0.15	0	0
SCT-1	winter	0	0	0	0	0	0
	summer	0	0	0	0	0	0
SCT-2	winter	0	0	0	0	0	0
	summer	0	0	0	0.25	0	0
SCT-3	winter	0	0	0	0	0	0
	summer	0.015	0	0	0.5	0.005	0
UNT-1	winter	-	-	-	-	-	-
	summer	0.11	0	0.03	1.11	4.59	1.96

- = No sampling conducted.