State of the

Lesser Slave Watershed

2009

Lesser Slave Watershed Council

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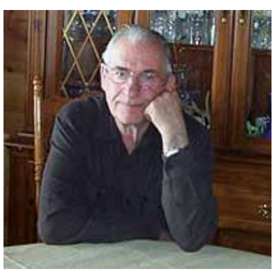
Bald Eagle. Photo by Ron Davis.

Message from the Chair, Lesser Slave Watershed Council



Lesser Slave Lake and its watershed is a major source of water for domestic, municipal, agriculture, recreational and industrial use. The on-going socio-economic activity on the lake and surrounding watershed, can and will over time, threaten water quality and water reserves. The State of the Watershed Report provides detailed information on the sustainability of future growth and what must be done to preserve this very important resource, **The Lesser Slave Lake Watershed**.

The State of the Watershed Report is a tool that can be used by present and potential users to determine the feasibility and sustainability of their projects. This report can be used as predicable information that alerts government, both provincial and municipal, to the importance of sustainable and prudent socio-economic planning and financing for future watershed development.

I would like to thank our Executive Director Meghan Payne for the time and energy she has put into this report.

Brian Elliott

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1.0 Introduction

West Prairie River in the fall, 2009. Photo by Meghan Payne.

1.1 Purpose of the Report

The Lesser Slave Watershed is a diverse ecosystem located in central Alberta. The region provides important habitat to many fish and wildlife species as well as supports many communities, commercial and industrial development and recreation opportunities. The area has experienced increased pressure through industry needs and a growing human population since the 1950's. With this pressure, government and the public have become progressively more concerned with the health of the Lesser Slave Watershed.

In the 1970's, the public in the Lesser Slave area became concerned with a drop in lake levels. Since then various committees made up of members of the public have formed to express concerns with various aspects of watershed health. In 2007, the Lesser Slave Watershed Council (LSWC) was designated as a Watershed Planning and Advisory Council under the provincial governments Water for Life Strategy to promote watershed health. The LSWC is a non-profit group of volunteers who work with the provincial government to maintain the health of the Lesser Slave Watershed. It is made up of representatives from government, towns, municipalities, first nation communities, industry, cottage owners, recreation and tourism groups. The mission of the LSWC is to be a "proactive organization working towards the sustainability of the Lesser Slave Watershed with regard to economic, social and environmental health of the region and its citizens".

Under the Water for Life Strategy the LSWC committed to producing a state of the watershed report for the Lesser Slave Watershed. The purpose of this report is to summarize the existing and current knowledge of the Lesser Slave Watershed based on water quality, water quantity, land use, and biology. These features work together to contribute to the health of the watershed on a whole. This report identifies knowledge gaps and serves as a baseline from which further research can be compared to. It is also intended to be a comprehensive document that can be used to make informed decisions regarding water management throughout the basins. Future reports will be produced that update and improve upon the current document, integrating new data and addressing new pressures on the health of the watershed as they arise.

1.2 Scope of the Report

This report compiles current and historical data that has been collected within the watershed. The Lesser Slave watershed is made up of two main watersheds; the Lesser Slave Lake Watershed which includes the lake and the tributaries that drain into the lake and the Lesser Slave River Watershed, which consists of the Lesser Slave River and its tributaries. For use throughout this report we will combine these watersheds into one, the Lesser Slave Watershed. The watershed can be broken down even further into five sub-basins as classified by the Water Survey of Canada (Table 1); the South Heart/East and West Prairie Rivers (07BF), Driftpile River (07BH), Swan River (07BJ), Lesser Slave Lake North (07BG), and the Lesser Slave River (07BK).

Table 1: Sub-basins of the Lesser Slave Watershed

Water Survey of Canada Designation	Sub-basin Name	Area (km^2)
07BF	South Heart River/East & West Prairie Rivers	6,886.75
07BH	Driftpile River	1,428.90
07BJ	Swan River	2,818.31
07BG	Lesser Slave Lake North	1,324.11
07BK	Lesser Slave River	6,507.03
	Lesser Slave Lake (excludes Buffalo Bay)	1,138.90
Total area of the Lesser Slave watershed		**20,100**

Section 2.0 describes indicators of watershed health that have been selected for use throughout the report, along with rating systems where possible. Section 3.0 provides a general overview of the Lesser Slave Watershed on a whole describing basin wide characteristics. The following sections, 4.0 to 9.0, describe each sub-basin and the lake itself in greater detail in relation to the watershed indicators. Section 10.0 discusses recommendations for future research and data collection and section 11.0 discusses stewardship within the watershed through various programs and organizations.

No new data collection or sampling was completed for this report. Within each section, the most recent data was used to establish a baseline or starting point. It should also be noted that there may be additional data from various organizations that was not readily available; therefore it has not been included.

2.0 Watershed Indicators

2.1 Selection of Indicators

Indicators are easily measureable characteristics that provide useful information on the conditions of the ecosystem they occur in and can be monitored to show trends and changes over time (AENV, 2008). As defined by Alberta Environments Handbook for State of the Watershed Reporting, good indicators should reflect watershed health, be objective and comparable, sensitive to stressors, interpretable and understandable, relevant to social concerns, have the ability to measure progress and be cost efficient to monitor (AENV, 2008). Three types of indicators are typically recognized; condition, pressure and response indicators. Condition indicators address the state of the environment. Pressure indicators possess potential to cause negative impacts and describe the natural processes or human influences that can impact environmental quality. Response indicators are in the form of actions or management plans to prevent or mitigate negative environmental impacts (AENV, 2008).

Indicators selected for this report were drawn from four broad categories; water quality, water quantity, land use and biological. In some cases, indicators were selected where little present data was available as a recommendation for future studies and data collection. The indicators and metrics shown in Table 2 were chosen to display watershed health throughout this report.

Table 2: Indicators of Watershed Health and Metrics

Indicator Category		Metric	Indicator Type
Water	**Water Quality**	River Water Quality Index/Lake Trophic Status	Condition
		Escherichia coli	Condition
		Nutrient budget (P:N ratio)	Condition
		Sediment contamination	Condition
	Water Quantity	Water allocation (surface/ground/wastewater return)	Pressure
Land Use		Riparian Health	Condition
		Linear Development Stream Crossings	Pressure Pressure
		Land use inventory	Condition/Pressure
		Livestock density	Pressure
		Wetland Inventory	Condition
Biological		Fish (population estimates)	Condition
		Blue/green algae outbreaks (lake only)	Condition

2.2 Indicator Details

2.2.1 Water Quality

Changes in water quality over time can indicate a change not just to the water body but to the entire watershed. These fluctuations can indicate changes in land use, management practices, natural climatic events or other disturbances to the landbase. In short, water quality can be influenced by many anthropogenic and natural factors. Regular monitoring of water quality can also identify areas where the management of land use practices is poor and watershed health can be improved.

2.2.1.1 River Water Quality Index

The Alberta River Water Quality Index (ARWQI) was developed to summarize physical, chemical and biological data collected through water sampling into an easily understood number (AENV, 2009a). This number can then be used to compare water quality of rivers and streams over multiple years at a single location or between locations throughout the province.

The index value is based on sub-indices calculated for four groups; metals (subset of up to 22 metals and ions), bacteria (E. coli and fecal coliforms), nutrients (up to 6 variables) and pesticides (up to 17 commonly used products). The components that contribute to the index number can be viewed in Table 3 .The overall index value is an average of the combined variable groups. Variables in the metals, bacteria and nutrients are then compared to the Alberta Water Quality Guidelines (AENV, 2009a) and Federal CCME Water Quality Guidelines (CCME, 2001).

Table 3: River Water Quality Variables (AENV, 2009a)

Metals and Ions						
	Aluminum	Arsenic	Copper	Thallium	Molybdenum	Vanadium
	Beryllium	Lithium	Iron	Manganese	Nickel	Zinc
	Mercury	Uranium	Lead	Cobalt	Selenium	Cyanide
	Cadmium	Fluoride	Silver			
Pesticides						
	2,4-D	Picloram	Bromoxynil	Chlorpyrifos	MCPP	Dicamba
	Cyanazine	Diuron	MCPA	Triallate	Imazamethabenz	Malathion
	Diazinon	Atrazine	Methoxychlor	Dichlorprop	Lindane	
Nutrients & Related Variables						
	Dissolved Oxygen	Total Phosphorus	Nitrite-Nitrogen (NO2-N)	pH	Total Nitrogen	Ammonia Nitrogen
Bacteria						
	Fecal Coliforms	*Escherichia coli*				

Typically, the index is only calculated for data collected for the Alberta Environments Long Term River Network (LTRN). There are no LTRN collection stations located within the Lesser Slave Watershed, however, to remain consistent with other State of the Watershed reports throughout the province we have decided to use this as an indicator. Score ranges have already been established by Alberta Environment for use with the ARWQI and can be viewed in Table 4.

Table 4: Alberta Water Quality Index categories and score range (AENV, 2009a)

Water Quality	Value Range	Description
Excellent	96-100	Guidelines almost always met; "best" quality
Good	81-95	Guidelines occasionally exceeded, but usually by small amounts; threat to quality minimal
Fair	66-80	Guidelines sometimes exceeded by moderate amounts; quality occasionally departs from desirable levels
Marginal	46-65	Guidelines often exceeded, sometimes by large amounts; quality is threatened, often departing from desirable levels
Poor	0-45	Guidelines almost always exceeded by large amounts; quality is impaired and well below desirable levels; "worst" quality

Lake Trophic Status

Since the ARWQI does not apply to lakes, lake trophic status will be used to measure water quality in Lesser Slave Lake. Trophic status provides a general assessment of a lakes' productivity based on measures of total phosphorus, chlorophyll 'a' and Secchi-disk visibility.

In Alberta, there are four categories of lake trophic status; oligotrophic, mesotrophic, eutrophic and hypertrophic (AENV, 2009b). Oligotrophic lakes have low phosphorus and chlorophyll-a and high water visibility as measured by secchi-disk. There is very limited biological production (plant growth) within these lakes; oligotrophic lakes tend to be clear and have sufficient oxygen to support fisheries and other aquatic organisms. Mesotrophic lakes have a moderate concentration of phosphorus, therefore more aquatic plant growth (chlorophyll-a). These lakes tend to be moderately clear and may experience oxygen depletion in deeper areas. Eutrophic lakes have high concentrations of phosphorus, which leads to increased plant and algae growth. Productive fisheries are also often found in eutrophic lakes. During the warmest summer months, algae blooms on the lake surface may occur. Hypereutrophic lakes have very high concentrations of phosphorus and chlorophyll-a. Algal blooms are common in the late summer and can last into the fall months. With such high algal and plant growth, oxygen depletion can occur at various times throughout the year and on occasion may cause fish kills (AENV, 2009b).

Secchi-disk

Secchi-disk is a disk, divided into black and white quarters, that is used to gauge water clarity by measuring the depth at which it is no longer visible from the surface.

2.2.1.2 *Escherichia coli*

Escherichia coli is a bacteria that naturally occurs in the intestines of humans and other warm blooded mammals, but does not occur naturally on plants or in soil and water (Health Canada, 2006). Since E. coli does not occur naturally in water it is a good indicator of contamination by human and/or livestock populations within a watershed.

E. coli counts of 0-100 are deemed "good" and counts > 100 are deemed "poor".

2.2.1.3 Nutrient Budget

Total nitrogen and total phosphorus are important for the general assessment of the nutrient budget within water systems. In lakes, nitrogen and phosphorus are the main nutrients that control the amount of phytoplankton occurring there. Excessive phosphorus can have many negative impacts to aquatic systems, including algal blooms and fish kills.

For use throughout this report, total phosphorus concentrations of <0.05 mg/L are deemed "good", concentrations of 0.05 to 0.10 mg/L are deemed "fair" and concentrations of >0.10 mg/L are deemed "poor". Total nitrogen concentrations of <1.0 mg/L are deemed "good", concentrations of 1.0-1.5 mg/L are deemed "fair" and >1.5 mg/L are deemed "poor". The "good" rating for both phosphorus and nitrogen correspond to the Canadian Environmental Quality for the Protection of Aquatic Life and the Surface Water Quality Guidelines for Use in Alberta (CCME, 1999, 2001 & AENV, 1999).

2.2.1.4 Sediment Contamination

Sediment contamination can negatively influence water quality. The amount of sediment can provide information on sediment input for example, poor road crossings, culvert installation, or bank erosion. Sediment is also important because many nutrients and contaminants cling to it and settle out in areas of low flow; pools of rivers and lakes. Amounts and movement of total suspended sediment throughout the watershed will be examined.

Within the Lesser Slave Watershed, sediment data has not been collected over the last 11 years. The most recent data and publications have been used throughout this report.

2.2.2 Water Quantity

Water quantity is important in maintaining a healthy aquatic ecosystem and riparian zone. Instream flow needs (IFN) assessments aim to determine what the minimum flow within a stream/river can be while still maintaining healthy aquatic populations, riparian areas as well as allowing water usage for municipal, industrial, recreational and other water users.

Although the Lesser Slave Watershed Council would like to get to this degree of assessment within the watershed currently no IFN studies have been completed. In 2004 a scoping study was done on the Lesser Slave River to determine available data, data gaps and create a work plan to complete an IFN study (Golder, 2004). To date no study has been carried out, therefore at this time, IFN studies cannot be used as an indicator. Instead stream flow data from streamflow monitoring stations within the watershed will be discussed.

2.2.2.1 Water Allocation

Water licenses for both surface and ground water withdrawal are examined. Within the Lesser Slave Lake watershed, most water licenses are for surface water to a variety of users including, oil and gas activity, pulp production, municipalities and towns, and agricultural operations. It should be noted that water licenses are based on the maximum amount of water that will be used annually and therefore do not necessarily represent actual water use. For the major water users the annually reported numbers of actual use were used, however, in some cases these numbers were not available. In these situations water allocations were used throughout the report to represent water usage as a worst case scenario of the present conditions.

Water allocation has been included in the report but a rating system has not been assigned to it.

2.2.3 Land Use

Over time changes in land use reflect major development and contribute to changes in water quality and quantity. Five categories have been used to assess changes in land use throughout the watershed; riparian health, linear development including stream crossings, land use inventory, livestock density and wetland inventory.

Of the five land use categories only riparian health is applicable to section 8.0, Lesser Slave Lake.

2.2.3.1 Riparian Health

Healthy riparian area, West Prairie River, and unhealthy riparian, Salteaux River after fire and erosion.
Photos by Meghan Payne.

The health of riparian zones is an extremely important indicator for the overall health of a watershed. Riparian areas represent the transitional zone between the upland areas and watercourses and/or water bodies. They serve many important ecological functions including trapping and storing sediment, maintaining banks and shorelines, storing water (reducing flooding), recharging aquifers, filtering out contaminants, reducing water velocity (erosion), maintaining biodiversity and creating areas of primary productivity (Fitch & Ambrose, 2003).

Ratings for riparian areas in the Lesser Slave Watershed follow those developed by Mills and Scrimgeour (2003) and Cows and Fish (Fitch *et al.*, 2001 and Ambrose *et al.*, 2004). Aerial videography of riparian areas was recorded and used with a scorecard consisting of weighted multiple choice questions regarding both vegetative and human disturbances. The scorecard values were then added together and put into categories of 'good', 'fair' and 'poor' for tributaries and 'healthy', 'moderately impaired' and 'highly impaired' for the shoreline of Lesser Slave Lake (Osokin & Hallett, 2007 and Johns & Hallett, 2009). In addition to work completed in the Lesser Slave Watershed, aerial video assessments coupled with a scorecard rating system have been used in other studies throughout Alberta (Mills & Scrimgeour, 2003; Teichreb & Walker, 2008).

2.2.3.2 Linear Development

The extent of linear development over a watershed provides a general measure of the degree of human disturbances and habitat fragmentation. In this report, linear development features include access roads, pipelines, large transmission lines, railways and cutlines taken from the provincial data set. Cutlines include seismic activity and a general width of 6 meters was used for all cutlines. The totals were quantified through GIS analysis of the dispositions provincial 1:20,000 data set.

For this report, linear development of <2% is considered "good", between 2-3% is considered "fair" and >3% is considered "poor". Percentages represent the amount of linear disturbance versus the total area of each sub-basin.

2.2.3.2.1 Stream Crossings

Within each sub-basin, the number of stream crossings by linear features per kilometre of stream was extrapolated from GIS data by the Fish and Wildlife Division of Alberta Sustainable Resource Development (ASRD, 2005a). The total number of road crossings per kilometre of stream was also calculated. All crossings can have a negative impact on streams, however road crossings have the potential to cause the most damage including increases in sediment entering streams, preventing fish passage and disrupting water flow.

Data included in this report was calculated by Fish and Wildlife (ASRD, 2005a) as part of a linear disturbance study of sub-basins in north-western Alberta. The 1:20,000 provincial base data was used for both linear and watercourse data. No quantitative rating system has been assigned, instead the sub-basin with the largest number of crossings per kilometre is considered 'high' risk, the sub-basin with the lowest number of crossings per kilometre considered 'low' risk and all sub-basins in between deemed 'medium' risk.

2.2.3.3 Land Use Inventory

Land use inventory quantifies the amount of land within each basin that is used by a variety of land uses. This will allow the amount of land undisturbed versus developed (forestry, oil and gas activity, agriculture, urban development) to be calculated.

Due to insufficient data, quantifying land use by each category was not possible; instead it is presented purely qualitatively.

2.2.3.4 Livestock Density

Cattle. Photo by Ron Davis.

Areas with a high density of livestock animals can have detrimental effects to downstream aquatic systems and riparian areas. Livestock can disturb riparian areas and watercourse banks causing increased erosion and sediment entering streams, cause bacterial contamination and changes to nutrients in the water.

No quantitative rating system has been assigned, instead the sub-basin with the highest density is considered 'high' risk, the sub-basin with the lowest density considered 'low' risk and all sub-basins in between deemed 'medium' risk.

2.2.3.5 Wetland Inventory

Wetlands play a valuable role in the functioning landscape including water storage, recharging aquifers and groundwater supply, important wildlife habitat and act as a natural filtration system filtering out excess sediment and nutrients. The loss or impairment of wetlands can have very serious effects on the watershed health and water quality and quantity.

Maintenance of existing wetlands and gain of wetlands is deemed "good" and loss of wetlands is deemed "poor".

2.2.4 Biological Indicators

Biological indicators include data from both flora and fauna sources that provide insight into some aspect of ecosystem health. Usually biological indicators include species that are sensitive to environmental stressors or changes in the environment.

2.2.4.1 Fish Populations

Changes in the aquatic environment can cause increases or decreases in the population of certain species of fish. Fish population data was quite limited in some areas of the watershed. Fish population dynamics are included where possible and habitat is discussed.

No rating system is defined.

2.2.4.2 Blue/Green Algae Outbreaks

The outbreaks of blue/green algae will be examined in Lesser Slave Lake only. The amount of plants and algal growth are typically measured by the concentration of chlorophyll-a which is a reflection of total phosphorus. This indicator is closely tied to the lake trophic status and nutrient budget.

* * *

In addition to the indicators listed above, the Provincial *Species at Risk* data will be reviewed.

It should also be noted that ratings given for each indicator within the sub-basins are based on limited data. Throughout the watershed, data is limited in several different ways; data is quite old, incomplete, or in some cases we have data for only a portion of the sub-basin however the rating is applied to the entire sub-basin.

3.0 Lesser Slave Watershed General Overview

3.1 Introduction

This section gives a general overview of the Lesser Slave Watershed describing basin wide characteristics. It has been broken down into the following sections; geography, climate, hydrology, ecosystems, species at risk, populations and land use.

3.2 Geography

Lesser Slave Lake, the third largest lake in Alberta, is located approximately 250 km northwest of Edmonton and encompasses an area of 1,160km^2 (Mitchell and Prepas, 1990). The watershed that drains this system is made up of essentially two major basins, the Lesser Slave Lake Watershed and the Lesser Slave River Watershed, together comprising an area of approximately 20,100 km^2. This translates to approximately 3% of Alberta's landbase. For use throughout this report we will combine these watersheds into one, the Lesser Slave Watershed.

The Lesser Slave Watershed is comprised of five sub-basins, four of which drain water flowing into the lake and one that flows out of the lake also draining land east of Lesser Slave Lake (Figure1). Drainage of the western most sub-basin is via the South Heart River into Buffalo Bay. Land to the south of Lesser Slave Lake in the Swan Hills area is drained by the East and West Prairie, Driftpile and Swan Rivers. North of the lake water enters through many smaller tributaries. Water flows out of the lake to the east via the Lesser Slave River which joins the Athabasca River approximately 75 kilometres downstream.

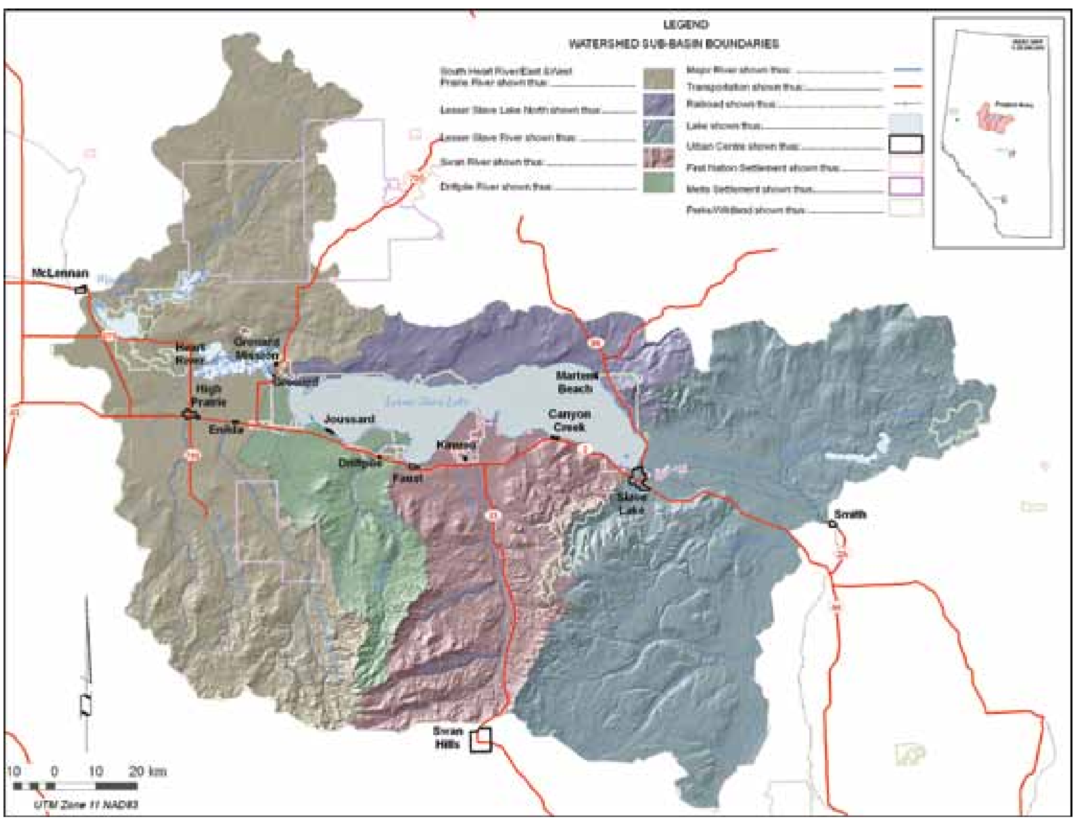


Figure 1: Lesser Slave Watershed overview

3.3 Climate

The Lesser Slave Watershed experiences similar climate to the rest of Northern Alberta in having long cold winters and short, warm summers. This climate regime is classified as Continental. Climate is affected by the size of the lake and the surrounding hills to the south and east. Prevailing winds are usually from the west and southeast during the winter and from the southwest during the summer months (Chabaylo & Knight, 1997).

Average monthly temperatures for High Prairie and Slave Lake were computed for the last 5 years, 2005-2009 (Table 5). With the exception of data collected in the summers from fire towers, data for Swan Hills was not available for this time period, the most recent 5 years were used as a comparison, 1991-1995 (Table 6). To account for variability between years, data from Slave Lake and High Prairie were included for the 1991-1995 period.

Table 5: Average climate conditions within the Lesser Slave Watershed, 2005-2009 (Environment Canada, 2009)

Weather Station	Station levation (m)	Average Monthly Temperature (°C)	
		January	July
High Prairie	601.7	-12.3	16.7
Slave Lake	582.8	-13.1	16.7
Swan Hills	1058.6	No data	15.3

Table 6: Average climate conditions within the Lesser Slave Watershed, 1991-1995 (Environment Canada, 2009)

Weather Station	Station Elevation (m)	Average Monthly Temperature (°C)	
		January	July
High Prairie	601.7	No data	No data
Slave Lake	582.8	-13.7	15.2
Swan Hills	1058.6	-11.5	13.7

Average annual precipitation, including snow fall, for Slave Lake and High Prairie was computed for the most recent years available, 2003-2006 (Table 7). Data from this time period was not available for Swan Hills so the next most recent years were used, 1991-1994; data for Slave Lake was included from this time period for comparison. Based on the available data, Swan Hills receives the greatest amount of precipitation within the watershed, sometimes by 150 mm and Slave Lake experiences only slightly more than High Prairie.

Table 7: Average annual precipitation for the Lesser Slave Watershed (Environment Canada, 2009)

Weather Station	Average Annual Precipitation (includes snowfall) (mm)	
	1991-1994	2003-2006
High Prairie	No data	429.2
Slave Lake	454.0	441.5
Swan Hills	611.9	No data

3.4 Hydrology

The majority of flow through the Lesser Slave Lake drainage basin (does not include the Lesser Slave River sub-basin) originates in the Swan Hills area (Figure 2). As noted in the previous section, this region seems to consistently receive more precipitation and snowfall combined compared to the lower portions of the watershed. Snow accumulates here in the winter and the area also receives more rain throughout the summer months. Two of the rivers that drain the Swan Hills area, the Driftpile and Swan Rivers, contribute almost twice as much runoff to the lake system than the relative size of their drainage area (Seneka, 2002). In comparison, the South Heart River sub-basin comprises 55% of the lakes catchment area; however it only contributes 38% of the total runoff (Seneka, 2002).

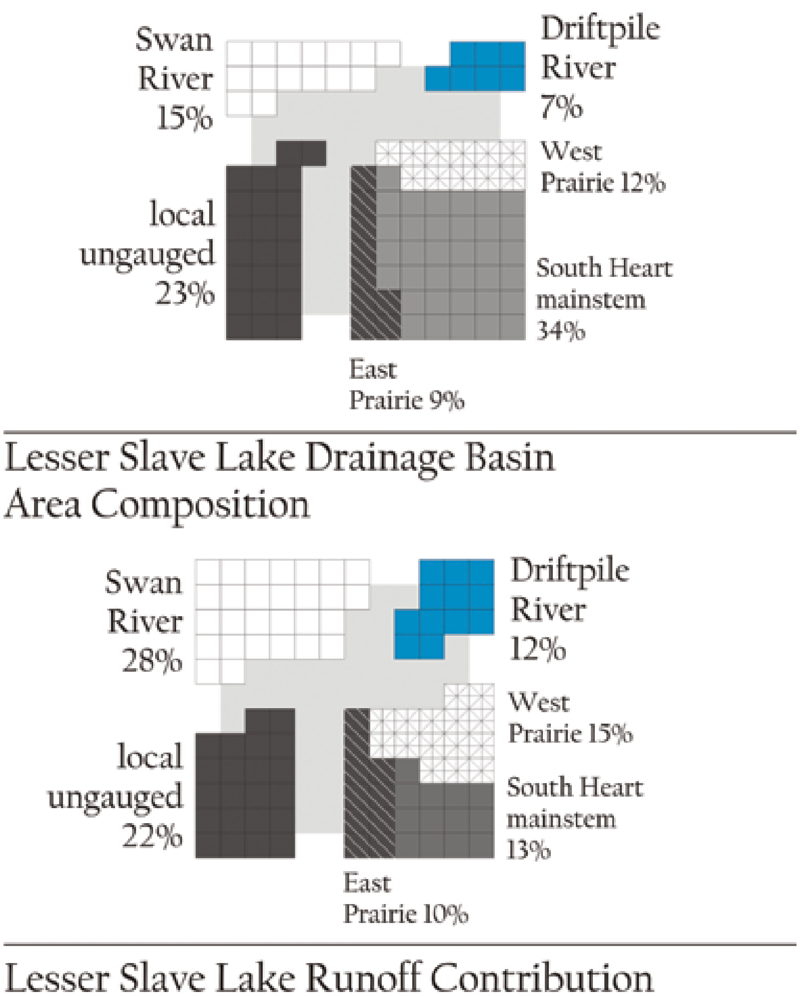


Figure 2: Comparison of area versus runoff contribution of the major tributaries

On average, the total annual precipitation on the lake surface is approximately 470 mm, which contributes 545 million m^3 of water to the lake (Seneka, 2002). Evaporation from the lake surface is approximately 610 mm annually equalling a loss of 708 million m^3. This means there is a net loss of 163 million m^3 from the lake annually just through evaporation. However, of the total water entering the Lesser Slave Lake system (inflow), approximately 79% is from runoff and only 21% is from direct precipitation, so the loss through evaporation is compensated for through runoff.

The Water Survey of Canada has streamflow monitoring stations established on all of the major tributaries within the Lesser Slave Watershed; totalling 13 stations. Since these stations were established, two have been closed while others are used to collect seasonal data, March or April to October instead of year round data collection (Table 8). Data was available up until 2008 and has been used to calculate mean discharges for 8 of the stations occurring within the watershed (AENV, 2010). Annual mean discharges have been calculated for stations with year-round available data and seasonal mean discharges for stations with only seasonal data (AENV, 2010).

Table 8: Mean and total annual discharges at streamflow monitoring stations (AENV, 2010)

Station	Station Name	Period of Record*	Station Operation	Mean Discharge (m3/s)	Average Total Discharge (dam3)**
07BF001	East Prairie River near Enilda	1921-1931 1959-2009	Seasonal	10.8	230,490
07BF002	West Prairie River near High Prairie	1921-1931 1959-2009	Seasonal to 1970 Annual since 1970	4.52	142,458
07BF004	South Heart River near High Prairie	1921-1930	Seasonal	-	-
07BF009	Salt Creek near Grouard	1986-2009	Seasonal	0.80	16,857
07BF010	South Heart River near Peavine	2000-2009	Seasonal	2.21	51,650
07BH003	Driftpile River near Driftpile	1972-1986	Seasonal	8.42	166,300
07BJ001	Swan River near Kinuso	1915-1917 1961-2009	Seasonal to 1970 Annual since 1970	13.1	407,540
07BK009	Sawridge Creek near Slave Lake	1976-2009	Seasonal	2.36	49,908
07BK001	Lesser Slave River at Slave Lake	1915-1940 1960-2009	Annual	38.3	1,267,100

*data until 2008 was used for calculations
** 1 $dam^3 = 1000\ m^3$

All of the tributaries entering Lesser Slave Lake are very seasonal in terms of flow, having very low flows during the winter months and much higher flows in the spring and summer (Noton, 1998). Lesser Slave River typically does not experience exaggerated seasonal flow differences because of the buffer provided by the lake.

Water Quality

Lesser Slave Lake receives much of its water from runoff through its tributaries; therefore, the water quality of the lake is directly related to water quality of the tributaries. In 1991 a comprehensive water quality assessment was initiated by Alberta Environment (Noton, 1998), prior to this very little was known about water quality within the watershed. A follow up study was completed between 2000 and 2002 but a large scale water quality assessment has not been completed since and is currently a major data gap.

During the 1991-93 water quality sampling as reported by Noton (1998), it was determined that most of the surface water within the watershed is well oxygenated, however some rivers experience an oxygen deficit in the winter, particularly the South Heart River. Throughout the system, calcium and bicarbonate are the dominant ions, which is consistent with most central Alberta lakes and boreal streams. The lake is slightly alkaline and is eutrophic, meaning it has moderately high nitrogen and phosphorus concentrations. High nitrogen and phosphorus concentrations were seen fairly consistently throughout the watershed and were highest in the South Heart River. These high concentrations in the South Heart River could be attributed to the productive soils, agriculture and large amounts of marshes in the area. The Lesser Slave River was lower in phosphorus than the rest of the system indicating biological uptake and sedimentation in the lake.

Similar results were found during water quality sampling completed between the years 2000 and 2002 (Wolanski, 2006). The lake is well oxygenated, even throughout the winter, probably due to high wind action. Calcium and bicarbonate remain the dominant ions throughout the system; concentrations of which are relatively low compared to other central Alberta lakes and are slightly higher in the west basin than the east basin of the lake. Concentrations of phosphorus and nitrogen were moderately high with the west basin consistently experiencing higher concentrations than the east basin. Furthermore, data from the 2000-02 study supports Noton's (1998) conclusions that phosphorus was released from bottom sediments during the spring and summer creating peak concentrations in late summer. Chlorophyll-a concentrations, which are the main measure of algal growth, are quite high for the amount of phosphorus present. When based on chlorophyll-a levels both basins are hypereutrophic however when based on total phosphorus concentrations the east basin is mesotrophic and the west basin is eutrophic. In summary, most water quality variables including pesticides, trace metals and other elements complied with the Alberta Surface Water Quality Guidelines (AENV, 1999) for protection of aquatic life with the exception of the higher concentrations of total phosphorus and total nitrogen (Wolanski, 2006).

Water Allocation

Within the Lesser Slave Watershed a total annual volume of 23,110,211 m^3 of surface water has been allocated for a variety of uses (AENV, 2009c) including oilfield injection, industrial and commercial, municipal, agricultural and recreation uses. Of the water license and registries within the watershed 56% are for oilfield injection, 23% for industrial and commercial use, 18% for municipal, 2% for agriculture and household uses and 1% for recreation (Figure 3).

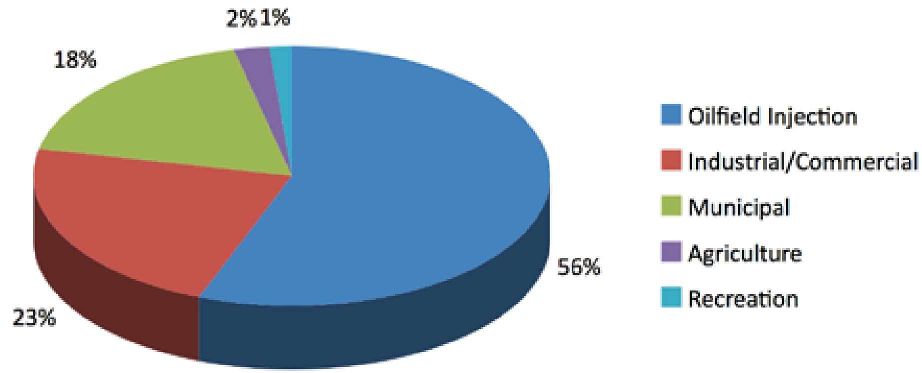


Figure 3: Lesser Slave Watershed surface water allocation (AENV, 2009c)

In addition to the surface water allocated within the watershed, 1,397,955 m3 of groundwater is allocated for withdrawal annually (AENV, 2009c). Allocated groundwater is used for wood processing, industrial and commercial activities, oilfield injection, agriculture and recreation. Wood processing accounts for 40% of the total groundwater allocated, 25% is for industrial and commercial activities, 14% for oilfield injection, 14% for agriculture and 7% for recreation (Figure 4).

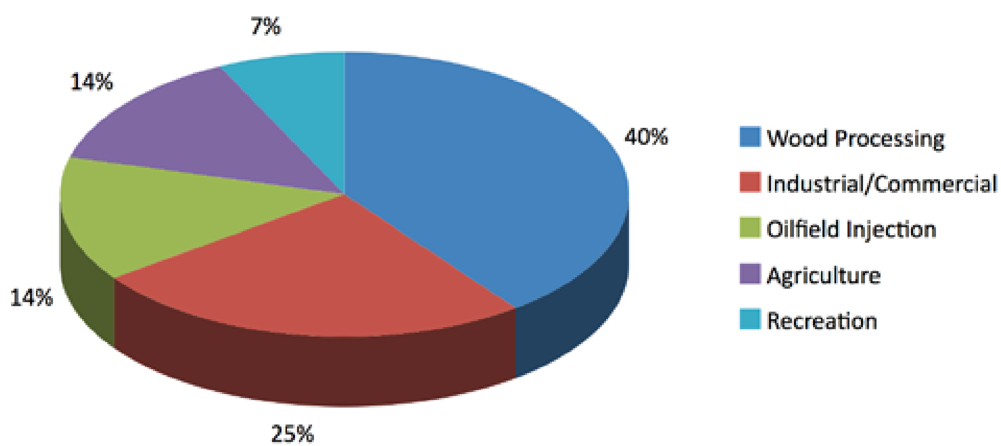


Figure 4: Lesser Slave Watershed groundwater allocation (AENV, 2009c)

Water allocation and use for surface water and groundwater within each sub-basin will be discussed in greater detail in the following chapters. Throughout these sections you will see that there are very different uses between the Lesser Slave Lake drainage basin and the Lesser Slave River.

Engineering works

Flooding throughout the lower populated portions of the Lesser Slave Lake drainage basin has been a concern of residents since the early 1900's, mainly for agricultural reasons (Nessman, 2003). In 1968, a land purchase policy was implemented for landowners who held land at elevations below 579.73 meters (1 meter above the lakes highest levels). According to Nessman (2003), 12,800 acres of land was purchased by 1975 in the High Prairie, Faust and Kinuso areas. Land continued to be purchased as a means of compensation for flooding into the early 2000's. Other purchase policies were implemented along the East and West Prairie Rivers and for portions of the Swan River in 1976 to the early 2000's (Nessman, 2003).

Heart River dam. Photo by Ron Davis.

In addition to the land purchase policy, many regulation projects have been completed throughout the watershed to deal with flooding and erosion concerns of residents, including channelization, creating stream cutoffs, erosion control and the construction of a weir at the outflow to the Lesser Slave Lake. The West Prairie River, East Prairie River, South Heart River, Driftpile River, Swan River, Sawridge Creek and Lesser Slave River all experienced some level of modifications over the last century.

Flood control engineering projects on the West Prairie River began in 1950 with the construction of two cutoffs to create a straight channel through the town of High Prairie (AENV, 1991). In the late 1960's and early 1970's the West Prairie River was channelized (straightened and widened) from High Prairie to its confluence with the South Heart River, for a total of approximately 8.2 kilometres. Numerous bank protection and erosion control projects were undertaken over the next 30 years that were concentrated in the Town of High Prairie and upstream (AENV, 1991 & AENV, 2001).

The East Prairie River experienced the most extensive engineering works beginning in 1963 with the channelization of 8.5 kilometres just south of its confluence with the South Heart River (AENV, 1991). In later subsequent years the confluence with the South Heart River and the remaining portion north of Highway 2 were also channelized making the total channelization approximately 13.5 kilometres. Numerous bank protection and erosion control projects have been completed since (AENV, 1991 & AENV, 2001).

Wooden groynes installed for erosion reduction on the West Prairie River. Photo by Meghan Payne.

Between1950 and 1960, several water management strategies were implemented in the reaches of the Upper South Heart River to supply a steady flow of water into Winagami Lake to stabilize the lake level and provide a consistent water supply for the Towns of McLennan, Donnelly, Falher and Girouville, located west of the

Lesser Slave Watershed (AENVa, no date). This included some channelization, the construction of two dams and a spillway. In response to these modifications, the Peavine Metis Settlement claimed that these changes were causing flooding of some upstream lands (AENVa, no date); compensation was provided as a result. Channelization also occurred on the Lower South Heart River downstream of is confluence with the West Prairie River, all the way to the East Prairie River. In addition to channelization, several dykes, cutoffs and overflow channels were constructed in the Horse Lakes portion of the South Heart, just upstream of Buffalo Bay (AENV, 1991). The flood control works completed on the West and East Prairie Rivers and the South Heart River have decreased flooding to the point of elimination for the surrounding farm land in Enilda and High Prairie (Nessman, 2003).

A flood damage reduction project was untaken on the Driftpile River within the Driftpile River First Nation reserve. Dykes were installed along most of the river to protect the community in 1997 (AENVb, no date). Modifications to the Swan River commenced in 1979 and included dykes, flood relief channels, a series of 7 cutoffs, and the installation of erosion control measures (AENVc, no date). At the eastern end of the watershed, completed works to the Sawridge Creek have included the construction of a floodway channel, dykes, cutoffs and erosion control and bank protection (AENVd, no date). After flood events in 1988 (Nessman, 2003) and 2004, the floodway was enlarged.

As a result of the extensive channelization in the above river systems, sediment transport into Lesser Slave Lake has become a concern. Channelization can increase sediment transport, at least until the stream has had time to re-stabilize, through increasing the stream velocity, confining the stream to the channel during flood events when sediment would have settled out in flooded areas upstream and over the banks. According to Nessman (2003), the modifications in the Driftpile River and Sawridge Creek are not likely to contribute to the sediment load entering the lake for the following reasons; modifications to the Driftpile River involved offset dykes (river training) and the Sawridge Creek enters the system below the lake.

Lake Regulation Project

As petitioned by local residents, numerous modifications to the Lesser Slave River were proposed and investigated in the 1970's to determine the best way to limit maximum lake levels to elevations of 577.6 meters and maintain minimum lake levels above 575.5 meters (AENV, 1978 & NHCL, 1979). Flooding of the lake was quite common because the only outlet from the Lesser Slave Lake is the Lesser Slave River. Heading downstream from the lake, the first 48 kilometres of the Lesser Slave River is quite level, 0.1 m/km; after the Saulteaux Rapids, the gradient drops rapidly to 0.7 m/km (AENV, 1993 & Nessman, 2003). The rivers shallow slope gives it an inability to deal with large amounts of water at one time, causing the lake to flood in high runoff events. It was determined that constructing 8 meander cutoffs and a fixed crested weir, with a fishway, on the Lesser Slave River would accomplish the goals of the project while having the least amount of impact on the environment. In 1980, construction of the 8 cutoffs began, the weir was constructed in 1983 and the fishway was installed in 1984 (AENV, 1993).

Lesser Slave River regulation weir during normal flows.
Photo by Meghan Payne.

Benefits of the regulation project include a decrease in the frequency and severity of high water levels (floods), low water levels are not as extreme, average water levels are lowered by 0.3 meters from the natural conditions, lake level fluctuation is reduced from 3.5 meters to 2.7 meters and approximately 25,500 hectares of agricultural land surrounding the lake experience flood protection (reduced severity and frequency of floods) (AENV, 1993 & AENV, 2002).

A comparison between natural and regulated flow at the outflow from Lesser Slave Lake can be viewed in Figure 5. The natural lake water levels represent data collected before the weir was installed and simulated data from after the weir was constructed, essentially showing what lake levels would be without the regulation project. Regulated lake levels are compiled from simulated data showing what lake levels would have been had the regulation project occurred in 1916 (AENV, 1993). For some time after the regulation project actual lake levels were slightly different than the simulated regulated levels. However, an information update report in 2002, states that recorded data is almost the same as the regulated data which suggests the Lesser Slave River has completely adjusted to the modifications (AENV, 2002).

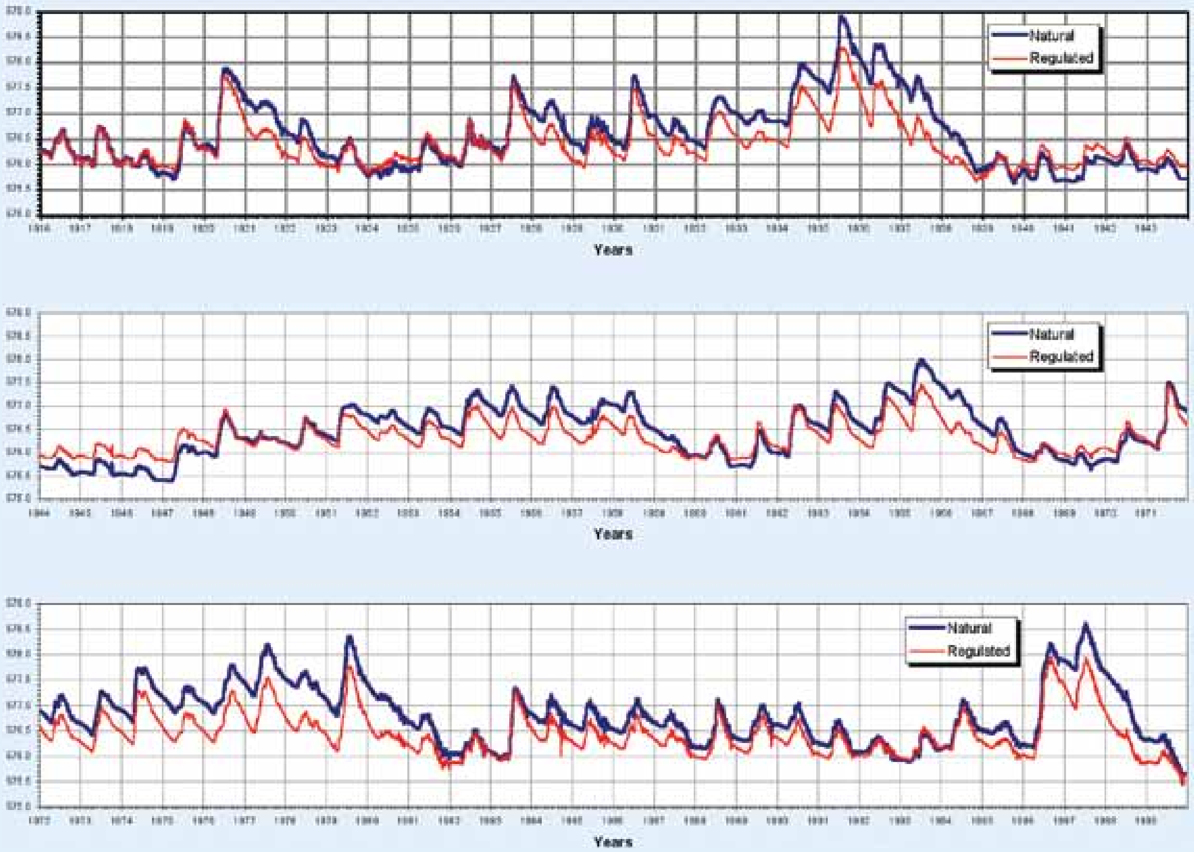


Figure 5: Natural versus regulated lake levels (Seneka, 2002)

3.5 Ecosystems

3.5.1 Terrestrial Habitat

The Lesser Slave Watershed is situated within portions of both the Foothills and Boreal Natural Regions of Alberta (Figure 6). The Foothills Natural Region extends along the eastern side of the Rocky Mountains including an easterly extension into the Swan Hills area, the Marten Hills and Pelican Mountains located within the Lesser Slave River sub-basin, and the Saddle Hills north of Grande Prairie (NRC, 2006). The Boreal Natural Region is the largest, covering 58% of the province, and encompasses the majority of Northern Alberta.

Black bear. Photo by Ron Davis.

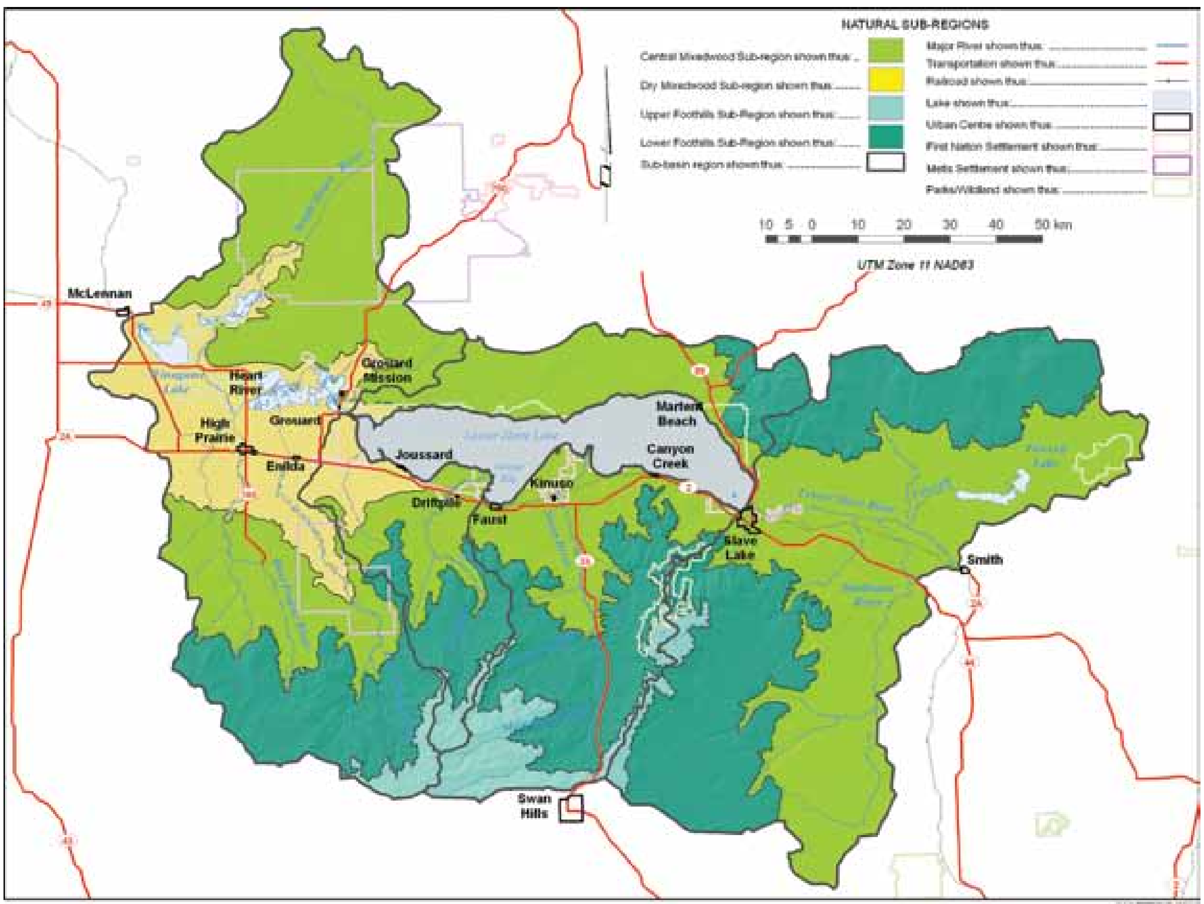


Figure 6: Natural sub-regions of the Lesser Slave Watershed

The Foothills Natural Region can be broken down into the upper foothills and lower foothills sub-regions, both of which occur within the watershed. The upper foothills sub-region occurs in the highest areas of the Swan Hills, basically the junction between the South Heart/East & West Prairie River, Driftpile River and Swan River sub-basins and extends north along the Swan River and Lesser Slave River sub-basin boundary. The region is characterized by strongly rolling to steep terrain, and is generally slightly cooler than the lower foothills with more precipitation and snowfall (NRC, 2006). The growing conditions favour conifers and the area is predominately lodgepole pine forest with a black spruce understory or balsam fir. Stands of white spruce can be found along the edge of rivers and mixed wood or deciduous stands occur on south and west facing slopes (NRC, 2006). The boundary between the upper and lower foothills is often marked by the shift from conifer dominated forest to predominately mixed-wood forest and the presence of dwarf bramble (dwarf raspberry) (NRC, 2006).

Moose. Photo by Ron Davis.

Within the watershed, the lower foothills sub-region occurs between the upper foothills discussed in the previous paragraph and the plains near Lesser Slave Lake as well as the Marten Hills and Pelican Mountains northeast of Lesser Slave Lake. This region is characterized by rolling and undulating terrain and has a slightly longer growing season than the upper foothills but less winter precipitation (NRC, 2006). Low areas can produce species rich forests because of a moisture surplus and groundwater high in nutrients (NRC, 2006). Forests are quite diverse in this sub-region with pure and mixed-wood stands of the following species; aspen, balsam poplar, white birch, lodgepole pine, black spruce, white spruce, balsam fir and tamarack (NRC, 2006). Devil's club which is typically found in west-central Alberta can be found within this sub-region of the watershed.

Two of the numerous sub-regions of the Boreal Natural Region occur within the watershed; the central mixedwood and dry mixedwood. The central mixedwood natural sub-region is the largest within Alberta; comprising 25% of the province (NRC, 2006). Within the watershed this sub-region surrounds the lake with the exception of the land directly west of the lake, in the High Prairie area, which is predominately used for agriculture. This sub-region is characterized by a mix of aspen dominated deciduous stands, aspen-white spruce mixedwood and white spruce or jackpine dominant stands (NRC, 2006). A wide range of vegetation occurs within this sub-region depending on the moisture regime of the site.

The dry mixedwood sub-region occurs directly west of Lesser Slave Lake and continues west until the border with British Columbia. This sub-region is typically slightly drier than the central mixedwood and is characterized by aspen forests with prickly rose, low-bush cranberry, beaked hazelnut and Canada buffaloberry understory (NRC, 2006). Drier areas are predominately jackpine forests, which can be seen in Winagami Lake Wildland Park while wetter, poorly drained areas produce a variety of rich bogs and fens. Outside of parks within the watershed much of this sub-region has been cleared and cultivated for agricultural use.

The Lesser Slave Watershed provides diverse habitat for many animal species. Within the watershed, there are approximately 47 species of mammals; of these there are 5 species of ungulates, 16 carnivores, 15 rodents, 1 hare, 5 species of bats, and 5 species of shrews (Chabaylo & Knight, 1997). In addition to mammalian species, the area surrounding Lesser Slave Lake is rich with bird species. Approximately 190 species of birds have been observed within the watershed (Chabaylo & Knight, 1997) making the area surrounding Lesser Slave Lake a biologically significant area for bird life.

3.5.2 Riparian and Wetland Habitat

Riparian areas occur along the banks of all major watercourses and tributaries throughout the Lesser Slave Watershed, surround Lesser Slave Lake and occur along the margins of wetlands and smaller lakes throughout the region. Riparian areas represent the transitional zone between upland terrestrial areas and areas that are truly aquatic. Wetlands are found over much of the watershed but primarily occur in the low lying areas in the central and northern portions.

Wetland in the south Mitsue area. Photo by Meghan Payne.

Riparian areas and wetlands perform many important ecological functions acting as buffers between land and aquatic resources. They filter and trap sediment, store excess water protecting against flooding, remove contaminants by filtering runoff and provide diverse habitat for numerous plant, animal and bird species (Fitch & Ambrose, 2003). These areas are extremely important for maintaining healthy water quality and quantity within the Lesser Slave Watershed.

To date there is limited data on riparian areas and the extent of wetlands within the Lesser Slave Watershed. Where assessments on riparian health have been completed bank erosion, cultivation and livestock grazing in close proximity to watercourses and stream modification projects including channelization have had detrimental effects to riparian areas. Along the south shore of Lesser Slave Lake, particularity the east basin, there is considerable cottage and housing development, which in some cases has had negative effects to riparian health.

Wildlife diversity on the shores of Lesser Slave Lake. Photo by Ron Davis.

3.5.3 Aquatic Habitat

The Lesser Slave Lake, its tributaries and many smaller lakes within the watershed provide extensive habitat for aquatic organisms, including aquatic mammals, plants, birds, invertebrates and fish. There are 17 species of fish that have been found in Lesser Slave Lake and 15 species in Lesser Slave River (Table 9). Five additional species have been recorded in various streams within the watershed that have not been collected in the lake including northern pikeminnow, pearl dace, finescale dace, longnose dace and flathead minnow (Table 10).

Table 9: Fish species in the Lesser Slave Lake Watershed (Golder, 2004)

Common Name	Scientific Name	Relative Abundance	
		Lesser Slave Lake	**Lesser Slave River**
Arctic Grayling	Thymallus arcticus	Rare	Rare
Brook Stickleback	Culaea inconstans	Rare	-
Burbot	Lota lota	Abundant	Rare
Cisco	Coregonus artedii	Very abundant	Rare
Emerald Shiner	Notropis atherinoides	Common	Abundant
Goldeye	Hiodon alosoides	Rare	Rare
Lake Chub	Couesius plumbeus	-	Rare
Lake Trout	Salvelinus namaycush	Extirpated	-
Lake Whitefish	Coregonus clupeaformis	Abundant	Abundant
Longnose Sucker	Catostomus catostomus	Very abundant	Abundant
Mountain Whitefish	Prosopium williamsoni	Rare	Abundant
Northern Pike	Esox lucius	Abundant	Abundant
Spoonhead Sculpin	Cottus ricei	Rare	-
Spottail Shiner	Notropis husdonius	Abundant	Abundant
Trout-perch	Percopsis omiscomaycus	Common	Rare
Yellow Perch	Perca flavescens	Abundant	Rare
Walleye	Sander vitreus	Common	Rare
White Sucker	Catostomus commersoni	Common	Abundant

Table 10: Additional fish species in the watershed (ASRD, 2009a)

Common Name	Scientific Name
Northern Pikemnnow	*Ptychocheilus oregonensis*
Pearl Dace	Margariscus margarita
Finescale Dace	*Phoxinus neogaeus*
Longnose Dace	Rhinichthys cataractae
Flathead Minnow	

In the early 1900's, lake trout was a popular and abundant fish in Lesser Slave Lake. However, by the 1940's the lakes population was extirpated due to changes in the lake and overfishing (Mitchell & Prepas, 1990). Lake trout are a very slow growing fish, often taking 8-10 years to reach maturation; therefore they are very sensitive to heavy fishing pressure (ASRD, 2009h). This species can reach 20-25 years of age exceeding 10 kg in weight.

Surface water within the Lesser Slave Watershed provides cool water aquatic habitat. The upper reaches of the East Prairie, West Prairie, Driftpile and Swan Rivers are turbid with steep slopes and high velocities. While the lower reaches are slower flowing with sand substrates over much of the streambed. Conversely, from the outlet at Lesser Slave Lake, the Lesser Slave River is slow moving with a low gradient and a sand bed. This area has many pools and large oxbows that are important fish habitat. Heading downstream, the rivers slope increases significantly after the Saulteaux River providing riffles with gravel and cobble substrate and some deep pools (Golder, 2004).

3.6 Species at Risk

Every five years, the Fish and Wildlife Division of Alberta Sustainable Resource Development conducts a general status exercise evaluating the well-being of wild species populations within Alberta. The status of each species is ranked based on several criteria including population size, distribution and trends, and habitat threats (ASRD, 2009b).

The most recent report was completed in 2005, *The General Status of Alberta Wild Species 2005*, and contains assessments of 2,811 species. The report covers a broad range of taxa including mammals, birds, reptiles, amphibians, fish, invertebrates (eg. butterflies, snails) and vascular plants (ASRD, 2009b). The evaluation process is identical to those used by other provinces and territories throughout Canada therefore cross country comparisons can be made. Understanding the status of each species permits sound planning and decision-making for conservation programs, and is a critical step towards setting management priorities.

Throughout the general status exercise, species are rated as 'At Risk' or 'May be at Risk' of extinction, 'Sensitive' to human disturbances or natural events, or 'Secure' within the province (ASRD , 2009b). Detailed status assessments are completed for species listed as 'May be at Risk' to determine if there is reason to consider them 'At Risk'. Species rated as 'At Risk' are given legislative protection under the *Alberta Wildlife Act* as 'Endangered' or 'Threatened' species (ASRD, 2009b).

Based on the detailed status reports developed for 'At Risk' and 'May be at Risk' species, the Endangered Species Conservation Committee (ESCC) evaluates and assigns species at risk status appropriately. Species will be placed in the following categories based on evaluation by the ESCC (ASRD, 2009b):

Endangered: A species facing imminent extirpation or extinction.

Threatened: A species likely to become endangered if limiting factors are not reversed.

Species of Special Concern: A species of special concern because of characteristics that make it particularly sensitive to human activities or natural events. A non-legislated category that identifies the need for special management.

Data Deficient: A species for which there is insufficient scientific information to support status designation.

For species listed as 'Endangered' or 'Threatened' recovery teams are established made up of species' experts, wildlife and land managers and various stakeholders that may be affected by the recovery initiatives (ASRD, 2009b). Recovery plans identify conservation and recovery actions that are required for the benefit of the species in question. The actual recovery actions may be carried out by various sectors of government, conservation partners or private individuals (ASRD, 2009b). Management plans are completed by Fish and Wildlife for 'Species of Special Concern'. These are much less detailed than a recovery plan and are developed by a provincial species' lead within the division.

Over time as conservation efforts succeed, species are removed from the list or down-listed accordingly. Many projects are focused on 'Species of Special Concern' to prevent them from becoming 'Endangered' or 'Threatened'.

As of December 2009, there are fourteen species at risk that occur within the Lesser Slave Watershed: four are considered 'Threatened', five are 'Species of Special Concern', two are 'Data Deficient' and three are' In Process' (Table 11).

Table 11: Species at risk within Lesser Slave Watershed (ASRD, 2009b)

Legal Designation	Common Name	Scientific Name
Threatened	Woodland caribou	*Rangifer tarandus caribou*
	Northern leopard frog	*Rana pipiens*
	Trumpeter swan	*Cygnus buccinator*
	Peregrine falcon	*Falco peregrinus*
Species of Special Concern	Barred owl	*Strix varia*
	White-winged scoter	*Melanitta fusca*
	Sprague pipit	*Anthus spragueii*
	Arctic Grayling	Thymallus arcticus
	Western grebe	Aechmophorus occidentalis
Data Deficient	Wolverine	*Gulo gulo*
	Canadian toad	*Bufo hemiophrys*
In Process	Bay breasted warbler	*Dendroica castanea*
	Cape may warbler	*Dendroica castanea*
	Grizzly bear	*Ursus arctos*

A brief introduction to each species at risk and the threats that they face within the Lesser Slave Watershed is discussed in the following paragraphs.

Woodland Caribou

The Woodland caribou, *Rangifer tarandus caribou*, is listed as 'Threatened' by the Endangered Species Conservation Committee (ASRD, 2009b). This species of caribou is a sub-species that is distributed across the forested and mountainous regions of Canada (Dzus, 2001). The primary food source of Woodland caribou is lichens, which are extremely slow growing and have very limited methods of dispersal therefore they are usually only found in old growth mature forests. However, Woodland caribou in the northern portion of the province, including the Lesser Slave Watershed, typically remain confined to muskegs dominated by black spruce and tamarack trees as well as islands of jackpine stands (Dzus, 2001).


Woodland Caribou. Photo by Kuchera, Dreamstime.

Currently within the Lesser Slave Watershed, the range of Woodland caribou is mostly within the Lesser Slave River sub-basin along the Lesser Slave River and the western side of the Athabasca River. A smaller area surrounding Marten Hills in the Lesser Slave Lake North sub-basin is also within the Woodland caribou range. Historically, this range was much larger with sightings throughout much of the watershed, however the trend for most caribou ranges within the province is one of decline (Dzus, 2001).

The main threats to stable Woodland caribou populations are predation, habitat loss and alteration, linear corridors and other human disturbances, and climate (Dzus, 2001). The interactions between these main threats are quite complex but are all partially dependent on one another. For example, the threat of predation can be increased with linear disturbances as they provide increased access for both predators and humans into previously isolated expanses of forest.

Over the last twenty years, human activities have been increasing rapidly within the Woodland caribou range. Linear development has reduced the effectiveness of habitat on 28-70% of habitat assessed within major northern caribou ranges (Dzus, 2001). In response, Alberta Sustainable Resource Development requires all industry operating within caribou ranges, designated on Wildlife Land Management Referral Maps, to submit an annual Caribou Protection Plan outlining all projects planned within caribou ranges and mitigation strategies to protect caribou and their habitat.

Northern Leopard Frog

The Northern leopard frog, *Rana pipiens*, is listed as 'Threatened' by the Endangered Species Conservation Committee (ASRD, 2009b). Within Alberta, Northern leopard frogs are typically associated with clear fresh water; some studies have shown that this species is more sensitive to acidity than other frog species (Vatnick *et al*., 1999). Northern leopard frogs utilize warm standing water for breeding and spawning.


Northern Leopard Frog. Photo by Pancaketom, Dreamstime.

In Alberta, rapid population declines of this species were first noted in 1979 (ASRD, 2003b). Since this time populations in central and western Alberta appear to have been extirpated and populations have declined in southern Alberta (ASRD, 2003b). However, a population in north eastern Alberta remains; possibly because of its isolation from other populations and human impacts (ASRD, 2003b). Within the Lesser Slave Watershed, prior to 1981 northern leopard frogs were observed in Lesser Slave Lake Provincial Park (Lesser Slave Lake North sub-basin) and in backwaters of the Lesser Slave River (Lesser Slave Rive sub-basin). Between 2000 and 2001, sampling was completed along the Lesser Slave River but no specimens were found (ASRD, 2003b).

On a global scale over the last fifty years amphibian populations have been in a state of decline (ASRD, 2003b). In some cases this can be explained but in others it is difficult to pinpoint a cause. The cause for the sudden decline of Northern leopard frogs within Alberta is unknown (ASRD, 2003b). However, the most likely threats to Northern leopard frog populations within Alberta are climate, habitat fragmentation and loss, livestock activity in riparian areas, water acidification, and the introduction of game fish or exotic species (ASRD, 2003b).

Trumpeter Swan

The Trumpeter swan, *Cygnus buccinator*, is listed as 'Threatened' by the Endangered Species Conservation Committee (ASRD, 2009b). Trumpeter swans are divided into three breeding populations, the Pacific Coast Population, the Rocky Mountain Population and the Interior Population (James & James, 2001). The Lesser Slave Watershed is within the Rocky Mountain Population. Within the watershed, the range of Trumpeter swans is mostly within the northern half of the South Heart River/East & West Prairie River sub-basin and the Lesser Slave Lake North sub-basin. The results of a survey completed in 2000 combined with those from previous studies show that populations of Trumpeter swans continue to grow in the High Prairie area and within Alberta (James & James, 2001).

Trumpeter swans establish nests on shallow lakes and marshes and will prevent other swans from inhabiting the same waterbody. They are sensitive to loud noises and repeated disturbances. The main threat to stable population sizes is a lack of wintering ground (located in Idaho, Montana and Wyoming); other threats include predation, lead poisoning, accidental shootings and electrocution by powerlines (ASRD, 2009b).

Land use practices and recreation in close proximity to lakes can have detrimental effects to Trumpeter swan populations. In an effort to continue the recovery of Trumpeter swan populations in Alberta the Fish and Wildlife Division of Alberta Sustainable Resource Development has developed some recommended land use practices for operations near Trumpeter swan habitat (ASRD, 2001). Recommendations include timing restrictions and limiting access to lakes with known Trumpeter swan habitat.

Peregrine Falcon

The Peregrine falcon subspecies, *Falco peregrinus anatum*, is listed as 'Threatened' by the Endangered Species Conservation Committee (ASRD, 2009b). The subspecies was down-listed in the year 2000 from 'Endangered' status. Historically, the breeding range of this subspecies covered most of Alberta, excluding the eastern edge of the province (Rowell & Stepnisky, 1997). Populations of Peregrine falcons were stable in Alberta prior to the 1960-70's, when populations crashed due to the world-wide use of pesticides, mainly the use of DDT (Rowell & Stepnisky, 1997). Pesticides were causing reproductive failure by thinning the eggshells.

The primary threat to stable Peregrine falcon populations is contaminant levels (Rowell & Stepnisky, 1997). As populations increase habitat loss and degradation may become a threat as well as human disturbance.

Barred Owl

The Barred owl, *Strix varia*, is listed as a 'Species of Special Concern' by the Endangered Species Conservation Committee (ASRD, 2009b). It is considered sensitive because the species requires large areas of undisturbed mature forested habitat (ASRD, 2005b). Barred owls prefer mixed wood forests and are often associated with riparian and wetland areas (ASRD, 2005b). This species has been observed throughout the forested areas of the Lesser Slave Watershed.

The main threat to Barred owls within Alberta is a loss of continuous mature old growth forest with snags and large diameter trees for nesting (ASRD, 2005b). Policies for the forest industry require older stands to be harvested first, which can conflict with habitat of Barred owls. Currently, riparian areas that are restricted from logging provide the majority of potential nesting sites for the species (ASRD, 2005b).

White-winged Scoter

The White-winged scoter, *Melanitta fusca deglandi,* is listed as a 'Species of Special Concern' by the Endangered Species Conservation Committee (ASRD, 2009b). The White-winged scoter is a sea duck that breeds inland on large permanent wetlands and overwinters along the east and west coasts of Canada (ASRD, 2002). Historically, breeding grounds for the White-winged scoter covered almost all of Alberta, however, since the early 1900's this range has retracted northward (ASRD, 2002). Populations in the northern half of the province have also seen dramatic declines.

The main limiting factors on population size for the White-winged scoter are unknown. Most explanations propose that it is due to a decline of local populations through loss of breeding sites by human interference and increased recreation, limitations in wintering ground or localized hunting pressures (ASRD, 2002).

Sprague Pipit

The Sprague pipit, *Anthus spragueii,* is listed as a 'Species of Special Concern' by the Endangered Species Conservation Committee (ASRD, 2009b). The Sprague pipit is a small songbird that winters in the southern United States and breeds in the prairie provinces of Canada (Prescott, 1997). This bird is typically found in native prairie grasses and avoids cultivated land and introduced grasses (Prescott, 1997). Populations have been declining in Alberta as well as across North America most likely due to land use changes on the prairies (Prescott, 1997).

The main threats to Sprague pipit populations are loss of native prairie habitat, which is typically modified for agriculture, and livestock grazing (Prescott, 1997).

Arctic Grayling

Arctic grayling, *Thymallus arcticus,* is listed as a 'Species of Special Concern' by the Endangered Species Conservation Committee (ASRD, 2009b). Arctic grayling are native to North America, and are found primarily in the northern portion of Alberta including the Athabasca, Hay and Peace River drainage systems (ASRD, 2005c). Arctic grayling typically migrate from lakes and larger rivers to smaller streams to spawn, which in Alberta usually occurs at the end of April or beginning of May (ASRD, 2005c). Population declines were first noticed between the 1950's to 1970's with "50% of Alberta's subpopulations declining over 90% in abundance" (ASRD, 2005c).

The main threats to Arctic grayling populations include habitat fragmentation, overharvesting by anglers and climate changes (ASRD, 2005c). Stream fragmentation through road construction and improper culvert installation creating barriers is a crucial limiting factor of Arctic grayling populations throughout Alberta and within the Lesser Slave Watershed (ASRD, 2005c).

Western grebe

The Western grebe, *Aechmophorus occidentalis,* is listed as a 'Species of Special Concern' by the Endangered Species Conservation Committee (ASRD, 2009b). Western grebes are colonial birds that overwinter on the Pacific coast and breed inland on medium or large lakes and wetlands (ASRD & ACA, 2006). This species occurs only in North America and is relatively uncommon in Alberta. Lesser Slave Lakes Western grebe population is considered nationally important (ASRD & ACA, 2006). Data from four different collection periods is available for the Lesser Slave Lake population, which shows periods of decline and apparent recovery over the last 40 years. Western grebe population size was quite low in the 1970's but had increased by the end of the decade, similarly in the year 2000 populations were extremely low but had increased by 2002 (ASRD & ACA, 2006).

Western grebes are very sensitive to human development and disturbance. The main threats to maintaining healthy populations within Alberta are habitat degradation through the alteration of wetlands for residential industrial and agricultural development, direct human disturbances through boating and livestock grazing in riparian areas, oil spills, pollution (accumulation of heavy metals and chlorinated hydrocarbons) and changes to forage fish populations, the main food source of Western grebes (ASRD & ACA, 2006).

Wolverine

The Wolverine, *Gulo gulo*, is listed as 'Data Deficient' by the Endangered Species Conservation Committee (ASRD, 2009b). The Wolverine is both a scavenger and a predator, occasionally preying on large ungulates during the winter. Wolverines typically inhabit remote areas with little human disturbance or development. Historically, the Wolverine had a circumboreal distribution; however its range has retreated since the early 1900's (ASRD, 2009b). This species used to occur all across Alberta but is now restricted to the northern half of the province and along the Rocky Mountains (ASRD, 2009b). As indicated by trapping harvest records, Wolverine populations are thought to be declining within Alberta (Peterson, 1997).

The main threats to stable Wolverine populations within Alberta are likely direct impacts such as trapping and indirect impacts, in the form of habitat loss (Peterson, 1997). Increased human development in remote areas is most likely shrinking the amount of suitable habitat available.

Canadian Toad

The Canadian toad, *Bufo hemiophrys*, is listed as 'Data Deficient' by the Endangered Species Conservation Committee (ASRD, 2009b). Within Alberta, the Canadian toad is not well studied but seems to prefer permanent wetlands for reproduction (Hamilton *et al.*, 1998). Since the early 1990's populations have declined and disappeared in some areas of central Alberta (Hamilton *et al.*, 1998). Within the Lesser Slave Watershed, observations of Canadian toads have been made in the Lesser Slave River sub-basin but there is little recent data available.

The main limiting factors on Canadian toad populations are disturbance to hibernacula, which are vulnerable to human disturbance, forestry operations, wetland loss and alteration and global factors, such as, climate change and disease (Hamilton *et al.*, 1998).

Bay-breasted Warbler

The Bay-breasted warbler, *Dendroica castanae*, is listed as 'In Process' by the Endangered Species Conservation Committee (ASRD, 2009b). The Bay-breasted warbler is a neotropical migratory songbird that breeds in the boreal forest and overwinters in Panama and the northern portion of South America (Norton, 2001a). This species prefers coniferous old growth forests; however, unpublished data suggests that it may also use deciduous dominant forests (Norton, 2001a). Within the Lesser Slave Watershed, Bay-breasted warblers have been observed over much of the area but remain relatively uncommon (Norton, 2001a).

The main limiting factor causing concern over the status of the Bay-breasted warbler is habitat loss and fragmentation caused by agriculture, forestry and oil and gas activity (Norton, 2001a). The amount of suitable stopover habitat for the Bay-breasted warbler during migration to and from the overwintering range is also decreasing. Other threats to stable populations are nest predation and parasitism (Norton, 2001a).

Cape May Warbler

The Cape may warbler, *Dendroica tigrina*, is listed as 'In Process' by the Endangered Species Conservation Committee (ASRD, 2009b). The Cape may warbler is a neotropical migratory species that breeds in the boreal and foothills of Alberta and overwinters in the West Indies and the east coast of Central America (Norton, 2001b). This species prefers coniferous old growth forest made up of predominately white spruce. Within the Lesser Slave Watershed, observations of this species have been made along the north side of Lesser Slave Lake. Currently there is not enough data to show population trends within Alberta (Norton, 2001b).

Concern for stable populations of this species is mainly due to habitat loss and fragmentation caused by agriculture, forestry and oil and gas activity (Norton, 2001b). The amount of suitable stopover habitat for the Cape may warbler during migration to and from the overwintering range is also decreasing. Other threats to stable populations are nest predation and parasitism (Norton, 2001b).

Grizzly Bear

The Grizzly bear, *Ursus arctos*, is listed as 'In Process' by the Endangered Species Conservation Committee (ASRD, 2009b). Historically, the range of Grizzly bears covered the majority of the western half of North America however this range has reduced dramatically to north western Canada and Alaska (Kansas, 2002). The Lesser Slave Watershed is within the current Grizzly bear range but the number of individuals in the area is unknown.

Historically, reductions to Grizzly bear populations were related to clearing of land for agriculture and unrestricted hunting (Kansas, 2002). Current threats to stable Grizzly bear populations in Alberta are attributed to human caused mortality, increased access to previously undisturbed areas and habitat loss (Kansas, 2002).

3.7 Populations

Within the Lesser Slave Watershed there are approximately 18,500 residents. The Towns of Slave Lake and High Prairie are the largest centers located within the watershed with populations of 6,703 and 2,750 respectively (Statistics Canada, 2006). A large proportion of the population are rural inhabitants while others live in the 12 smaller centres, 3 Metis settlements and 5 First Nation communities that are within the watershed. The majority of communities are located on the south side of the lake along Highway 2 and many are located quite close to the shores of Lesser Slave Lake, illustrating the lakes importance to inhabitants of the area.

3.8 Land Use

In a general sense, there are two broad land use categories within the Lesser Slave Watershed; the green zone and white zone. The majority of the watershed is designated as green zone. Land within this zone is predominately publicly owned and managed for multiple uses including timber production, oil & gas exploration and development, surface material removal, livestock grazing, recreation, watershed protection, and fish and wildlife habitat. This zone is generally not available for individual or community settlement. The white zone contains most of the land deemed suitable for cultivation, and is predominantly privately owned. However, a wide range of other uses are allowed in the white zone; some parcels of land are also retained by the province for environmental reasons and natural resource management (ASRD, 2003a). Within the watershed, the white zone is concentrated within the South Heart/East & West Prairie River sub-basin and along the south shore of Lesser Slave Lake (Figure 7), coinciding with settled areas and agricultural development.

Agricultural lands in the region are used for a variety of activities including forage, seed crops, cultivation and livestock grazing. Crops grown within the watershed include wheat, barley, oats, canola, seed and forage crops (LSLCDC, 2003). Cultivation practices can negatively impact water quality and quantity through excessive or improper use of herbicides and pesticides, elimination of natural riparian vegetation, soil compaction from equipment, and wind or water erosion of exposed soils. Many of these detrimental impacts can be mitigated through proper land use practices, for example, buffering waterbodies, protecting riparian areas and planting wind breaks to decrease wind erosion.

Livestock farmed within the watershed include but are not limited to, cattle, bison, horses, sheep, pigs and chickens; however, the numbers of each species are not available. Similar to cultivation, livestock operations can have negative effects on water quality and quantity including soil compaction, alteration of riparian areas causing an increase in erosion, and if operations and livestock watering are located in close proximity to watercourses, fecal matter can enter streams causing bacterial contamination.

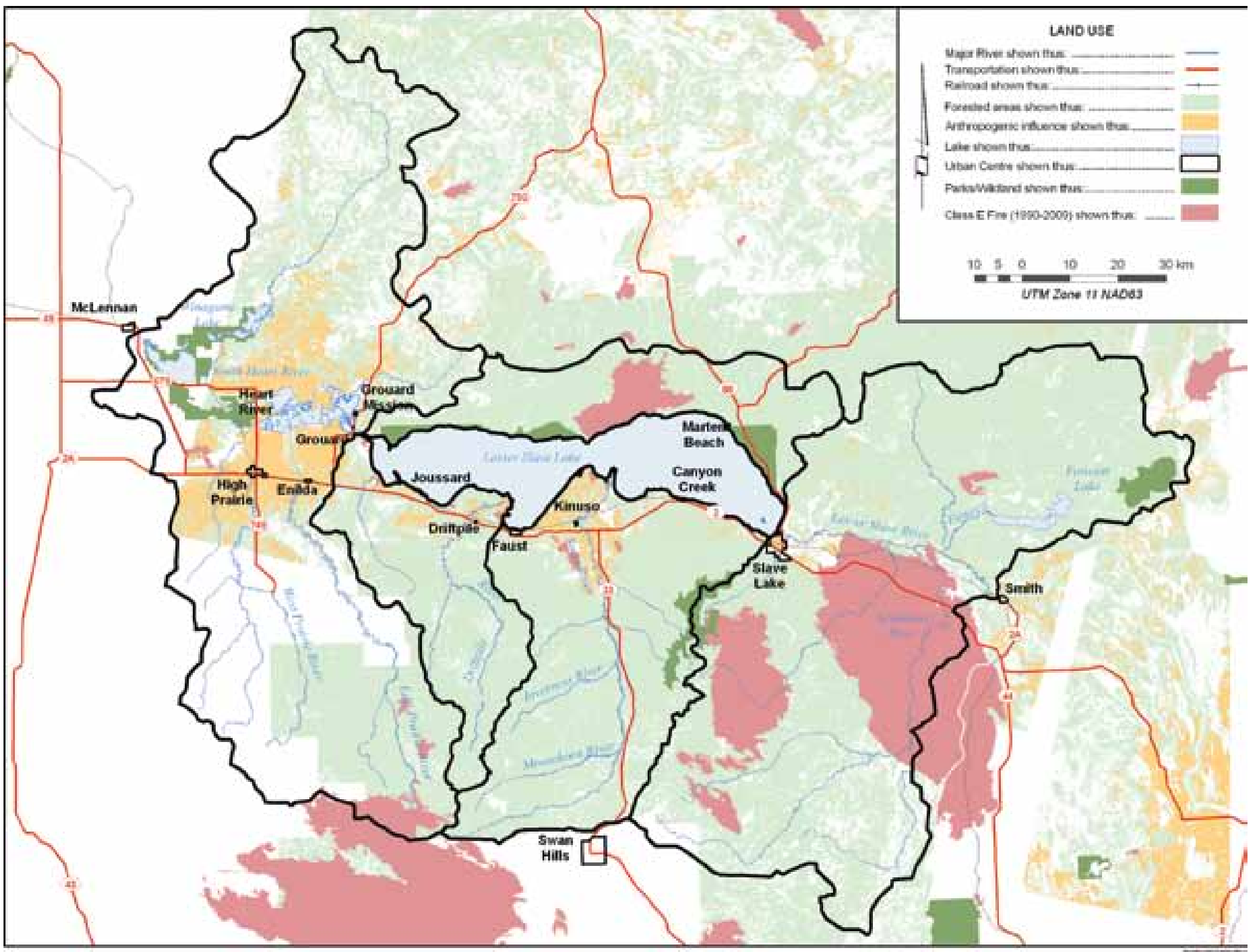


Figure 7: Generalized land use within the Lesser Slave Watershed.

Note: to account for forest regeneration after a fire only forest fires occurring in the last 20 years have been included.

Within the Lesser Slave Watershed, there are 16 parks and protected areas, covering 52,776 hectares, or 2.8 % of the land base. These parks include a range of classifications that offer varying degrees of protection, including Provincial Parks, Wildland Parks, Provincial Recreation Areas, Ecological Reserves, and Natural Areas. As outlined by Alberta Tourism, Parks and Recreation (2009), Provincial Parks are designed to "preserve natural heritage; they support outdoor recreation, heritage tourism and natural heritage appreciation activities that depend upon and are compatible with environmental protection. Wildland Parks preserve and protect natural heritage and provide opportunities for backcountry recreation. Recreation Areas support outdoor recreation and tourism; they often provide access to lakes, rivers, reservoirs and adjacent Crown land (green zone). Ecological Reserves preserve and protect natural heritage in an undisturbed state for scientific research and education. Natural Areas preserve and protect sites of local significance and provide opportunities for low-impact recreation and nature appreciation activities".

Most of the protected areas within the watershed are concentrated around lakes, including Winagami Lake, Lesser Slave Lake, Otter Lake and Orloff Lake. In addition to the protected areas around these lakes, Grizzly Ridge Wildland Park covers a portion of the ridge between the Swan River and Lesser Slave River sub-basins. This area includes the headwaters of Sawridge, Mooney, Island and Adams Creeks, as well as the Assineau River. This protected area is also important habitat for Grizzly bears, a potential species at risk within Alberta (see section 3.6).

Within provincially protected areas, the Government of Alberta honours existing mineral commitments that were in place prior to a protected area being established. Since the *Provincial Parks Act* and the *Wilderness Areas, Ecological Reserves, Natural Areas and Heritage Rangelands Acts* were both established to protect these areas, extensive and careful planning along with sound operational practices must be implemented when carrying out any activities in protected areas (Alberta Energy, 2003). Impacts to the natural landscape, fish and wildlife resources and vegetative cover must be minimized when completing mineral exploration or extraction in these areas (Alberta Energy, 2003).

The majority of industrial activity within the watershed is associated with the oil and gas industry, though other industries, such as the forest, sand and gravel, rail, and electrical utility industries also occur in the watershed. Industrial activity impacts watershed health through the construction of roads, well sites, pipelines, electrical lines, gravel pits and many other associated facilities. Impacts are greatest through activities that disturb and displace soils, such as road construction, particularly in close proximity to watercourses, where a combination of slopes, runoff, and exposed soils provide ideal conditions for erosion and siltation. In an effort to improve several stream crossings in the Marten Hills area, BP Canada voluntarily removed four culverts and replaced them with bridges (I. Johnston, ASRD, pers. comm.). Crossings were replaced on Muskeg Creek, Meridian Creek and two of the main tributaries of the Driftwood River.

The Government of Alberta Land-Use Framework is a comprehensive approach for planning and better management of both public and private lands, as well as "natural resources to achieve Alberta's long-term economic, environmental and social goals" (ASRD, 2009c). Through the Land Use Framework, regional plans will be developed that use a cumulative effects management approach to manage the impacts of development on land, water and air (ASRD, 2009c). The Lesser Slave Watershed is within the Upper Athabasca land-use planning region. The development of a regional plan for the Upper Athabasca region has not commenced at the time of publication, but is planned to begin shortly.

A large portion of the Lesser Slave Watershed is within Alberta's Forest Reserve. Within the watershed, nine forestry companies have either sole or joint Forest Management Agreements (FMA's) with the Alberta Government granting them timber rights (Table 12). In addition, there are quota holders who operate within each FMA. The FMA holders are responsible for the development of a Detailed Forest Management Plan that outlines higher level planning, including long term sustainability objectives and the management of impacts on wildlife, water quality and water quantity. This is accomplished in several ways including the development of a spatial harvest sequence (SHS) and an access development plan. The spatial harvest sequence is basically a map depicting forest stands to be harvested over the next 20 years. Through the development of a SHS, the forest industry is able to analyze and report on the amount of harvesting within watersheds and sub-basins. The access development plan consists of a map showing how each area in the spatial harvest sequence will be accessed, and is an essential component for integration of access planning within each Forest Management Area.

Table 12: Forest Management Agreements within the Lesser Slave Watershed (ASRD , 2009d)

FMA Number	FMA Agreement Holder	Agreement Duration	Total FMA Area (hectares)
9100029	Alberta Pacific Forest Industries Inc. (Al-Pac)	September 1, 1991 to August 31, 2011	5,812,185
7500020	Blue Ridge Lumber Inc.	May 1, 2008 to April 30, 2028	662,392
8900027	Daishowa-Marubeni International Ltd. (DMI)	July 1, 2009 to April 30, 2029	1,713,761
0200039	Gordon Buchanan Enterprises Ltd. and Tolko Industries Ltd.	March 5, 2002 to March 4, 2022	246,243
9700034	Millar Western Forest Products Ltd.	May 14, 1997 to May 13, 2017	440,680
9000028	Slave Lake Pulp Corporation	November 15, 1990 to November 14, 2020	655,789
9700033	Tolko Industries Ltd.	May 13, 1997 to May 12, 2017	246,243
0600043	Tolko Industries Ltd., Vanderwell Contractors Ltd and Alberta Plywood Ltd.	January 1, 2006 to April 30, 2026	727,043
9700036	Vanderwell Contractors Ltd	August 1, 1997 to July 31, 2017	58,535

Note: only a portion of AlPac, Blue Ridge, DMI, and Millar Western's FMA's are within the watershed.

Additionally, forestry companies develop operational level plans that demonstrate how the higher level objectives are being achieved. At the operational level, planners develop and analyze multiple route and site selection options based upon the impacts on multiple values, including wildlife, water quality and water quantity. This process is conducted by industry, reviewed by professionals within Alberta Sustainable Resource Development, and is also subject to a stakeholder consultation process.

Multiple levels of government and industry have invested in the development of guide materials that describe best management practices for operations taking place near water bodies. Some examples of these guides are provided below:

Federal Department of Fisheries and Oceans – Operational Statements

Alberta Provincial Government – Timber Harvest Planning and Operating Ground Rules, Public Lands Handbook, Guides to the Code of Practice for Watercourse Crossings

Forest Engineering Research Institute of Canada – Multiple instructional manuals on protecting soils and water bodies during forest operations.

Canadian Association of Petroleum Producers/Canadian Energy Pipeline Association/Canadian Gas Association – Pipeline Associated Watercourse Crossings 3rd Edition.

In all cases, users of private and public lands are required to meet legislated requirements for the protection of watercourses, riparian areas, and fish and wildlife habitat.

Forest fires are a natural and normal disturbance within all watersheds. Over the last 20 years there have been a number of large forest fires within the Lesser Slave Watershed classified as class E by Alberta Sustainable Resource Development. The largest of these is the Chisholm fire which started on May 23, 2001 and burned approximately 116,000 hectares of land; two thirds of which is within the Lesser Slave Watershed (NRC, 2009).

A water bomber practices at Mitsue. Photo by Meghan Payne.

Forest fires can have both positive and negative impacts on watersheds, depending on the management objectives. Fires help to diversify wildlife habitat, assist in nutrient cycling, and improve forest health. Negative effects on watersheds include exposing large areas of the landbase which leads to higher peak flows and increased runoff. If fires burn hot enough the soil properties can be altered creating water-repellent soils which can further increase runoff, but does not appear to effect regeneration (Bladon & Redding, 2009).

Though the infestation is in its early stages within Alberta, forests killed by Mountain Pine Beetle, *Dendroctonus ponderosae*, can result in detrimental changes to watershed hydrology and loss of suitable fish and wildlife habitat. There are large stands of pine forests throughout the watershed that are susceptible to attack by Mountain Pine Beetle. The province is funding initiatives to slow the easterly spread of Mountain Pine Beetle in the highly connected pine forests of central Alberta (ASRD, 2009e), including the Lesser Slave Watershed. There was a massive flight of Mountain Pine Beetle into the western edge of the Lesser Slave Watershed in 2006, the province reacted by initiating a Mountain Pine Beetle control program in 2007 on both private and publicly owned lands. Each year the Mountain Pine Beetle spreads further east, and the size and location of control programs are adjusted accordingly. The forest industry has also responded by revising spatial harvest sequences to target harvest activities into predominantly pine forests.

The Town of Slave Lake is the largest community within the watershed and is located on the south-eastern shores of Lesser Slave Lake; many smaller communities are located along the south shore of the lake and along Highway 2. Urban development within the watershed is fairly minor however the majority of communities are located on or near the Lesser Slave Lake shoreline, which can have detrimental effects on water quality and riparian areas. Furthermore, urban development impacts natural drainage patterns and can cause increases in the rate of runoff after storm events.

4.0 South Heart /East and West Prairie River Sub-basin

The South Heart/East and West Prairie River sub-basin is located in the western portion of the Lesser Slave Watershed (Figure 8). The sub-basin drains an area of approximately 6,887 square kilometres (km^2) and can be further broken down into two sub-basins, the South Heart River which drains the north half and the East and West Prairie Rivers which drain the south. The northern South Heart River portion drains an area of approximately 3,324 km^2 and the southern portion, East and West Prairie Rivers, drain an area of 3,563 km^2.

Photo by Ron Davis.

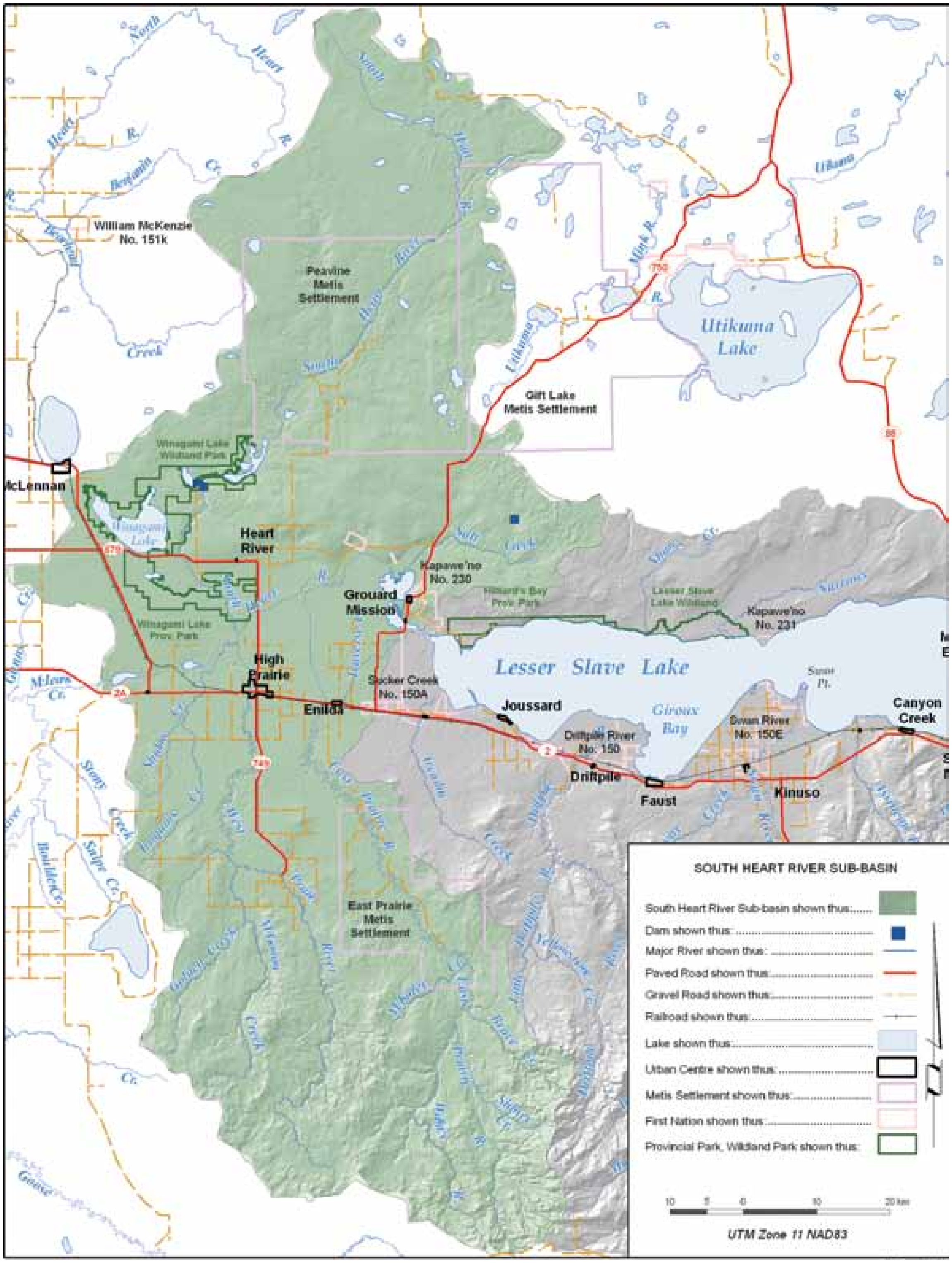


Figure 8: Overview of the South Heart/East and West Prairie River sub-basin

Within the northern portion of the sub-basin, the South Heart River and Salt Creek are the only major tributaries that drain this region. However, many smaller tributaries join the South Heart River and many lakes occur in the sub-basin including Seal Lake, Pentland Lake, Sutton Lake, Webster Lake, Winagami Lake and the Horse Lakes-Buffalo Bay system. The South Heart River is a low velocity river due to the relatively flat land that it drains.

Within the southern portion of the sub-basin, Lost Hope Creek, Pipe Creek, McGowan Creek, Golden Creek, Coalmine Lick Creek, Iroquois Creek and Shadow Creek join the West Prairie River and Sidney Creek, Wallace River, Bruce Creek and McKinley Creek are the major tributaries that join the East Prairie River. Traverse Creek and Mud Creek also drain the northern portion of this area and flow into the Grouard Channel south of Buffalo Bay. There are also many smaller tributaries that join these rivers before their confluence with the South Heart River. The largest lakes within the southern portion of the sub-basin are Maurice Lake and Iroquois Lakes; many smaller waterbodies are also located within the system. Both the West and East Prairie Rivers have two distinct parts, a steep upper section and a flatter lower section. In the upper sections channel slopes are reported between 0.003 and 0.025, whereas the flatter downstream portions have slopes of 0.0006 (Hydrocon, 1984).

All four of the natural sub-regions of Alberta that occur within the watershed are within the South Heart/East & West Prairie River sub-basin; the upper foothills, lower foothills, central mixedwood and dry mixedwood. The southeast tip of the sub-basin, the headwaters of the East Prairie River, is within the upper foothills. This region is characterized by strongly rolling to steep terrain (NRC, 2006). The growing conditions favour conifers and the area is predominately lodgepole pine forest with a black spruce understory or balsam fir. Stands of white spruce can be found along the edge of rivers and mixed wood or deciduous stands occur on south and west facing slopes (NRC, 2006). The headwaters of the West Prairie River occur in the lower foothills. This area is characterized by rolling and undulating hills with mixedwood forests made up of a combination of the following species; aspen, balsam poplar, white birch, lodgepole pine, black spruce, white spruce, balsam fir and tamarack (NRC, 2006). The central mixedwood sub-region occurs in two areas within the sub-basin, a band between the lower foothills and the agricultural lands around High Prairie and the majority of the northern half of the sub-basin. This area is characterized by a mix of aspen dominated deciduous stands, aspen-white spruce mixedwood and white spruce or jackpine dominant stands (NRC, 2006). The central portion of the sub-basin is within the dry mixedwood sub-region and is characterized by aspen forests with prickly rose, low-bush cranberry, beaked hazelnut and Canada buffaloberry understory (NRC, 2006). Additionally, this sub-region is quite good for agricultural development.

Eight environmentally significant areas (ESA's) occur within the sub-basin, of both international and provincial significance. The Lesser Slave Lake and surrounding riparian zone are considered internationally significant. The other ESA's are of provincial significance including the area surrounding Winagami Lake and Wildland Provincial Parks, the Swan Hills area, non-pattern fens and slope fens in the McLennan area, and three areas with important wildlife habitat, one near Lesser Slave lake and the others close to the junction between Highway 2 and 2A. The selection of ESA's is based on seven criteria, areas that contain conservation concerns, rare or unique landforms, habitat for focal species, important wildlife habitat, riparian areas, large natural areas and other sites of recognized significance (Fiera, 2009). ESA's are used as a "decision support tool for land use planning" within Alberta over the long term (Fiera, 2009).

There are five parks within the South Heart/East & West Prairie River sub-basin totalling approximately 208 km^2 or 3.0% of the sub-basin. Parks within the sub-basin include Winagami Lake Provincial Park, Winagami Wildland Provincial Park, Heart River Dam Provincial Recreation Area, Goose Mountain Ecological Reserve and Police Point Natural Area.

Communities within the sub-basin include Enilda, High Prairie, Grouard and the Peavine, Gift Lake and East Prairie Metis Settlements. The Peavine and Gift Lake Metis Settlements are located in the northern portion of the sub-basin and the East Prairie Metis Settlement is within the southern part (Figure 8). Based on population, High Prairie is the largest community in the sub-basin with approximately 2,750 people (Statistics Canada, 2006).

4.1 Water Quality

4.1.1 River Water Quality Index

There is insufficient water quality sampling data to calculate the River Water Quality Index for this sub-basin. This data gap should be addressed in future water quality studies.

4.1.2 *Escherichia coli*

To date, there is no data on counts of *Escherichia coli* within the South Heart/East and West Prairie River sub-basin. This data gap should be addressed in future water quality studies.

4.1.3 Nutrient Budget

Currently, data on total nitrogen and phosphorus within the South Heart/East and West Prairie River sub-basin is at least 10 years old. This data gap should be addressed in future water quality monitoring.

4.1.4 Sediment Contamination

The South Heart River/East & West Prairie Rivers are one of the highest contributors of sediment entering Lesser Slave Lake within the watershed (Choles, 2004; AMEC, 2005). On average 847,000 tonnes of sediment per year are transported downstream by the East Prairie River and 284,000 tonnes per year by the West Prairie River (Table 13). The upper reaches of both rivers have a high carrying capacity for sediment based on their slopes and flow velocities. The engineering works during the 1950-1970's (see section 3.4) have locally increased the amount of channel erosion and downcutting, therefore increasing sediment transport within these rivers (AMEC, 2005), but it is unknown how much of an increase this caused. Eventually these channels with degrade and stabilize.

Table 13: Seasonal or annual total suspended sediment loads for East & West Prairie Rivers (AMEC, 2005)

River Channel	Seasonal or Annual Total Suspended Sediment Load (tonnes/year)*		
	Minimum	**Mean**	**Maximum**
East Prairie River	20,200	847,000	6,950,000
West Prairie River	5,870	284,000	1,930,000

*only the West Prairie had sufficient data to calculate annual loads, seasonal loads were calculated for the East Prairie

Approximately 38% of the runoff water entering Lesser Slave Lake travel through Buffalo Bay before entering the lake. It was estimated that 85% of the sediment entering Buffalo Bay settles out upstream in the marshes (AENV, 1977). Other publications increased this to 90% (Hardy, 1989). At any rate only a small proportion of the total sediment carried by the South Heart River enters Buffalo Bay and Lesser Slave Lake. AMEC (2005) computed a sediment budget for Lesser Slave Lake using the mean values in Table 13 as well as 139,000 tonnes for the South Heart River and 23,000 for ungauged tributaries. This produces a total annual sediment load of 1,290,000 tonnes. Assuming 85% of the sediment settles out upstream of Buffalo Bay, only 190,000 tonnes are carried through the Grouard Channel and into Lesser Slave Lake, or when converted to volume, 0.002% of the total lake volume.

A large portion of the East Prairie River channel is diverted directly into the Grouard Channel. As a result the river delta on the north shore of Buffalo Bay is primarily caused by the South Heart River, the West Prairie River and Salt Creek. Based on analysis of historical aerial photos, the delta in Buffalo Bay has grown by approximately 500 meters in the last 53 years (AMEC, 2005).

4.2 Water Quantity

The South Heart/East and West Prairie River sub-basin makes up approximately 55% of the total drainage area for Lesser Slave Lake (this does not include the Lesser Slave River sub-basin) but only contributes 38% to the total runoff entering the lake (Seneka, 2002). Furthermore, the majority of runoff comes from the East and West Prairie Rivers which contribute approximately 25% of the total runoff (38%) from the sub-basin (Seneka, 2002). In other words, the mainstem of the South Heart River combined with other local tributaries contribute only 13% of the runoff but make up 34% of the area.

Mean discharges are outlined in Table 14, however it should be noted that annual mean discharges were calculated for stations with year-round data and seasonal mean discharges for stations with only seasonal data (AENV, 2010). These numbers do not equal the same percentages discussed above as they are percentages of the total water entering Lesser Slave Lake from the drainage basin not just the South Heart/East and West Prairie River sub-basin.

Table 14: Mean and total annual discharges at streamflow monitoring stations in the South Heart River sub-basin (AENV, 2010)

Station	Station Name	Period of Record*	Station Operation	Mean Discharge (m3/s)	Average Total Discharge (dam3)**
07BF001	East Prairie River near Enilda	1921-1931 1959-2009	Seasonal	10.8	230,490
07BF002	West Prairie River near High Prairie	1921-1931 1959-2009	Seasonal to 1970 Annual since 1970	4.52	142,458
07BF009	Salt Creek near Grouard	1986-2009	Seasonal	0.80	16,857
07BF010	South Heart River near Peavine	2000-2009	Seasonal	2.21	51,650

*data used for calculations (until 2008)
** 1 dam^3 = 1000 m^3

4.2.1 Water Allocation

Water allocation within the South Heart/East and West Prairie River sub-basin is mainly for municipal, agricultural and recreation purposes. Of the total surface water allocated from the South Heart River 404,430 m3, 215,860 m3 is allocated to the Town of McLennan (located just west of the Lesser Slave Watershed), 138,000 m3 to the Peavine Metis Settlement and the remaining 50,570 m3 allocated for livestock watering (AENV, 2009c). Based on historical water usage data from 1993-2003, the Town of McLennan uses only about 67% of the water allocated for its use.

The West Prairie River has the most surface water allocated within the sub-basin, 1,038,680 m3 (AENV, 2009c). Of this, 863,440 m3 is allocated to supply the Town of High Prairie, 156,040 m3 for agricultural use both irrigation and livestock watering and the remaining 19,200 m3 is for recreational use supplying a golf course. Historical data from 1998-2008 shows the Town of High Prairie uses approximately 81% of its allocated water, 94% of which is treated and returned to the river (AENV, 2009c).

Surface water allocated from the East Prairie River is used for both municipal and agricultural use; supplying the East Prairie Metis Settlement and livestock watering. A total of 113,560 m3 of water are allocated, the majority of which 100,000 m3 is for municipal use (AENV, 2009c).

There are 95 water licenses within the South Heart/East and West Prairie River sub-basin for ground water withdrawal. The majority of these, 82, are registries for private household wells where water use is not tracked. The remaining licenses for ground water are for livestock watering, municipal use, wood processing, water supply to remote camps and the oil and gas industry (AENV, 2009c).

4.3 Land Use

4.3.1 Riparian Health

A riparian health assessment using aerial videography was completed on selected portions of the South Heart and West Prairie Rivers in the summer of 2006. The South Heart River was assessed from the South Heart River Dam to its outlet into Lesser Slave Lake, which translates to roughly 90 kilometres (Johns & Hallett, 2009). The riparian areas along the West Prairie River were assessed from its confluence with the South Heart River upstream approximately 16 kilometres. To date, no riparian health assessments have been completed on the East Prairie River.

South Heart River

According to Johns and Hallett (2009), 62% of the riparian areas of the South Heart River are in good condition, 13% in fair condition and 25% in poor condition. The highest scores, healthy, were reached along the Winagami Lake Provincial Park and the lowest scores were observed along channelized sections of the river. Figure 9 and Figure 10 were taken directly from the report and illustrate the current riparian health of the South Heart River.

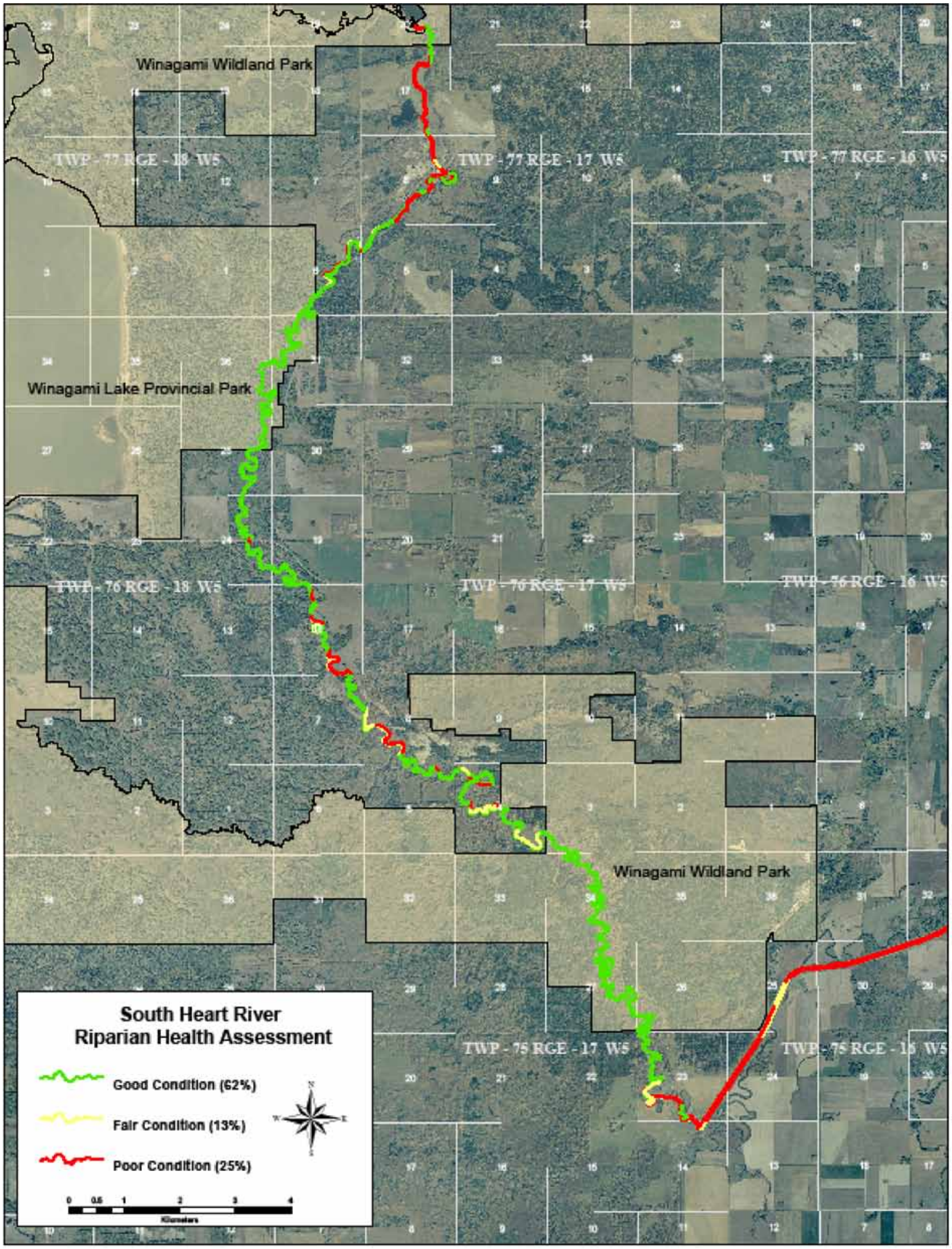


Figure 9: Riparian health scores for the upper section of the South Heart River (Johns & Hallett, 2009)

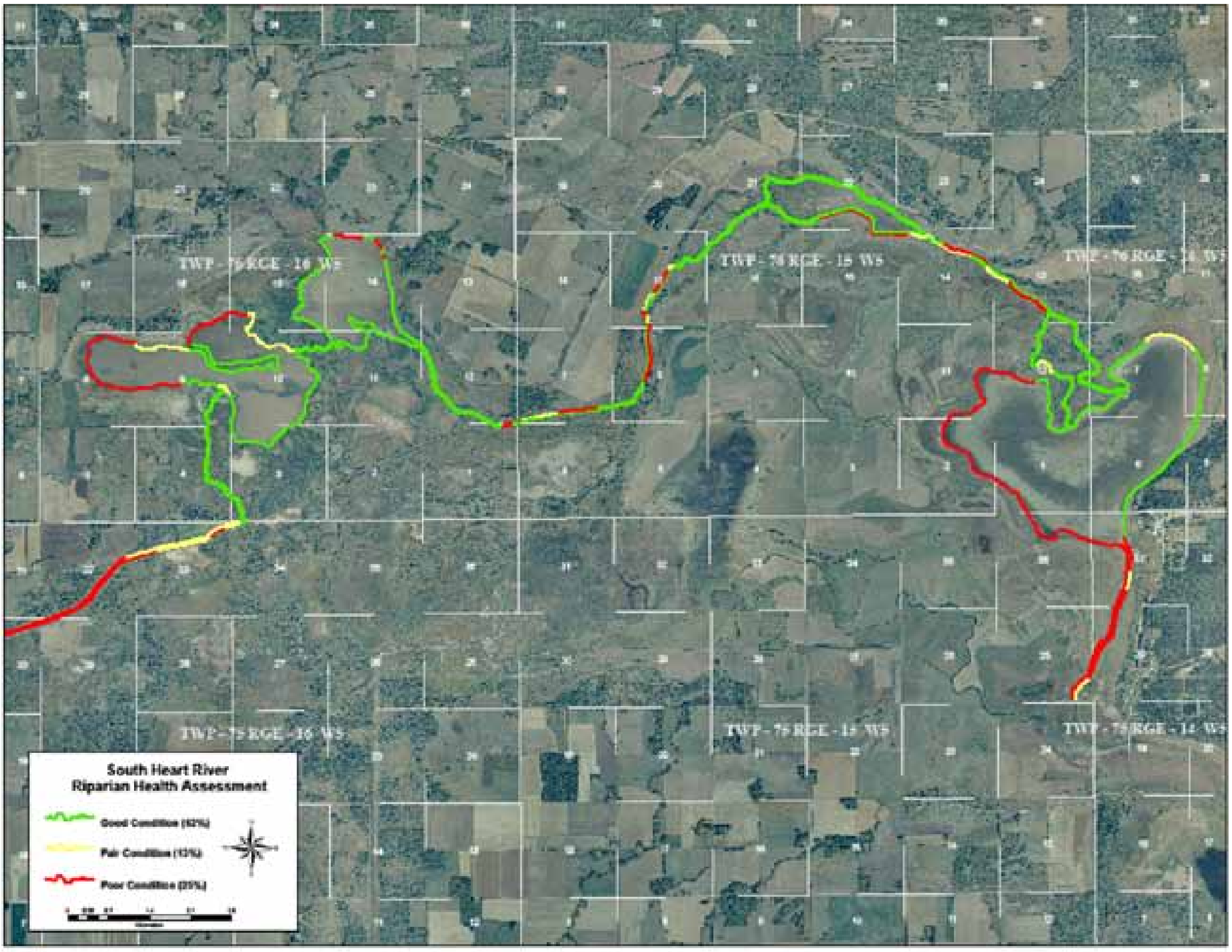


Figure 10: Riparian health scores of the lower section of South Heart River (Johns & Hallett, 2009)

Generally, areas with poor riparian health are attributed to bank erosion, clearing of riparian vegetation for farming, unrestricted cattle access and intensive agricultural practices next to stream banks (Osokin & Hallett, 2007).

West Prairie River

As determined by Johns and Hallett (2009), 43% of the riparian areas adjacent to the West Prairie River are in good condition, 30% are in fair condition and 27% are in poor condition. The channelized portions of the river, portions within the Town of High Prairie and where cultivation occurs alongside the river exhibited the lowest riparian health scores. Figure 11 and Figure 12 from Johns and Hallet's report illustrates the riparian health of both banks.

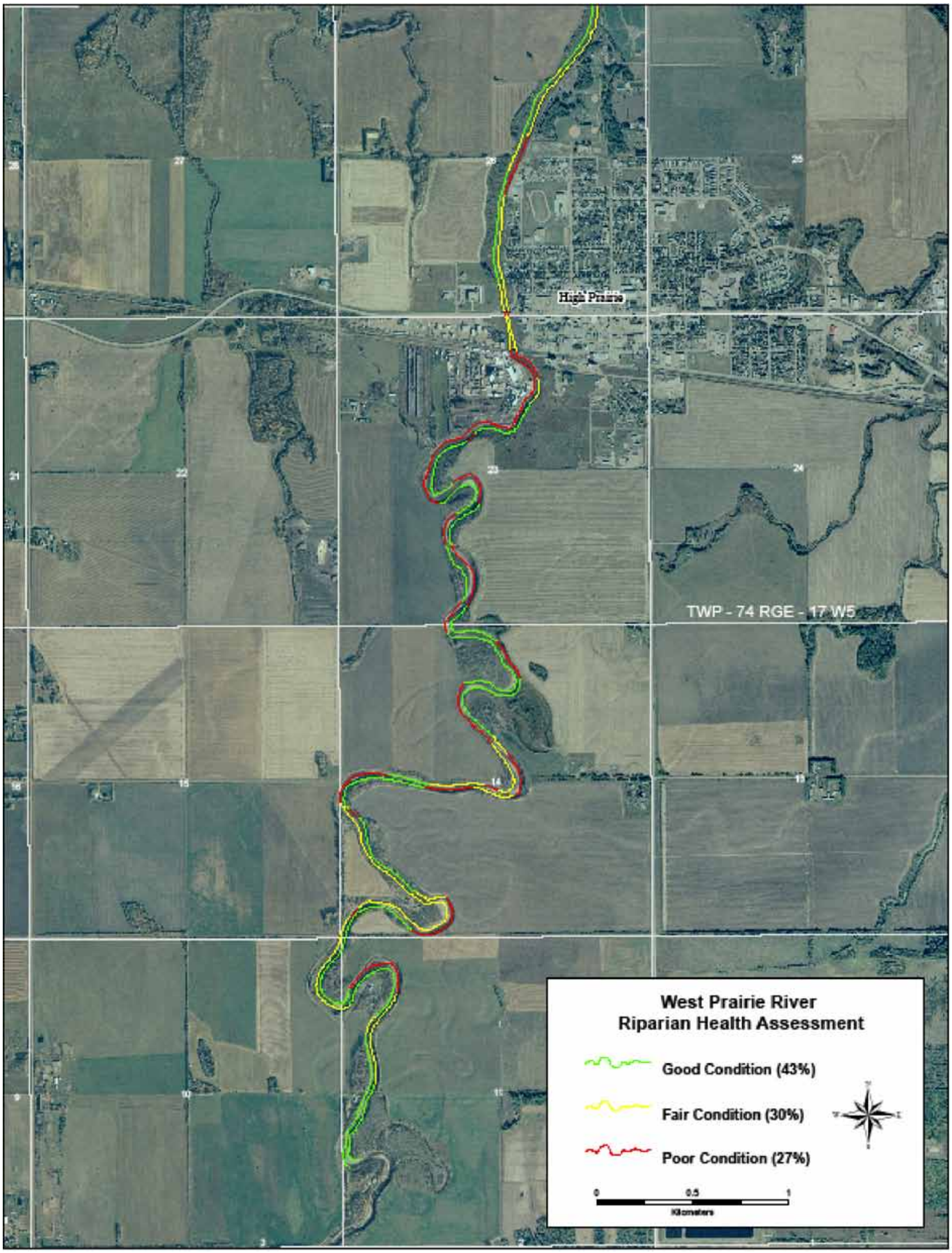


Figure 11: Riparian health scores for the upper section of the West Prairie River (Johns & Hallett, 2009)

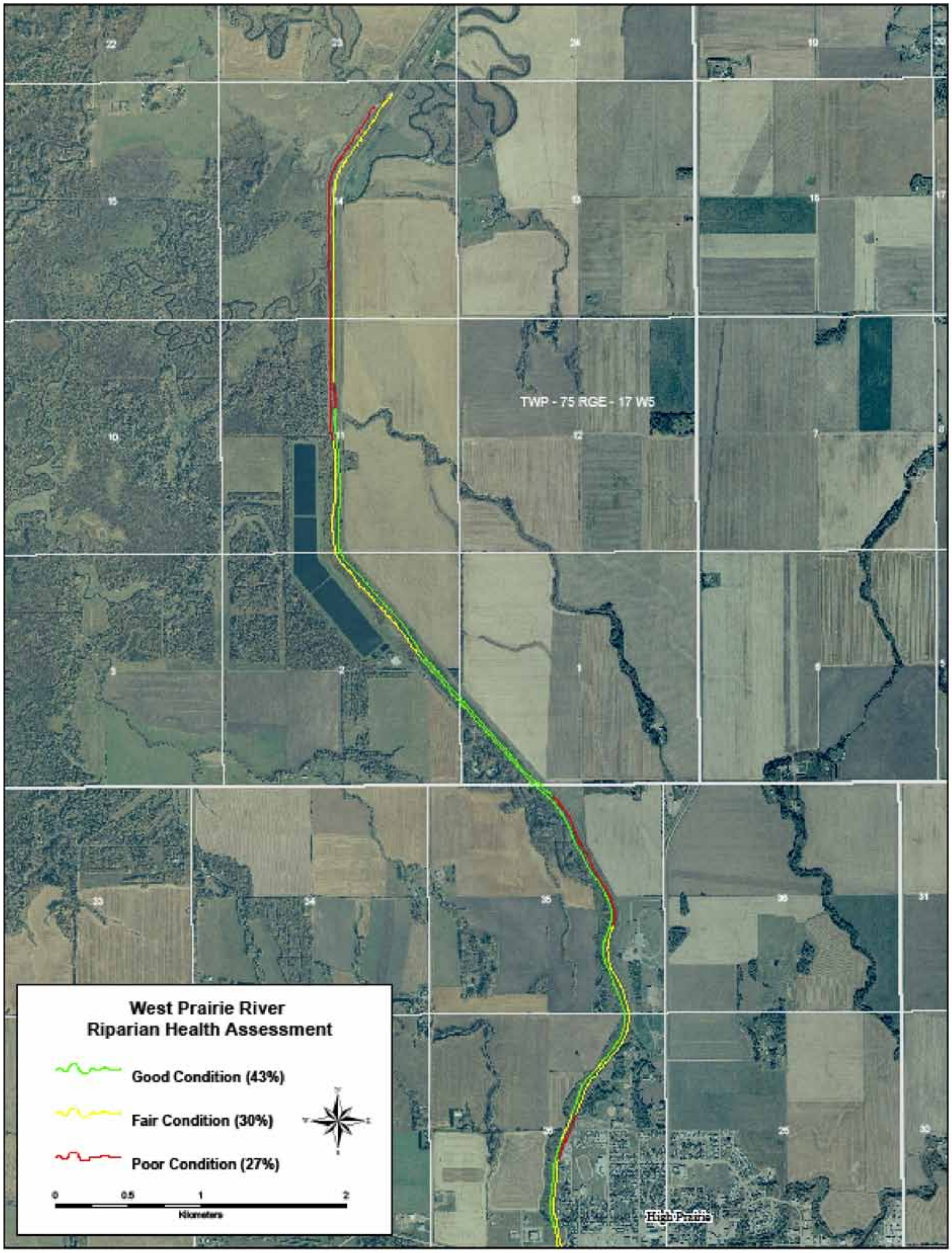


Figure 12: Riparian health scores for the lower section of the West Prairie River (Johns & Hallett, 2009)

4.3.2 Linear Development

Approximately 2.3% of the South Heart/East and West Prairie River sub-basin has been affected by linear disturbance which is the same as the average for the entire Lesser Slave Watershed. However, when the north and south portions are separated into South Heart River (north) and East and West Prairie Rivers (south), the percentages are 2.8% and 1.9% respectively. When separated into the two areas, north and south, the South Heart River shows the highest percentage affected by linear development compared to the entire Lesser Slave Watershed.

4.3.2.1 Stream Crossings

The South Heart/East and West Prairie River sub-basin has the largest number of stream crossings by linear features per stream kilometre than any other sub-basin within the watershed. For every kilometre of stream within the sub-basin there are 1.49 crossings, ranking it as 'high' risk. The crossing type can be viewed in Table 15. The number of road crossings per stream kilometre within the sub-basin is the second highest in the watershed at 0.14 (ASRD, 2005a).

Table 15: Breakdown of linear feature stream crossings within the South Heart/East and West Prairie River sub-basin (ASRD, 2005a)

Linear Feature	Total	Crossings/km of Stream	Percent of Total Crossings (%)
Cutlines	8733	1.3063	87.51
Pipelines	241	0.0361	2.42
Powerlines	52	0.0078	0.52
Railroads	29	0.0043	0.29
Roads	924	0.1382	9.26
Summary	**9979**	**1.4927**	**100**

4.3.3 Land Use Inventory

The South Heart/East and West Prairie River sub-basin contains the majority of land used for agricultural production within the Lesser Slave Watershed. Agriculture in this area consists of a combination of livestock grazing and crop land; however, there is currently no accurate inventory of the area under agricultural uses within the sub-basin. In addition to private lands managed for agricultural production, there are areas of crown land that are being managed as Provincial Grazing Leases for livestock grazing. The Government of Alberta has also set aside 28,204 acres of land as the High Prairie Provincial Grazing Reserve, which is managed for summer livestock grazing (ASRD, 2009f). Currently, there are 10,300 acres of developed fenced pasture within the grazing reserve; primarily in the western portion of the reserve since there is a large muskeg located in the centre of the reserve. The remaining land is available for other uses (ASRD, 2009f).

Land designated as park or protected area makes up approximately 3% of the sub-basin as outlined in Table 16. The majority of the protected areas are surrounding Winagami Lake and the South Heart River.

Table 16: Parks and protected areas within the South Heart/East and West Prairie River sub-basin

Name	Provincial Designation	Size (ha)	% of Sub-basin
Winagami Lake	Provincial Park	6,542.28	0.95
Winagami	Wildland Provincial Park	12,666.63	1.84
Heart River Dam	Provincial Recreation Area	17.61	0
Goose Mountain	Ecological Reserve	1,246.48	0.18
Police Point	Natural Area	312.26	0.05
Total		**20,785**	**3.02**

In the northern reaches of the sub-basin, there are four Forest Management Units (FMU) being managed to meet sustainable forest management principles. These include S16, which is managed by the province, S19 is managed by Tolko Industries, S21 is managed jointly by Gordon Buchanan Enterprises and Tolko Industries, and P3 which is managed by Daishowa-Marubeni International Ltd (DMI). In the southern half of the sub-basin there are also four Forest Management Unit's; S16 is managed by the province, S20 is managed by Slave Lake Pulp Corporation, S21 is managed jointly by Gordon Buchanan Enterprises and Tolko Industries and a small portion of W13, managed by Millar Western, falls within the sub-basin.

Detailed Forest Management Plans have been developed and approved for each FMU, except for S16, that establish the goals and objectives of forest management, including the protection of wildlife, water quality and water quantity. The forest industry is also required to develop operational plans that detail how higher level objectives will be achieved at the operational level. A key component of the forest management planning process is continuous improvement, which requires monitoring of the objectives, to ascertain if they are being achieved, and to make recommendations on how to improve performance in the future.

Oilfield activity. Photo by Ron Davis.

Oil and gas activity within the South Heart/East and West Prairie River sub-basin is quite active with 3,132 well sites (both active and abandoned). The density of oil and gas well sites within the sub-basin is one for every 219 hectares, which is less dense than the average for the entire Lesser Slave Watershed. However, in addition to the surface disturbance of the well itself there are typically associated disturbances such as access, pipelines and powerlines with each site.

There is very little urban development within the sub-basin, with the largest community being the Town of High Prairie, with a population of 2,750 people (Statistics Canada, 2006). Other communities include Enilda, Grouard and the Peavine, Gift Lake, and East Prairie Metis Settlements.

4.3.4 Livestock Density

Within the South Heart/East and West Prairie River sub-basin there are 140 quarter sections that house livestock (ASRD, 2009g). These areas have fairly even distribution over the middle half of the sub-basin, on either side of Highway 2. The area these operations cover is 113.36 square kilometres, which as a percentage of the total basin area is 1.65%, posing a moderate threat to watershed health (Table 17).

Table 17: South Heart/East and West Prairie River sub-basin Livestock Density (ASRD, 2009g)

Sub-basin Name	Area with Livestock (km2)	As Percent of Total Basin Area (%)	Rating
South Heart River/East & West Prairie Rivers	113.36	1.65	MEDIUM RISK
South Heart River (north)	28.65	0.86	LOW RISK
East and West Prairie Rivers (south)	84.71	2.38	HIGH RISK

In relation to the rest of the watershed, there is a high risk of livestock density negatively impacting watershed health in the East and West Prairie River (south) sub-basin. Data on the numbers of livestock housed on each quarter section was unavailable.

4.3.5 Wetland Inventory

There is no recent data on the location and extent of wetland cover within the South Heart/East and West Prairie River sub-basin available. This data gap should be addressed in future studies.

4.4 Biological Indicators

4.4.1 Fish Populations

Portions of the sub-basin have been sampled quite extensively while others have very little available data. There are records of 14 species of fish within the sub-basin (Table 18) including arctic grayling, brook stickleback, burbot, emerald shiner, finescale dace, lake chub, lake whitefish, longnose sucker, northern pike, spottail shiner, yellow perch, walleye, white sucker and pearl dace (ASRD, 2009a).

Table 18: Fish species within the South Heart/East and West Prairie River sub-basin (ASRD, 2009a)

Common Name	Scientific Name
Arctic Grayling	*Thymallus arcticus*
Brook Stickleback	*Culaea inconstans*
Burbot	*Lota lota*
Emerald Shiner	*Notropis atherinoides*
Finescale Dace	*Phoxinus neogaeus*
Lake Chub	Couesius plumbeus
Lake Whitefish	*Coregonus clupeaformis*
Longnose Sucker	*Catostomus catostomus*
Northern Pike	*Esox lucius*
Spottail Shiner	*Notropis husdonius*
Yellow Perch	*Perca flavescens*
Walleye	*Sander vitreus*
White Sucker	*Catastomus commersoni*
Pearl Dace	*Margariscus margarita*

The upper reaches of the West Prairie River are not well sampled but records do show presence of brook stickleback (ASRD, 2009a). Blue Lake located near the headwaters of the West Prairie River, has been stocked with rainbow trout for a number of years. Stocking records for 2000, 2003, 2006 and 2007 were available and show 26,000 fish introduced in 2000, 26,000 in 2003, 13,000 in 2006 and 13,000 in 2007 (ASRD, 2009a). Considerably more sampling has been done in the lower West Prairie mainstem and tributaries. Fish species collected include brook stickleback, lake chub, longnose sucker, white sucker, northern pike, walleye, pearl dace and finescale dace.

Fish species collected in the upper reaches of the East Prairie River mainstem and tributaries include arctic grayling, brook stickleback, lake chub, and longnose sucker (ASRD, 2009a). A few records on habitat were also available and describe portions of the river as having abundant pools, abundant woody debris with log jams in places, sparse terrestrial canopy and some cobble/gravel bars (ASRD, 2009a). A tributary to the East Prairie, Bruce Creek, was reported as having good flow with high banks, diverse habitat with cobble substrate and good potential for arctic grayling habitat (ASRD, 2009a). The lower portions of the East Prairie River are slow moving with a relatively flat gradient with mostly shallow runs and some deeper runs and pools, slumping and bank undercutting were observed in some sections (ASRD, 2009a). The same species occur in this portion of the drainage with the addition of emerald shiner, white sucker, burbot, and northern pike (ASRD, 2009a).

The upper reaches of the South Heart River have very limited data; at the few locations sampled no fish were caught (ASRD, 2009a). Downstream, just north of the South Heart Dam, there are records of brook stickleback, northern pike and white sucker. Near the dam, walleye and yellow perch have also been observed (ASRD, 2009a).

Winagami Lake is a very shallow, marshy lake with depths averaging 1.7 meters; the lakes maximum depth is 4.7 meters (Mitchell & Prepas, 1990). The shoreline is mostly vegetated with a sandy beach on the east side. Fish species within the lake include lake whitefish, northern pike, spottail shiner, walleye, white sucker and yellow perch (ASRD, 2009a).

Grouard Channel. Photo by Ron Davis.

Buffalo bay is connected to Lesser Slave Lake via the Grouard Channel. The bay contains many of the same species found in the lake including burbot, lake whitefish, longnose sucker, northern pike, walleye, white sucker and yellow perch (ASRD, 2009a). In 2003 and 2004, radio transmitters were implanted into 89 adult walleye in an effort to increase the knowledge of spawning locations and migration patterns in the Horse Lake-Buffalo Bay complex and western end of Lesser Slave Lake (Osokin & Tchir, 2006). The data collected during this study seems to indicate that walleye have shifted the location of their spawning from historical locations such as the Horse Lakes outlet channel and Mullen's farm to new spots (Osokin & Tchir, 2006). Additional data collection is needed to confirm this inference. The lower South Heart River continues to be important habitat for spawning walleye. The Horse Lakes complex upstream of Buffalo Bay has recorded high numbers of forage fish and based on the 2003/04 walleye study appears to be an important feeding area and/or rearing area for walleye (Osokin & Tchir, 2006).

5.0 Driftpile River Sub-basin

Driftpile River. Photo by Meghan Payne.

The Driftpile River sub-basin is located on the south side of Lesser Slave Lake; its northern edge borders the lake (Figure 13). The Driftpile River originates in the Swan Hills and flows north into Lesser Slave Lake, entering the lake on the west edge of Giroux Bay. The sub-basin drains an area of approximately 1,429 square kilometres (km^2). The Little Driftpile River, Yellowstone Creek, Mabel Creek and many smaller tributaries flow into the Driftpile River. Arcadia Creek also drains a portion of the basin and flows into the west end of Lesser Slave Lake.

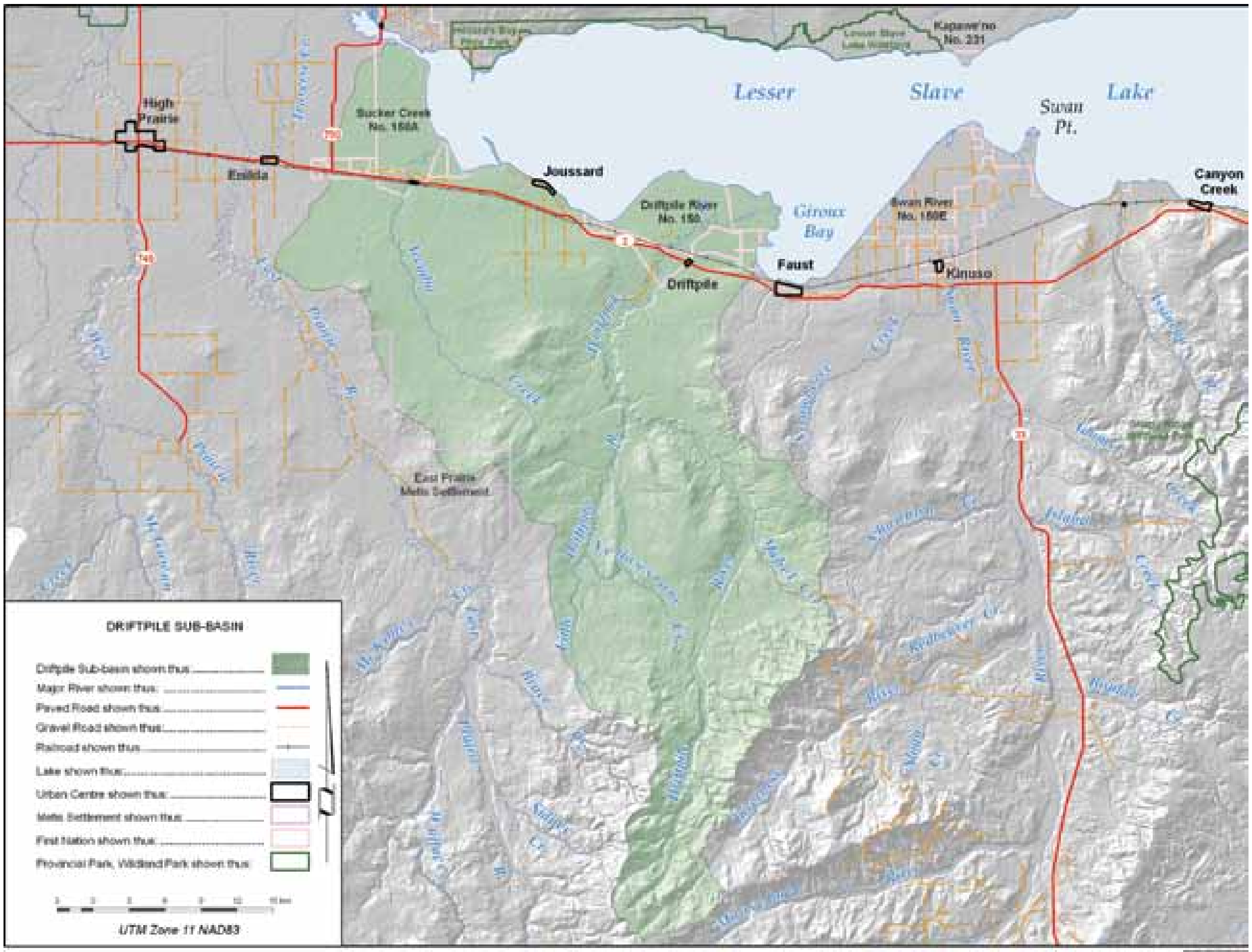


Figure 13: Overview of the Driftpile River sub-basin

The Driftpile River sub-basin occurs within the four natural sub-regions of Alberta that are present within the watershed; the upper foothills, lower foothills, central mixedwood and dry mixedwood. The southern tip of the sub-basin, the headwaters of the Driftpile River, is within the upper foothills. This region is characterized by strongly rolling to steep terrain (NRC, 2006). The growing conditions favour conifers and the area is predominately lodgepole pine forest with a black spruce understory or balsam fir. Stands of white spruce can be found along the edge of rivers and mixed wood or deciduous stands occur on south and west facing slopes (NRC, 2006). The lower foothills occur in the middle of the sub-basin and extend towards the lake along the west and east boundaries. This area is characterized by rolling and undulating hills with mixedwood forests made up of a combination of the following species; aspen, balsam poplar, white birch, lodgepole pine, black spruce, white spruce, balsam fir and tamarack (NRC, 2006). The eastern half of the remaining portion of the sub-basin is within the central mixedwood sub-region. This area is characterized by a mix of aspen dominated deciduous stands, aspen-white spruce mixedwood and white spruce or jackpine dominant stands (NRC, 2006). The dry mixedwood sub-basin occurs west of this area and is characterized by aspen forests with prickly rose, low-bush cranberry, beaked hazelnut and Canada buffaloberry understory (NRC, 2006) and is quite good for agriculture.

There are portions of two environmentally significant areas (ESA's) within the Driftpile River sub-basin; one internationally and one provincially significant. The Lesser Slave Lake and surrounding riparian zone are considered internationally significant and the area surrounding the headwaters of the Driftpile River, in the Swan Hills, is provincially significant. The selection of ESA's is based on seven criteria, areas that contain conservation concerns, rare or unique landforms, habitat for focal species, important wildlife habitat, riparian areas, large natural areas and other sites of recognized significance (Fiera, 2009). ESA's are used as a "decision support tool for land use planning" within Alberta over the long term (Fiera, 2009).

The majority of the communities within the sub-basin are located along Highway 2 and the south shore of Lesser Slave Lake. These include Joussard and the First Nation communities of Driftpile First Nation and Sucker Creek First Nation. A small portion of the East Prairie Metis Settlement is also located within the sub-basin.

5.1 Water Quality

5.1.1 River Water Quality Index

There is insufficient water quality sampling data to calculate the River Water Quality Index for this sub-basin. This data gap should be addressed in future water quality studies.

5.1.2 *Escherichia coli*

To date, there is no data on counts of *Escherichia coli* within the Driftpile River sub-basin. This data gap should be addressed in future water quality studies.

5.1.3 Nutrient Budget

Currently, data on total nitrogen and phosphorus within the Driftpile River sub-basin is at least 10 years old. This data gap should be addressed in future water quality monitoring.

5.1.4 Sediment Contamination

The Driftpile River is a major contributor of sediment entering Lesser Slave Lake within the watershed (Choles, 2004; AMEC, 2005) and has deposited a delta within the lake. On average 337,000 tonnes of sediment are transported annually into the lake by the Driftpile River (Table 19). The upper reaches of the Drifpile River have a high carrying capacity for sediment based on slope and flow velocity of this section. Flow velocity is reduced as the river transitions into the lower reaches on the plain near the lake and in turn, carrying capacity is reduced, resulting in channel deposition, aggradation, and potential flooding (AMEC, 2005).

Table 19: Seasonal total suspended sediment loads for Driftpile River (AMEC, 2005)

River Channel	Seasonal Total Suspended Sediment Load (tonnes/year)		
	Minimum	**Mean**	**Maximum**
Driftpile River	12,500	337,000	960,000

Based on analysis of historical aerial photos, the Driftpile River delta has advanced approximately 625 meters into Lesser Slave Lake over the past 53 years (AMEC, 2005).

5.2 Water Quantity

The Driftpile River sub-basin contributes almost twice the amount of runoff to Lesser Slave Lake compared to the size of its catchment area, 12% and 7% respectively (Seneka, 2002). This can be attributed to the proportionately larger amount of precipitation in the Swan Hills area, near the headwaters of the Driftpile River and the steep gradient of the upper portions of the river channel. Seasonal mean discharge for the Driftpile River is outlined in Table 20.

Table 20: Mean and total annual discharges at streamflow monitoring stations in the Driftpile River sub-basin (AMEC, 2005)

Station	Station Name	Period of Record	Station Operation	Mean Discharge (m3/s)	Average Total Discharge (dam3)*
07BH003	Driftpile River near Driftpile	1972-1986	Seasonal	8.42	166,300

*1 dam^3 = 1000 m^3

5.2.1 Water Allocation

Compared to other sub-basins there are very few water licenses within the Driftpile River sub-basin; 22 for surface water and 2 for ground water. Most of the water licences for surface water are registries for private household wells or livestock watering as are both groundwater licenses. The remaining surface water licenses are for flood control and minor diversions for transportation; these licenses do not consume any water. The total volume of surface and ground water allocated within the sub-basin is 9,543 m^3 and 6,250 m^3, respectively (AENV, 2009c).

5.3 Land Use

5.3.1 Riparian Health

Presently, no studies have been completed on the health of riparian areas within the Driftpile River sub-basin. This data gap should be addressed in future studies.

5.3.2 Linear Development

Linear development within the Driftpile sub-basin, as a percentage of the basin area, is the lowest within the Lesser Slave Watershed. Approximately 1.3% of the basin has been disturbed through linear disturbance; receiving a 'good' rating.

5.3.2.1 Stream Crossings

The Driftpile River sub-basin has the lowest number of stream crossings by linear features per stream kilometre than any other sub-basin within the watershed. For every kilometre of stream within the sub-basin there are 1.15 crossings, ranking it as 'low' risk. The crossing type can be viewed in Table 21. The number of road crossings per stream kilometre within the sub-basin is the second lowest in the watershed at 0.10 (ASRD, 2005a).

Table 21: Breakdown of linear feature stream crossings within the Driftpile River sub-basin (ASRD, 2005a)

Linear Feature	Total	Crossings/km of Stream	Percent of Total Crossings (%)
Cutlines	1663	0.9905	86.03
Pipelines	48	0.0286	2.48
Powerlines	31	0.0185	1.60
Railroads	21	0.0125	1.09
Roads	170	0.1012	8.79
Summary	**1933**	**1.1513**	**100**

5.3.3 Land Use Inventory

The majority of agricultural land within the Driftpile River sub-basin is located near Lesser Slave Lake, within approximately 12 kilometres of the lakes shoreline. Though this area is designated as white zone, there are significant areas of crown land that have not been cleared for agricultural production. However, there are no Provincial Parks or Protected Areas within the Driftpile River sub-basin.

The upper reaches of the sub-basin are designated as green zone. The majority of this land is within Forest Management Unit (FMU) S20, and is managed under a Forest Management Agreement held between the province and Slave Lake Pulp Corporation. The FMU is operated by Slave Lake Pulp as the FMA holder, and Alberta Plywood, Millar Western, Gordon Buchanan, Lakeshore Timber and Vanderwell Contractors are quota holders within the FMA.

There is slightly less oil and gas activity in the Driftpile River sub-basin than elsewhere in the watershed with 317 well sites. The density of oil and gas sites within the sub-basin is one for every 450 hectares, which is the lowest density found in any of the sub-basins in the Lesser Slave Watershed. In addition to the well site itself there are typically associated disturbances with each site, such as access, pipelines and powerlines.

There are no major urban areas within the Driftpile River sub-basin. The community of Joussard is located in the sub-basin, as are the First Nation communities of Sucker Creek and Driftpile. The majority of the urban development is located between Highway 2 and the shoreline of Lesser Slave Lake.

5.3.4 Livestock Density

Within the Driftpile River sub-basin there are eight quarter sections that house livestock (ASRD, 2009g), all of which are located in relatively close proximity to Highway 2. The area these operations cover is approximately 5.08 square kilometres, which as a percentage of the total sub-basin area is quite low, 0.36%. Based on the available data, there is a very low risk that livestock operations will have a large affect on the health of the Driftpile River sub-basin. However, more data should be collected for livestock operation in close proximity to watercourses and waterbodies. In addition to livestock operations on the landbase, there is one feedlot located within the sub-basin. Feedlots can require large quantities of water for livestock watering and careful management of the wastes produced.

5.3.5 Wetland Inventory

There is no recent data on the location and extent of wetland cover within the Driftpile River sub-basin. This data gap should be addressed in future studies.

5.4 Biological Indicators

5.4.1 Fish Populations

There is very limited data on fish populations within the Driftpile River sub-basin. There are eight species of fish that have been collected within the sub-basin (Table 22) including arctic grayling, burbot, lake chub, lake whitefish, longnose sucker, northern pikeminnow, yellow perch and white sucker (ASRD,2009a). Population dynamics within the sub-basin are unknown at this time.

Table 22: Fish species within Driftpile River sub-basin (ASRD, 2009a)

Common Name	Scientific Name
Arctic Grayling	*Thymallus arcticus*
Burbot	*Lota lota*
Lake Chub	Couesius plumbeus
Lake Whitefish	*Coregonus clupeaformis*
Longnose Sucker	*Catostomus catostomus*
Northern Pikeminnow	*Esox lucius*
Yellow Perch	*Perca flavescens*
White Sucker	*Catostomus commersoni*

6.0 Swan River Sub-basin

The Swan River sub-basin is located on the south side of Lesser Slave Lake; its northern boundary borders the lake (Figure 14). As the name suggests, the Swan River originates in the Swan Hills and enters Lesser Slave Lake at Swan Point, just east of the narrows. The sub-basin drains an area of approximately 2,818 square kilometres (km^2). The main tributaries contributing to the drainage of the basin are the Moosehorn and Inverness Rivers while there are many smaller tributaries including Sloan Creek, Boulder Creek, Redbeaver Creek, Island Creek, Shannon Creek and Adams Creek. The Assineau River, Mooney Creek and Strawberry Creek all flow directly into the lake and drain portions of the sub-basin.

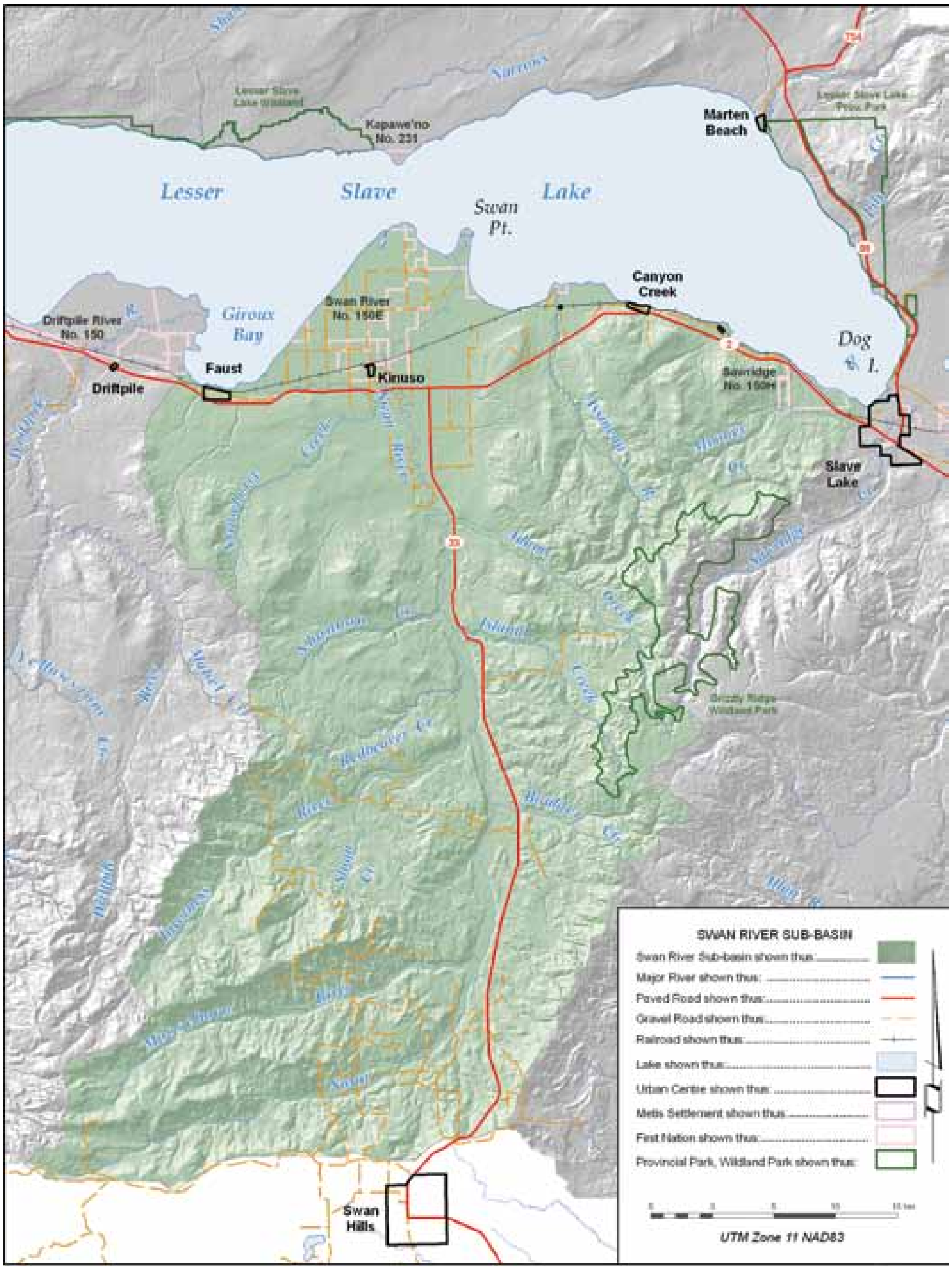


Figure 14: Overview of the Swan River sub-basin

The Swan River sub-basin occurs within three of Alberta's natural sub-regions; the upper foothills, lower foothills and central mixedwood. The upper foothills comprise the southern third of the sub-basin in the Swan Hills area. This region is characterized by strongly rolling to steep terrain (NRC, 2006). The growing conditions favour conifers and the area is predominately lodgepole pine forest with a black spruce understory or balsam fir. Stands of white spruce can be found along the edge of rivers and mixed wood or deciduous stands occur on south and west facing slopes (NRC, 2006). The lower foothills occur in the middle third of the sub-basin and are characterized by rolling and undulating hills with mixedwood forests made up of a combination of the following species; aspen, balsam poplar, white birch, lodgepole pine, black spruce, white spruce, balsam fir and tamarack (NRC, 2006). The northern third of the sub-basin, closest to Lesser Slave Lake, is within the central mixedwood sub-region. This area is characterized by a mix of aspen dominated deciduous stands, aspen-white spruce mixedwood and white spruce or jackpine dominant stands (NRC, 2006).

There are portions of four environmentally significant areas (ESA's) within the sub-basin; the riparian area surrounding Lesser Slave Lake is recognized as being internationally significant, while the other three are provincially significant. The provincially significant areas are located along the southern and eastern boundaries of the sub-basin and contain important headwaters, wildlife habitat and vegetative species. The selection of ESA's is based on seven criteria, areas that contain conservation concerns, rare or unique landforms, habitat for focal species, for example, grizzly bears, important wildlife habitat, riparian areas, large natural areas and other sites of recognized significance (Fiera, 2009). ESA's are used as a "decision support tool for land use planning" within Alberta over the long term (Fiera, 2009).

There are two parks within the Swan River sub-basin totalling approximately 72 km^2 or 2.6% of the sub-basin. Parks within the sub-basin include approximately 2/3 of Grizzly Ridge Wildland Provincial Park and Edith Lake Provincial Recreation Area.

All of the communities within the sub-basin are either along Highway 2 or the south shore of Lesser Slave Lake. These include Faust, Kinuso, Canyon Creek, Widewater and Wagner. The Swan River First Nation community and a portion of the Sawridge Band reserve are also within the sub-basin.

6.1 Water Quality

6.1.1 River Water Quality Index

There is insufficient water quality sampling data to calculate the River Water Quality Index for this sub-basin. This data gap should be addressed in future water quality studies.

6.1.2 *Escherichia coli*

To date, there is no data on counts of *Escherichia coli* within the Swan River sub-basin. This data gap should be addressed in future water quality studies.

6.1.3 Nutrient Budget

Currently, data on total nitrogen and phosphorus within the Swan River sub-basin is at least 10 years old. This data gap should be addressed in future water quality monitoring.

6.1.4 Sediment Contamination

The Swan River is a major contributor of sediment entering Lesser Slave Lake within the watershed (Choles, 2004; AMEC, 2005) and has deposited a substantial delta within the lake. On average 538,000 tonnes of sediment are transported annually into the lake by the Swan River (Table 23). The upper reaches of the river have a high carrying capacity for sediment based on slope and flow velocity of this section. Flow velocity is reduced as the river transitions into the lower reaches on the plain near Lesser

Slave Lake and in turn, carrying capacity is reduced, resulting in channel deposition, aggradation, and potential flooding (AMEC, 2005). Potential for sedimentation in the sub-basin is heightened by the high density of crossings, especially road crossings, per kilometre of stream (see section 6.3.2.1). Tchir *et al.* (2004) found that 19% of culvert crossings and 36% of bridge crossings had a high potential to contribute sedimentation to the watercourse that they crossed.

Table 23: Annual total suspended sediment loads for Swan River (AMEC, 2005)

River Channel	Annual Total Suspended Sediment Load (tonnes/year)		
	Minimum	**Mean**	**Maximum**
Swan River	28,600	538,000	2,800,000

The location where the Swan River enters Lesser Slave Lake has changed over the years. Prior to channel cutoffs constructed to reduce flooding in the area the river entered the lake at the northern tip of Swan Point with a north-easterly direction of discharge (AMEC, 2005). After the cutoffs were completed the river mouth shifted to the northwest side of the delta. Based on an analysis of historical aerial photos, the Swan River delta has advanced approximately 400 meters over the last 21 years (1982-2003) while the old delta has retreated approximately 200 meters (AMEC, 2005). Some of the new delta formation and part of the increased rate of formation may be due to littoral drift of sediment from the old delta.

6.2 Water Quantity

The Swan River sub-basin contributes almost twice the amount of runoff to Lesser Slave Lake compared to the size of its catchment area, 28% and 15% respectively (Seneka, 2002). This can be attributed to the proportionately larger amount of precipitation in the Swan Hills area, near the headwaters of the Swan River and the steep gradient of the upper portions of the river channel. Annual mean discharge for the Swan River is outlined in Table 24.

Table 24: Mean and total annual dischages in the Swan River (AENV, 2010)

Station	Station Name	Period of Record*	Station Operation	Mean Discharge (m3/s)	Average Total Discharge (dam3)**
07BJ001	Swan River near Kinuso	1915-1917 1961-2009	Seasonal to 1970 Annual since 1970	13.1	407,540

*only data until 2008 was used for calculations
**1 dam^3 = 1000 m^3

6.2.1 Water Allocation

All of the surface water allocation licenses within the Swan River sub-basin are for oilfield injection, with the exception of a license to withdraw water from Strawberry Creek for the service station on Highway 2. Water is used in oilfield injection to fill void spaces in the reservoir and increase the pressure to stimulate oil production. Total licensed allocation from the Swan River is 4,317,185 m^3 (AENV, 2009c). As outlined in Table 25, actual water used for oilfield injection is much lower than allocated by the licenses.

Table 25: Oilfield injection water allocation and use in the Swan River Sub-basin (AENV, 2009c)

Company	Total Licensed Allocation (m3)	Water Used (2008)		Average Use (1998-2008) (m3)
		(m3)	Percent of total allocation	
Pengrowth Corporation (formerly Conoco Philips)	259,035	74,856	29%	95,568*
Devon Canada (formerly Home Oil)	3,947,140	668,229	17%	976,981**
PennWest Petroleum	111,010	55,966	50%	20,075***

*2006-2007=no data
**2002-2003=no water used, 2004=no data
***1999-2002=no water used

Under the Alberta Environment guidelines, Water Conservation and Allocation Guidelines for Oilfield Injection (2006), policy requests permanent water license holders for oilfield injection to voluntarily review their use of non-saline water to promote conservation and alternatives. Holders are also encouraged to cancel or reduce their existing permanent licenses. Since the year 2000, Devon Canada has not diverted any water directly from the Swan River and instead has been using a man-made reservoir for its water needs (R. Davis, AENV, pers. comm.). Devon would like to maintain their pumping facility on the Swan River in case additional water is required in the future. In order to restore fish passage that was blocked by the water impoundment weir, in 2005 the pumping facility was scaled back and a spillway was installed (R. Davis, AENV, pers. comm.). Over the past 15 years, PennWest Petroleum has only withdrawn water directly from the Swan River once (1998). A man-made reservoir that stores surface water is utilized to supply the water required for PennWest's operations (R. Davis, AENV, pers. comm.).

In the future when existing licenses are up for renewal or new water licenses are applied for, Alberta Environment will assess the application using the desktop instream flow needs (IFN) method. Furthermore, withdrawals from the Swan River will be prohibited when river flows fall below weekly IFN values (R. Davis, AENV, pers. comm.).

In addition to the surface water licenses within the Swan River sub-basin there are 38 licenses for ground water withdrawal. Most of these are private water wells at rural households which are not regulated by the *Water Act*; 31,700 m^3 is allocated but actual water usage is unknown. The remaining ground water licenses are for livestock watering and natural gas processing (AENV, 2009c).

6.3 Land Use

6.3.1 Riparian Health

Presently, no studies have been completed on the health of riparian areas within the Swan River sub-basin. However, a riparian health assessment for portions of the Swan River is planned for the summer of 2010 by the Alberta Conservation Association and the Lesser Slave Watershed Council.

6.3.2 Linear Development

Linear development within the Swan River sub-basin affects approximately 2.3% of the total area. The sub-basin receives a rating of 'fair'.

6.3.2.1 Stream Crossings

For every kilometre of stream within the Swan River sub-basin there are 1.24 crossings, giving the sub-basin a ranking of 'medium' risk. Numbers and crossing types can be viewed in Table 26. The number of road crossings per stream kilometre within the sub-basin is the highest in the watershed at 0.19 (ASRD, 2005a).

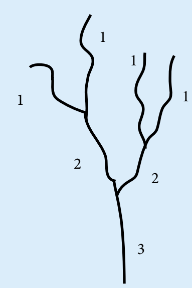
Table 26: Breakdown of linear feature stream crossings within the Swan River sub-basin (ASRD, 2005a)

Linear Feature	Total	Crossings/km of Stream	Percent of Total Crossings (%)
Cutlines	3,562	0.8414	67.69
Pipelines	777	0.1835	14.77
Powerlines	106	0.0250	2.01
Railroads	30	0.0071	0.57
Roads	787	0.1859	14.96
Summary	**5,262**	**1.2429**	**100**

A quantitative study on stream crossings within the Swan River sub-basin was completed in 2003 (Tchir *et al.*, 2004). Tchir *et al.* used GIS tools coupled with field assessments to document road stream crossing interactions and assess the crossings potential to fragment stream habitat and act as a sediment input source. Culverts were the dominant crossing type within the sub-basin; usually occurring on first, second and third order streams (Tchir *et al.*, 2004). Using field verification data it was determined that 74% of all crossings assessed had potential to act as a barrier and impede fish movement (Tchir *et al.*, 2004). Furthermore, the data suggests that fish populations are unable to access approximately 20% of the upper reaches (headwaters) of the Swan River (Tchir *et al.*, 2004). Habitat fragmentation in the sub-basin is predominately caused by hanging culverts, installation of improper culvert sizes and improper culvert placement (Tchir *et al.*, 2004), all of which can contribute to increased sediment entering streams.

Stream Orders

First order streams have no tributaries, when two first order streams come together they form a second order stream, when two second order streams join they form a third order stream etc.



6.3.3 Land Use Inventory

The majority of agricultural lands within the watershed occur within the northern portion of the Swan River near Lesser Slave Lake, Highway 2 and in the Swan River valley along Highway 33. Agriculture in this area consists of a combination of livestock grazing and crop lands.

Approximately 2.5% of the sub-basin is land designated as park or protected area (Table 27). The majority of the protected area is within the Grizzly Ridge Wildland Provincial Park which contains the headwaters of Island Creek, Adams Creek, Assineau River, and Mooney Creek. This protected area is also important habitat for Grizzly bears, a potential species at risk within Alberta (see section 3.6).

Table 27: Parks within the Swan River sub-basin

Name	Provincial Designation	Size (ha)	% of Sub-basin
Grizzly Ridge*	Wildland Provincial Park	7173.04	2.55
Edith Lake	Provincial Recreation Area	58.22	0
Total		**7231**	**2.55**

*Grizzly Ridge Wildland Provincial Park is a total of 10,706.06 hectares, and was assumed to be 1/3 in the Lesser Slave River sub-basin, and 2/3 in the Swan River sub-basin.

In the upper reaches of the Swan River sub-basin, the majority of land is within Forest Management Unit (FMU) S20, and is managed under a Forest Management Agreement held between the province and Slave Lake Pulp Corporation. The FMU is operated by Slave Lake Pulp Corporation as the FMA holder, and Alberta Plywood, Millar Western, Gordon Buchanan, Lakeshore Timber and Vanderwell Contractors are quota holders. A small portion of FMU W14, managed by Blue Ridge Lumber, occurs along the southern boundary of the Swan River sub-basin.

Oil and gas activity within the Swan River sub-basin is quite active; the Swan Hills area has the third largest oilfield deposit in Canada (LSLCDC, 2003). Currently, there are 2,043 oil and gas well sites and facilities within the sub-basin, equally a density of one for every 138 hectares, which is the highest density compared to other sub-basins within the watershed. In addition to disturbance caused by the well site itself, there are typically associated disturbances with each site, such as access, pipelines and powerlines.

Other industrial development within the Swan River sub-basin includes aggregate (gravel) exploration and excavation. Gravel extraction occurs throughout the sub-basin; in the lower reaches near the shore of Lesser Slave Lake, and in the upper reaches close to the Town of Swan Hills. Conservation and reclamation plans are required for all surface material pits outlining the site conditions prior to development, an operations plan along with protective strategies and reclamation plans of the site after material removal.

There is little urban development within the sub-basin. Most of the urban development is of farms and acreages along the shoreline of Lesser Slave Lake. The hamlets of Faust, Kinuso, Canyon Creek, Widewater and Wagner are within the sub-basin along with the First Nation community of Swan River and a portion of the Sawridge Band reserve.

6.3.4 Livestock Density

Within the Swan River sub-basin there are 35 quarter sections that house livestock (ASRD, 2009g). The majority of these are concentrated along the Swan River, Eula Creek, and Strawberry Creek; basically in the valley created by the Swan River and the delta near Lesser Slave Lake. The land area used by livestock is approximately 21.43 square kilometres, which as a percentage of the total sub-basin area is quite low, 0.76%. Based on the available data, there is a low risk that livestock will have a large affect on the health of the Swan River sub-basin. However, livestock grazing is concentrated in riparian areas and the delta which increases the potential for detrimental effects to watershed health.

6.3.5 Wetland Inventory

There is no recent data on the location and extent of wetland cover within the Swan River sub-basin. This data gap should be addressed in future studies.

6.4 Biological Indicators

6.4.1 Fish Populations

There are 13 native species of fish that have been collected in the Swan River sub-basin (Table 28) including, arctic grayling, burbot, longnose sucker, brook stickleback, white sucker, yellow perch, emerald shiner, longnose dace, flathead minnow and in the lower reaches close to Lesser Slave Lake northern pike, walleye and lake whitefish (ASRD, 2009a).

Table 28: Fish species within Swan River sub-basin (ASRD, 2009a)

Common Name	Scientific Name
Arctic Grayling	*Thymallus arcticus*
Brook Stickleback	*Culaea inconstans*
Burbot	*Lota lota*
Flathead Minnow	
Lake Chub	Couesius plumbeus
Lake Whitefish	*Coregonus clupeaformis*
Longnose Dace	*Rhinichthys cataractae*
Longnose Sucker	*Catostomus catostomus*
Northern Pike	*Esox lucius*
Emerald Shiner	*Notropis atherinoides*
Yellow Perch	*Perca flavescens*
Walleye	*Sander vitreus*
White Sucker	*Catastomus commersoni*

In recent years, fish sampling and habitat assessments were completed on the Assineau River and Mooney Creek drainages. Historically, there is very little data from either of these drainages, however, anglers have stated that arctic grayling was common in both drainages (Osokin, 2004). In 1987, a study was conducted throughout the Assineau River drainage; it determined that there was a small arctic grayling population within the river that was heavily reliant on the headwater portions of the river (Lucko, 1987a). A habitat assessment completed in 2003 determined that 36% of the sampling sites rated high to moderate for rearing potential of arctic grayling and the upper reaches were much more important than the lower reaches (Osokin, 2004). Low flows within the drainage are thought to be a limiting factor. Spawning potential sites for arctic grayling were quite low due to siltation and bank erosion however, some areas had moderate potential (Osokin, 2004). No arctic grayling were caught during the 2003 sampling; lake chub was the most common fish caught followed by burbot and white sucker (Osokin, 2004).

During sampling in 2003 of the Mooney Creek drainage (Osokin, 2004), fish were collected at only 2 of the 18 sampling locations. This can be attributed to low flows, which is the limiting factor on fish presence and suitable fish habitat within the drainage. When flows are higher there is high to moderate rearing potential for arctic grayling within the stream however, spawning potential is more limited (Osokin, 2004).

In addition to the native fish species within the sub-basin, Edith Lake has been stocked with brook trout. Brook trout are a common stocking fish and can withstand lower oxygen concentrations than other trout species (ASRD, 2009h). The Fish and Wildlife Management Information System has stocking records for 2000 and 2002-2007; approximately 2,000 fish were added each year (ASRD, 2009a). The Atlantic Richfield Reservoir is stocked with rainbow trout. Records from 2000-2007 are available. The waterbody was stocked with approximately 7,000 fish in 2000, 3,500 fish annually between 2001 and 2003, and 1,800 fish annually since 2003 (ASRD, 2009a).

7.0 Lesser Slave Lake North Sub-basin

The Lesser Slave Lake North sub-basin is the smallest sub-basin within the watershed, encompassing approximately 1,324 square kilometres (km^2). The major tributaries that drain this area are Shaw Creek, Narrows Creek, Marten Creek and Lily Creek (Figure 15). Shaw Creek enters Lesser Slave Lakes' west basin, Narrows Creek flows into the lake at the Narrows (the division between the west and east basins), Marten Creek and Lily Creek enter the east end of the lake flowing from the Marten Hills.

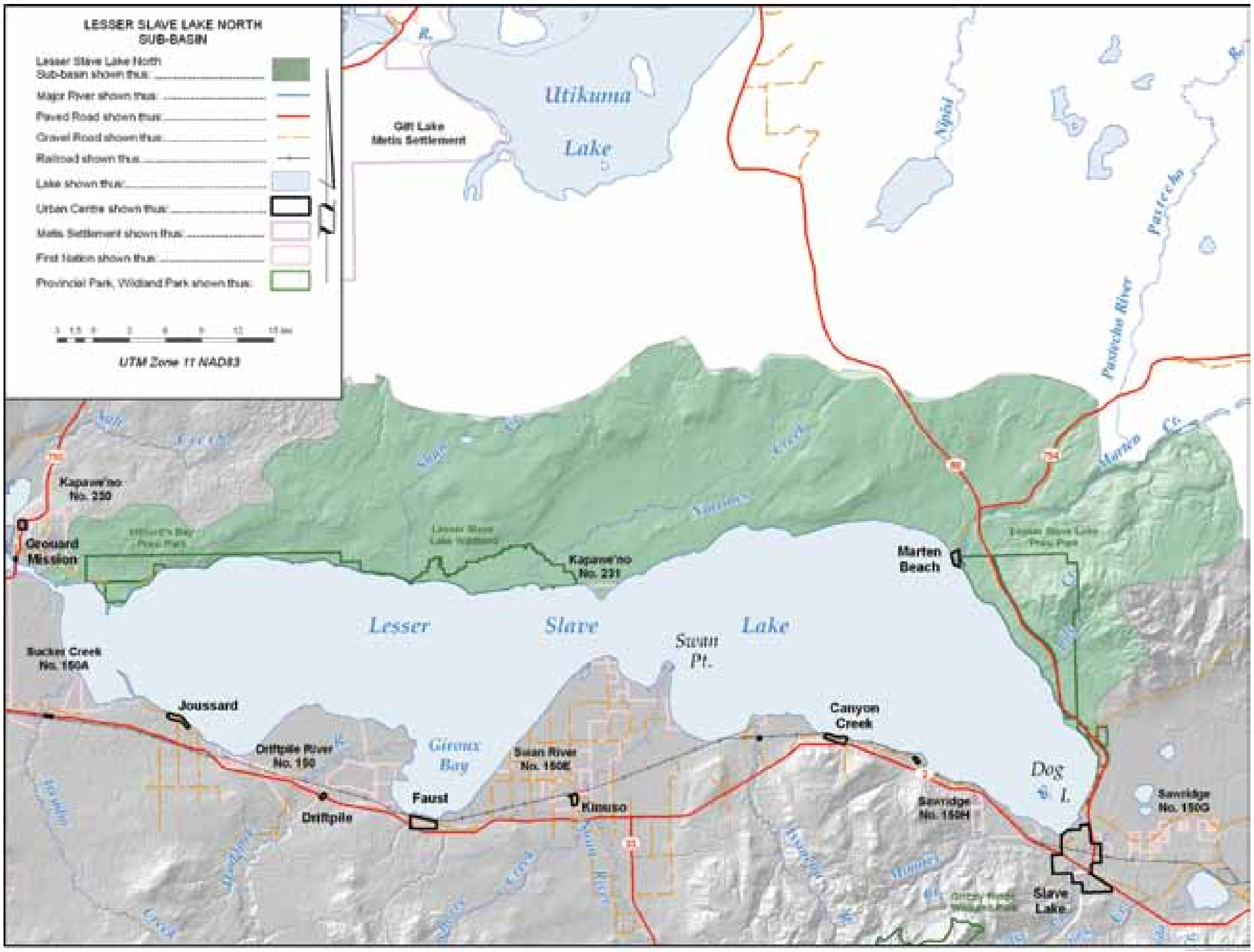


Figure 15: Overview of the Lesser Slave Lake North sub-basin

The sub-basin occurs within three of Alberta's Natural Sub-regions; the lower foothills, central mixedwood and dry mixedwood. The Marten Hills, located at the east end of the sub-basin are in the lower foothills sub-region. This area is characterized by rolling and undulating hills with mixedwood forests of a combination of the following species; aspen, balsam poplar, white birch, lodgepole pine, black spruce, white spruce, balsam fir and tamarack (NRC, 2006). The many springs and sandy soils in the Marten Hills can make soil slumping an issue when improper practices are used. The majority of the sub-basin is within the central mixedwood sub-region, which is characterized by a mix of aspen dominated deciduous stands, aspen-white spruce mixedwood and white spruce or jackpine dominant stands (NRC, 2006). Finally, a small section at the southwest end of the sub-basin occurs within the dry mixedwood sub-region. This sub-region is typically slightly drier than the central mixedwood and is characterized by aspen forests with prickly rose, low-bush cranberry, beaked hazelnut and Canada buffaloberry understory (NRC, 2006). Drier areas are predominately jackpine forests, while wetter, poorly drained areas produce a variety of rich bog and fen areas.

There are five environmentally significant areas (ESA's) that occur within the sub-basin; four are internationally significant and one is provincially significant. Areas of international significance surround Lesser Slave Lake and the parks that are located along the north and eastern shore. These areas contain important wildlife and bird habitat, stream headwaters, and rare vegetative species. The provincially significant area surrounds Marten Mountain to protect both patterned and northern ribbed fens that occur in the area. The selection of ESA's is based on seven criteria, areas that contain conservation concerns, rare or unique landforms, habitat for focal species, important wildlife habitat, riparian areas, large natural areas and other sites of recognized significance (Fiera, 2009). ESA's are used as a "decision support tool for land use planning" within Alberta over the long term (Fiera, 2009).

There are three parks within the Lesser Slave Lake North sub-basin totalling approximately 135 km^2 or 10.2% of the sub-basin. Parks within the sub-basin include Hilliard's Bay Provincial Park, Lesser Slave Lake Provincial Park, and Lesser Slave Lake Wildland Provincial Park. The percentage of protected lands within this sub-basin is the highest within the watershed. In addition to the provincial parks along the north shore of the lake, a protective notation has been placed along the remaining portions to protect the riparian areas and restrict development.

Very few communities are located within the Lesser Slave Lake North sub-basin. Marten Beach, a small subdivided hamlet located at the mouth of Marten Creek on the shores of Lesser Slave Lake is the largest community. Portions of Kapawe'no First Nation Reserve are also located within the sub-basin.

7.1 Water Quality

7.1.1 River Water Quality Index

There is insufficient water quality sampling data to calculate the River Water Quality Index for this sub-basin. This data gap should be addressed in future water quality studies.

7.1.2 *Escherichia coli*

To date, there is no data on counts of *Escherichia coli* within the Lesser Slave Lake North sub-basin. This data gap should be addressed in future water quality studies.

7.1.3 Nutrient Budget

There is insufficient data on total nitrogen and phosphorus concentrations from the Lesser Slave Lake North sub-basin. This data gap should be addressed in future water quality monitoring.

7.1.4 Sediment Contamination

No data exists on sediment contribution within the watershed for the Lesser Slave Lake North sub-basin. However, it is assumed to be quite insignificant since it contains no major watercourses and the majority of runoff comes from the East & West Prairie, Driftpile and Swan Rivers draining the southern portion of the watershed.

7.2 Water Quantity

No water quantity data is available for the Lesser Slave Lake North sub-basin. The runoff contribution to Lesser Slave Lake is fairly small compared to other sub-basins, especially south of Lesser Slave Lake.

7.2.1 Water Allocation

There are very few water licenses for surface water within the Lesser Slave Lake North sub-basin. The largest two, totalling 37,000 m^3 are for commercial use, more specifically aggregate washing. Similarly, there are only 3 ground water licenses; two for recreation purposes at Hilliard's Bay Provincial Park and the third for commercial use. In total 60,875 m^3 of ground water have been allocated within the sub-basin (AENV, 2009c).

7.3 Land Use

7.3.1 Riparian Health

Presently, no studies have been completed on the health of riparian areas within the Lesser Slave Lake North sub-basin. This data gap should be addressed in future studies.

7.3.2 Linear Development

Linear development within the Lesser Slave Lake North sub-basin, as a percentage of the basin area, is slightly below the watershed average. Approximately 2.1% of the basin has been disturbed through linear development; receiving a 'fair' rating.

7.3.2.1 Stream Crossing

A stream crossing. Photo by Ron Davis.

The Lesser Slave Lake North sub-basin has the second lowest number of stream crossings by linear features per stream kilometre than any other sub-basin within the watershed. For every kilometre of stream within the sub-basin there are 1.20 crossings, ranking it as 'medium' risk. The number and crossing type can be viewed in Table 29. The number of road crossings per stream kilometre within the sub-basin is in the mid-range within the watershed at 0.12 (ASRD, 2005a).

Table 29: Breakdown of linear feature stream crossings within the Lesser Slave Lake North sub-basin (ASRD, 2005a)

Linear Feature	Total	Crossings/km of Stream	Percent of Total Crossings (%)
Cutlines	1110	0.9771	81.50
Pipelines	92	0.0810	6.75
Powerlines	28	0.0245	2.06
Railroads	0	0	0
Roads	132	0.1162	9.69
Summary	**1362**	**1.1989**	**100**

7.3.3 Land Use Inventory

The Lesser Slave Lake North sub-basin has very little agricultural land. There is a small parcel of land on the east edge of Lesser Slave Lake that operates a bison farm. Most land within this sub-basin is green zone and cannot be privately owned.

Approximately 10.2% of the sub-basin is land designated as park or protected area (Table 30). The majority of the protected area is located adjacent to Lesser Slave Lake. Almost the entire north shore of Lesser Slave Lake is protected by parks or a protective notation to restrict development.

Table 30: Parks within the Lesser Slave Lake North sub-basin

Name	Provincial Designation	Size (ha)	% of Sub-basin
Hilliard's Bay	Provincial Parks	2,323.42	1.75
Lesser Slave Lake	Provincial Parks	7,617.01	5.75
Lesser Slave Lake	Wildland Provincial Park	3,581.45	2.70
Total		**13,521**	**10.2**

The majority of the sub-basin consists of provincial crown land held under two separate Forest Management Agreements. Tolko Industries and Gordon Buchanan Enterprises hold FMA 0200039, while Alberta Plywood, Tolko Industries and Vanderwell Contractors jointly hold FMA 0600043. Detailed Forest Management Plans have been developed and approved for each FMA that establish the goals and objectives of forest management, including the protection of wildlife, water quality and water quantity. The forest industry is also required to develop operational plans that detail how the higher level objectives will be achieved during operations. A key component of the forest management planning process is continuous improvement, which requires monitoring of objectives, to ascertain if they are being achieved, and to make recommendations on how to improve future performance.

There are 405 oil and gas sites located within the Lesser Slave Lake North sub-basin. The density of oil and gas sites within the sub-basin is one for every 327 hectares, which is the second lowest density within the entire watershed. In addition to the well site itself, there are typically associated disturbances with each site, such as access, pipelines and powerlines. Other industrial development includes a high density of surface material dispositions for sand and gravel extraction. These are located along Highway 754, some in very close proximity to Cabin Creek and Marten Creek. Conservation and reclamation plans are required for all surface material pits outlining the site conditions prior to development, an operations plan along with protective strategies and reclamation plans of the site after material removal.

Oil well in the south Mitsue area shows industry within wetlands. Photo by Meghan Payne.

There is very little urban development within the Lesser Slave Lake North sub-basin. The largest is the community of Marten Beach on the east end of Lesser Slave Lake. Portions of Kapawe'no First Nation's Reserve are also located within the sub-basin.

7.3.4 Livestock Density

No data on livestock density within the Lesser Slave Lake North sub-basin is available.

7.3.5 Wetland Inventory

There is no current data on the location and extent of wetland cover within the Swan River sub-basin. This data gap should be addressed in future studies.

7.4 Biological Indicators

7.4.1 Fish Populations

Fisheries information is very limited within the Lesser Slave Lake North sub-basin and is restricted to the Marten Creek drainage and a few smaller tributaries that flow into the east end of Lesser Slave Lake. Fish species that have been collected in the sub-basin include arctic grayling, brook stickleback, burbot, cisco, lake chub, lake whitefish, longnose dace, longnose sucker, northern pike, pearl dace, spottail shiner, trout-perch, yellow perch, walleye, and white sucker (Table 31). Population dynamics within the sub-basin are unknown.

Table 31: Fish species within Lesser Slave Lake North sub-basin (ASRD, 2009a)

Common Name	Scientific Name
Arctic Grayling	*Thymallus arcticus*
Brook Stickleback	*Culaea inconstans*
Burbot	*Lota lota*
Cisco	*Coregonus artedii*
Lake Chub	Couesius plumbeus
Lake Whitefish	*Coregonus clupeaformis*
Longnose Dace	*Rhinichthys cataractae*
Longnose Sucker	*Catostomus catostomus*
Northern Pike	*Esox lucius*
Pearl Dace	*Semotilus margarita*
Spottail Shiner	*Notropis husdonius*
Trout-perch	*Percopsis omiscomaycus*
Yellow Perch	*Perca flavescens*
Walleye	*Sander vitreus*
White Sucker	*Catastomus commersoni*

In addition to the fish species listed above, Lily Lake has been stocked with brook trout for a number of years to expand fishing and harvest opportunities in the area. Brook trout are a common stocking fish and can withstand lower oxygen concentrations than other trout species (ASRD, 2009h). The Fish and Wildlife Management Information System (FWMIS) contains stocking records for 2001, 2003, 2005 and 2007; approximately 3,000 fish were introduced during each of these years (ASRD, 2009a).

Five permanent sample plots were also established in the Marten Creek drainage to determine the presence/absence of arctic grayling within the mainstem and the importance of its tributaries; locations were sampled between 2000 and 2003 (Osokin, 2004). Arctic grayling were collected at four of the five locations, however, the numbers were low and appeared to be seasonal; it remains unknown whether successful spawning is occurring in the drainage. Osokin (2004) speculated the variable presence of the species was due to low water events, lack of mature adults, seasonal distributions and/or migration barriers. Throughout the study period arctic grayling and burbot were the only sport fish caught; non-sport fish included lake chub, longnose dace, brook stickleback, pearl dace, longnose sucker, white sucker, trout-perch and spottail shiner (Osokin, 2004).

8.0 Lesser Slave Lake

Ice Storm on Lesser Slave Lake. Photo by Nelson Lutz.

Lesser Slave Lake is the third largest lake in Alberta with a surface area of 1,160 square kilometres, including Buffalo Bay (Table 32). The lake is divided into two basins, west and east, separated by shallow water known as the Narrows (Figure 16). The maximum depth of the west basin is approximately 15.5 meters and the maximum depth of the east basin is about 20.5 meters (Mitchell and Prepas, 1990). Slopes in the lake bed of the west basin are quite gradual except for stretches along the central portion of the north and south sides. There is a sharp drop in depth along the north, west and south shores of the east basin and gradual slopes can be seen along the eastern edge of the basin (Mitchell and Prepas, 1990). Sandy beaches occur along the eastern shore, at Lesser Slave Lake Provincial Park. Buffalo Bay is a shallow, marshy, water body that the South Heart River flows through before joining the west basin of Lesser Slave Lake.

Table 32: Physical Characteristics of Lesser Slave Lake (Mitchell and Prepas, 1990; Noton, 1998 & Wolanski, 2006)

Area (including Buffalo Bay)	1,160 km2
Volume(including Buffalo Bay)	13,200 x 106 m3
Maximum Depth	20.5 m (east), 15.5 (west)
Mean Depth	11.4 m
Shoreline Length	241 km
Mean Annual Surface Inflow	1,550 x 106 m3
Mean Water Residence Time	9.5 yrs
Drainage basin area (excluding lake and Lesser Slave River basin)	12,400 km2

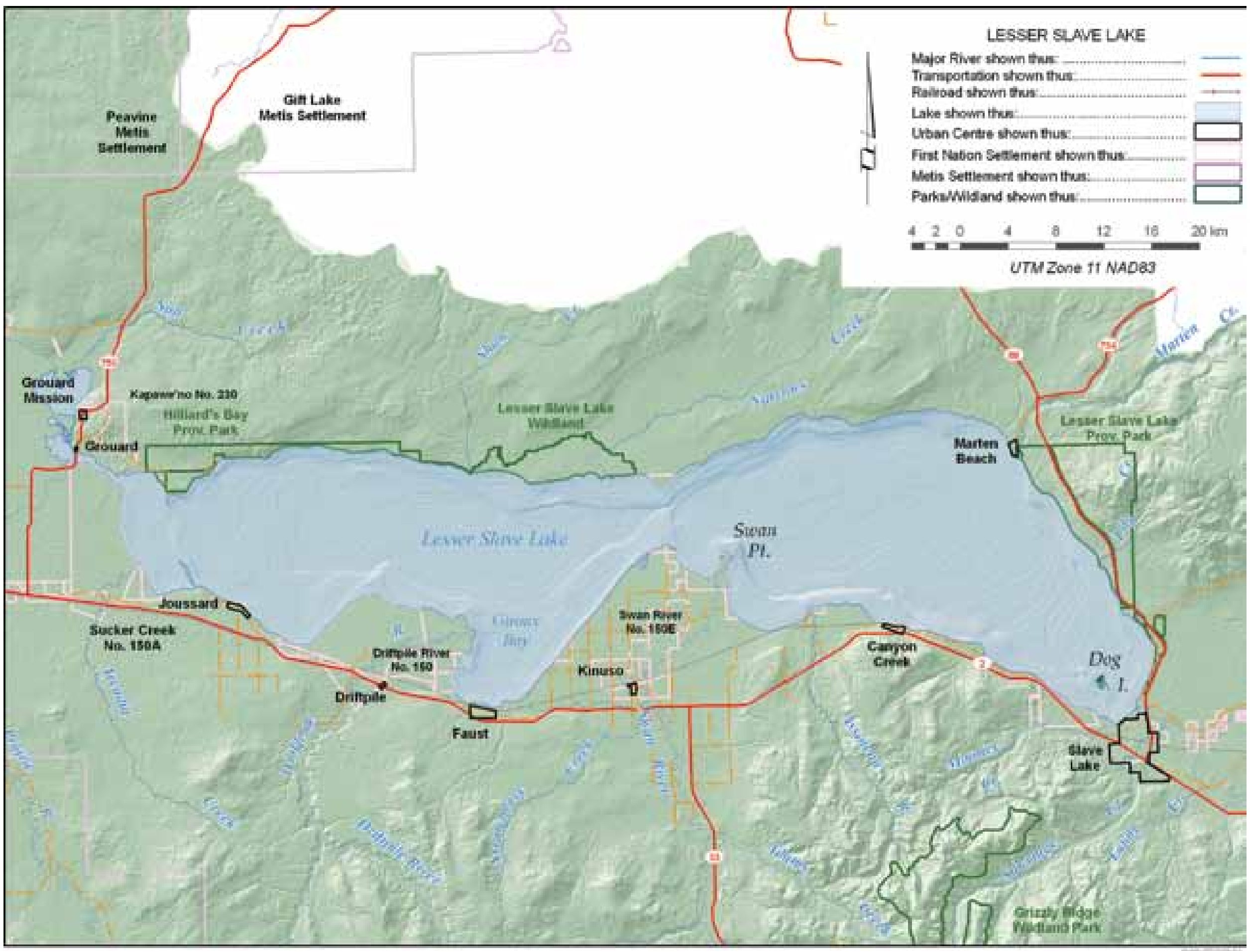


Figure 16: Overview of Lesser Slave Lake

Lesser Slave Lake provides extensive habitat to fish, aquatic invertebrates, birds and aquatic mammals. According to data collected in the late 1970's by Fish and Wildlife there are 28 species of aquatic macrophytes (Table 33) occurring in the lake (Mitchell and Prepas, 1990). Submergent weed beds were dominated by large-shealth pondweed, Richardson pondweed and stonewart. Emergent vegetation was generally quite spare consisting of common great bulrush and sedges. Buffalo Bay is made up of large areas of bulrush and also has much greater diversity of emergent and submergent aquatic plant life (Mitchell and Prepas, 1990).

Table 33: Species of aquatic macrophytes in Lesser Slave Lake (Mitchell and Prepas, 1990)

Vegetation Type	Common Name	Scientific Name
Emergent	Sedge	*Carex* spp.
	Water hemlock	*Cicuta* sp.
	Spike rush	*Eleocharis palustris*
	Horsetail	*Equisetum fluviatile*
	Wire rush	*Juncus balticus*
	Reed canary grass	*Phalaris arundinacea*
	Reed grass	*Phragmites communis*
	Common great bulrush	*Scirpus validus*
	Link	*Scolochloa festucacea*
	Giant bur-reed	*Sparganium eurycarpum*
	Common cattail	*Typha latifolia*
Free-floating	Lesser duckweed	Lemna minor
	Star duckweed	*L. trisulca*
	Common bladderwort	*Utricularia vulgaris*
Submergent	Water-starwort	*Callitriche hermaphroditicum*
	Coontail	*Ceratophyllum demersum*
	Stonewart	*Chara* sp.
	Northern watermilfoil	*Myriophyllum exalbescens*
	Pondweed	*Potamogeton friesii*
	Pondweed	*P. gramineus*
	Whitestem pondweed	*P. praelongus*
	Small-leaf pondweed	*P. pusillus*
	Rishardson pondweed	*P. richardsonii*
	Large-shealth pondweed	*P. vaginatus*
	Flat-stemmed pondweed	*P. zosteriformis*
	White water crowfoot	*Ranunculus aquatilis*
Floating-leaved	Yellow water lily	*Nuphar variegatum*
	Water smartweed	*Polygonum amphibium*

The Lesser Slave Lake and surrounding riparian areas are designated as an environmentally significant area (ESA) with international significance. The selection of ESA's is based on seven criteria, areas that contain conservation concerns, rare or unique landforms, habitat for focal species, important wildlife habitat, riparian areas, large natural areas and other sites of recognized significance (Fiera, 2009). ESA's are used as a "decision support tool for land use planning" within Alberta over the long term (Fiera, 2009). Lesser Slave Lakes' designation is based on 14 elements of conservation concern in the form of rare plants that are located around it, important bird habitat and wildlife habitat, important riparian areas and headwaters and the large number of parks along its shores (Fiera, 2009).

8.1 Water Quality

8.1.1 Lake Trophic Status

Recent water quality data for Lesser Slave Lake is quite limited. The most recent data available was included in this report to establish a baseline. Lesser Slave Lakes' west basin is considered eutrophic when based on total phosphorus and hypereutrophic based on chlorophyll-a concentrations. The east basin is mesotrophic based on total phosphorus and hypereutrophic based on chlorophyll-a. Noton (1998) and Wolanski (2006) state that chlorophyll-a concentrations were quite high based on the amount of phosphorus present.

On average the west basin has very high concentrations of total phosphorus which make it ideal for high densities of plant and algal growth (Figure 17). As a result algal blooms can be quite frequent, often beginning in late summer and lasting into the fall. In both 1992 and 1993, algal densities reached highs in mid to late summer and the blue-green algae, *Aphanizomenon flosaqua*, formed dense clumps in the west basin (Noton, 1998). Visibility was quite low at approximately 2 meters. Nessman (2003) also reports a blue-green algae bloom in 2002, although the details were not outlined.

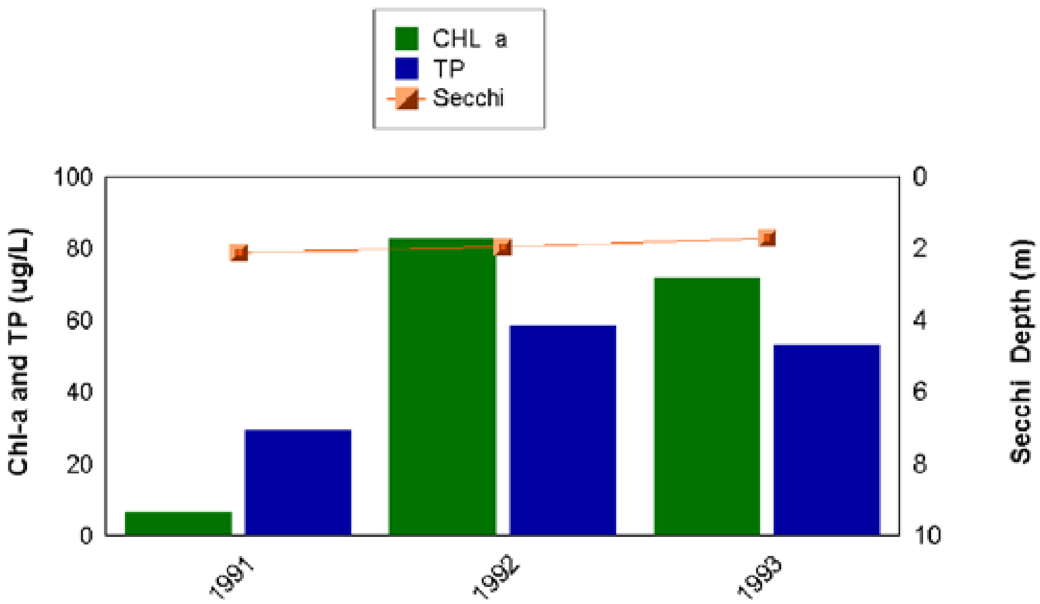


Figure 17: Average secchi depth, chlorophyll-a and total phosphorus concentrations, Lesser Slave Lake west basin, May to September (AENV, 2009d)

The east basin is significantly less productive than the west basin (Figure 18). Total phosphorus concentrations and chlorophyll-a are moderately high, algal blooms are much less common in this basin. Water clarity is moderate with secchi-disk visibility between 2 and 3 meters.

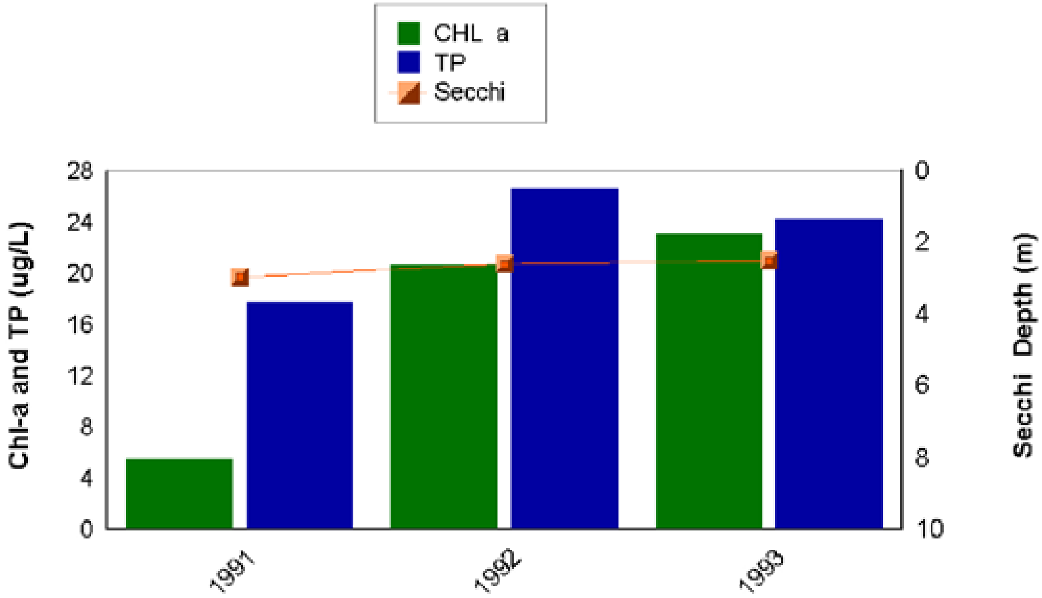
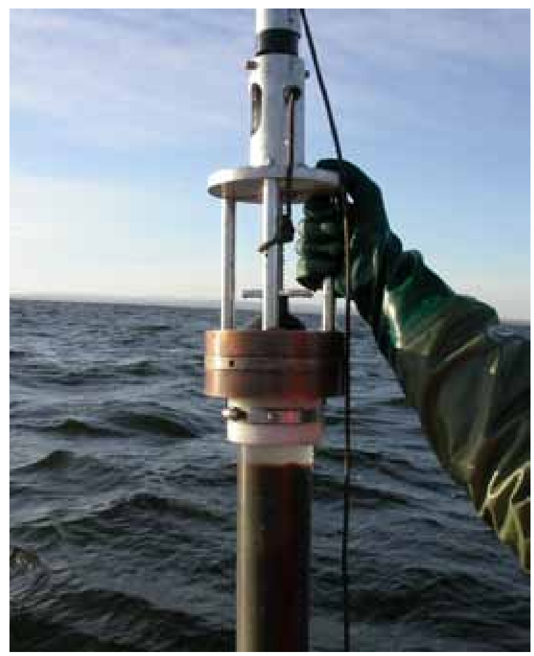


Figure 18: Average secchi depth, chlorophyll-a and total phosphorus concentrations, Lesser Slave Lake east basin, May to September (AENV, 2009d)

A trend analysis would be required to determine whether the current trophic status is consistent with the historical trophic status of Lesser Slave Lake. However, monitoring of the lake was not completed prior to 1940 therefore there is insufficient data to complete a trend analysis (Hazewinkel, no date). The current trophic status is consistent with other Alberta lakes and based on the comprehensive water chemistry analysis completed in the early 1990's (Noton, 1998) no significant difference was detected between 'developed' and 'undeveloped' sub-basins (Hazewinkel, no date). However, lake paleoecology suggests that productivity of the lake, in particular the east basin, was much lower prior to human influence began around the year 1750 (Hazewinkel, no date). Furthermore, productivity has increased since 1950 suggesting a relationship with human influences in the watershed which became much more prevalent at this time. Sediment cores taken from the east and west basins in 2005 and 2006 are currently being analyzed to determine historic total phosphorus concentrations and make inferences into changes to the lake environment over time (Hazewinkel, no date).



Core Sampling in Lesser Slave Lake. Photo from AENV.

8.1.2 *Escherichia coli*

To date, there is no data on counts of *Escherichia coli* within Lesser Slave Lake. This data gap should be addressed in future water quality studies.

8.1.3 Nutrient Budget

With the most recent available data, Alberta Environment calculated the total nitrogen and total phosphorus ratios for the west and east basins of Lesser Slave Lake (Table 34). The total nitrogen to total phosphorus ratios for both basins are consistently high, suggesting that phosphorus is the limiting factor to increased vegetative growth (Noton, 1998). When ratios are low, nitrogen is the limiting factor. Based on the high ratios calculated for both basins, Lesser Slave Lakes nutrient budget is consistent with most Alberta lakes.

Table 34: Nutrient budget of Lesser Slave Lake

West Basin		East Basin	
Collection year	**Average TN:TP**	**Collection year**	**Average TN:TP**
1991	19.0	1991	19.3
1992	20.2	1992	24.6
1993	20.8	1993	22.8
2000	17.3	2000	23.0

Since phosphorus is the limiting factor, to avoid increases in algal growth it is important to ensure phosphorus levels do not increase. Noton (1998) prepared a preliminary phosphorus budget for Lesser Slave Lake to show where most of the phosphorus input is coming from (Figure 19). The majority of phosphorus inputs to Lesser Slave Lake are from internal release (65%) and exceed that of external input (35%), which is consistent with most Alberta lakes (Noton, 1998). Since the majority of phosphorus input is from internal release, no obvious methods of reducing total phosphorus in the lake are available at this time. The phosphorus budget of Lesser Slave Lake should be monitored regularly to ensure inputs are not increasing.

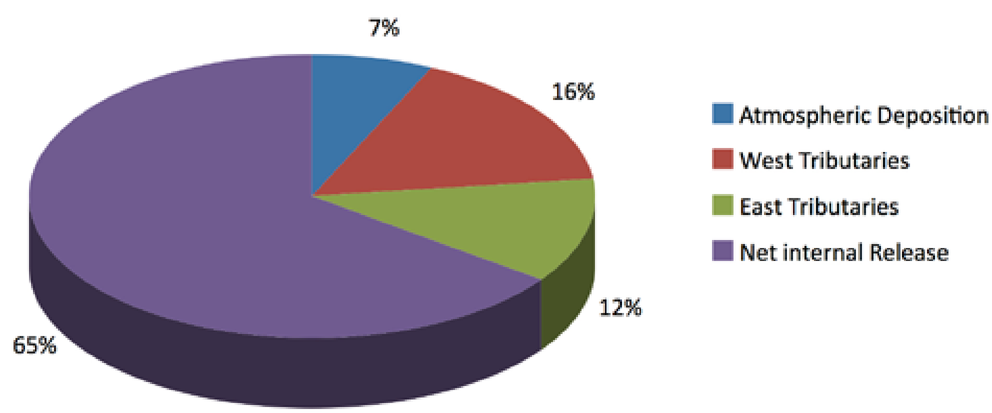


Figure 19: Lesser Slave Lake phosphorus budget estimates, 1991-93 (Noton, 1998)

8.1.4 Sediment Contamination

AMEC (2005) calculated a sediment budget for Lesser Slave Lake based on recorded flows of its major tributaries (Table 35). The majority of sediment in the system originates in the South Heart/East & West Prairie Rivers that enter the lake through Buffalo Bay. Based on previous studies approximately 85% of sediment entering Buffalo Bay will settle out upstream of the bay (AENV, 1977 & Hardy, 1989) caused by slower velocities and the filtering effects of marshy areas. This means that only 15% of the total sediment entering from this sub-basin will flow through Buffalo Bay into the lake, equalling approximately 190,000 tonnes annually (Table 35).

Table 35: Lesser Slave Lake sediment budget (AMEC, 2005)

Tributary Watershed	Computed Sediment Load (tonnes)
Horse Lakes/Buffalo Bay	
South Heart	139,000
West Prairie(upstream of South Heart)	284,000
East Prairie (at mouth)	847,000
Ungauged tributaries entering Buffalo Bay	23,000
Subtotal	1,290,000
Deposition upstream and in Buffalo Bay (85%)	1,100,000
Sediment outflow from Buffalo Bay (15%)	190,000
Driftpile River (at mouth)	337,000
Swan River (at mouth)	538,000
Ungauged Tributaries	146,000
Sediment outflow (to Lesser Slave River)	44,200
Net deposition in Lesser Slave Lake (sediment inflow minus outflow)	1,170,000

It is estimated that 97% of the sediment entering Lesser Slave Lake will settle out in the lake (AMEC, 2005). Based on this and bias-corrected annual suspended sediment loads collected at the mouth of the Lesser Slave River, approximately 44,200 tonnes of sediment leave the lake and flow downstream annually (AMEC, 2005). This means annual net deposition in Lesser Slave Lake is approximately 1,170,000 tonnes (Table 35). When converted to volume this equals less than 0.01% of the lakes total volume; at the current sedimentation rates it would take more than 10,000 years to fill in Lesser Slave Lake (AMEC, 2005). Even when the sediment input of the ungauged tributaries, which is an uncertainty, is doubled it would take approximately 9,500 years to fill in the lake (AMEC, 2005).

Based on sediment cores taken from the lakes east and west basin sediment deposition rates have increased dramatically since 1950 (Figure 20), especially in the west basin (Hazewinkel, no date). This coincides with an increase in human influence on the landbase as well as the channelization projects of the East and West Prairie Rivers (see section 3.4).

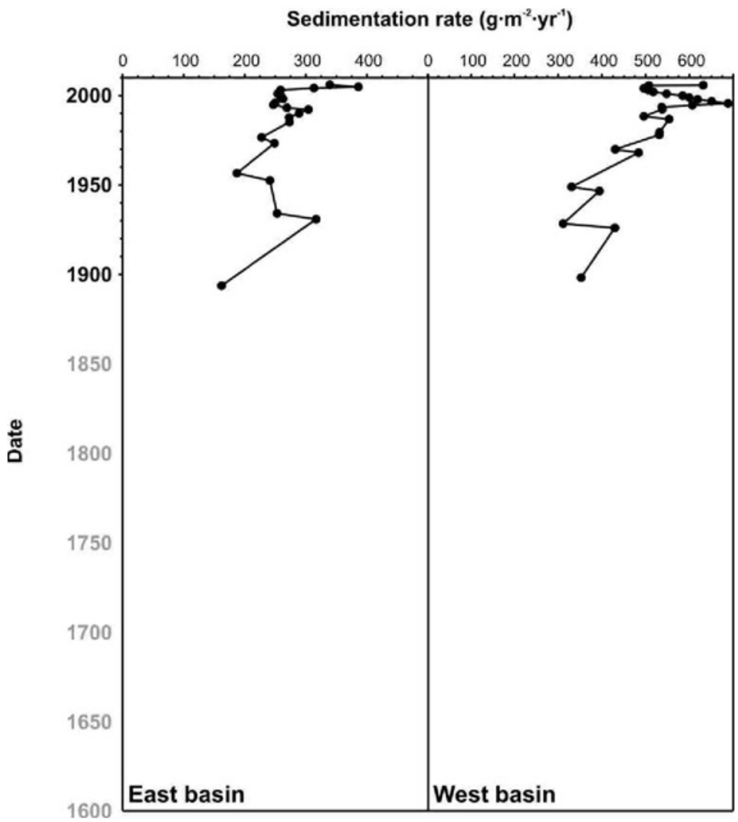


Figure 20: Sedimentation in Lesser Slave Lake (Hazewinkel, no date)

A common concern of residents surrounding Lesser Slave Lake is sedimentation in the lake at the outlet to the Lesser Slave River (LSWC, 2009). Excessive sedimentation in this location if caused by littoral drift, the movement of sediment along beaches by wave action and currents (LSWC, 2009), and the slow velocity of the Lesser Slave River, which means it cannot carry large amounts of sediment downstream. Sedimentation at the mouth of the river can lead to low flow conditions in the Lesser Slave River which pose many threats to the rivers health, as well as, impairing the water supply for the Town of Slave Lake and other industrial users along the river. On several occasions (1999, 2006 and 2009) dredging was completed at the mouth of the Lesser Slave River to maintain water flow. The Lesser Slave Watershed Council and Alberta Environment are currently working together to manage this issue (LSWC, 2009).

8.2 Water Quantity

The catchment area to surface area ratio of Lesser Slave Lake is 10.7:1 (Seneka, 2002). This means that 10.7 square kilometres of land provide runoff for each square kilometre of lake surface area. The larger this ratio is the more sustainable the lake is; resistant to long term wet/dry periods, extreme dry years tend to mean less flow rather than a drop in lake levels below the outlet and lake level fluctuations are typically above the levels needed for outflow to the Lesser Slave River. However, because the catchment area is large compared to the lake size, extreme runoff events can cause a rapid rise in lake levels (Seneka, 2002).

Lesser Slave Lakes annual water balance is heavily dependent on runoff. On average the lake receives approximately 1,532 million cubic meters (m^3) of water through runoff per year (Seneka, 2002). An additional 545 million m^3 are added through direct precipitation on the lake, totalling 2,077 million m^3. Outflow through the Lesser Slave River is approximately 1,369 million m^3 annually and there is a net loss of 708 million m^3 through evaporation (Seneka, 2002), totalling 2,077 million m^3. The output through the Lesser Slave River is equivalent to 38.3m^3/second (AENV, 2010).

Lake levels fluctuate on a natural basis based on climate and weather variations. Flooding can occur in Lesser Slave Lake because inflow rates can greatly exceed the outflow capacity of the Lesser Slave River. Low lake levels can also be a problem in Lesser Slave Lake because of the high dependence on surface runoff (Seneka, 2002). Surface water is much more variable, with extreme highs and lows, than precipitation. For example, in the West Prairie River, the highest runoff year (1996) equalled 342mm whereas the lowest runoff year (1998) equalled 32mm (Seneka, 2002). Ranked annual lake levels are included in Table 36. The most recent ranking shows Lesser Slave Lake as below normal levels in 2006. In 2002, 13 of the 27 selected lakes throughout Alberta also showed lake levels that were much below normal (AENV, 2007). Section 3.4 discusses the lake regulation project that was completed in the late 1970's and early 1980's when cutoffs were constructed in the Lesser Slave River and a weir was installed at the mouth of the river.

Table 36: Ranked annual lake levels for Lesser Slave Lake (AENV, 2007)

2002	2003	2004	2005	2006
Much below normal	Normal	Normal	Above normal	Below normal

8.2.1 Water Allocation

Surface water allocation for the Lesser Slave Lake is for oilfield injection, municipal use, recreation and agriculture. Of the 3,066,096 m^3 of allocated water, 58% is for oilfield injection, 32% for municipal use, 9% for recreation and the remaining 1% for agriculture (AENV, 2009c). Not all of the allocated water is used, for example, Apache Canada who holds the only license for oilfield injection of lake water only used about half of the allocated amount in2008. When water use over the last ten years is averaged this number drops to 39% of the total water allocated (AENV, 2009c). Apache withdraws water directly from the lake and transports it through a pipeline to its facility near Swan Hills. Updated records were not available but municipal water use is also typically much lower than the allocated amount.

8.3 Land Use

8.3.1 Riparian Health

The health of the Lesser Slave Lake shoreline was assessed using aerial videography in the summer of 2006. Through this assessment it was determined that 78.7% of the riparian zones directly surrounding the lake were healthy, 12.5% were moderately impaired and 8.8% were highly impaired (Osokin & Hallett, 2007). According to Osokin and Hallett (2007), the majority of the lakes shoreline, especially along the north shore is thought to be in its natural state. Areas that exhibited ratings of highly impaired experienced more intensive housing along the shore, recreational use or agricultural activity than areas with healthy or moderately impaired ratings.

8.4 Biological Indicators

8.4.1 Fish Populations

There are 17 species of fish within Lesser Slave Lake (Table 37). The most common species are burbot, cisco, lake whitefish, longnose sucker, northern pike, trout-perch and yellow perch; followed by emerald shiner, trout-perch, walleye and white sucker. Arctic grayling, brook stickleback, goldeye, mountain whitefish and spoonhead sculpin are relatively rare.

Table 37: Fish species within Lesser Slave Lake (LSWC, 2008)

Common Name	Scientific Name	Relative Occurrence
Arctic Grayling	*Thymallus arcticus*	Rare
Brook Stickleback	*Culaea inconstans*	Rare
Burbot	*Lota lota*	Abundant
Cisco	*Coregonus artedii*	Very abundant
Emerald Shiner	*Notropis atherinoides*	Common
Goldeye	*Hiodon alosoides*	Rare
Lake Chub	Couesius plumbeus	-
Lake Whitefish	*Coregonus clupeaformis*	Abundant
Longnose Sucker	*Catostomus catostomus*	Very abundant
Mountain Whitefish	*Prosopium williamsoni*	Rare
Northern Pike	*Esox lucius*	Abundant
Spoonhead Sculpin	*Cottus ricei*	Rare
Spottail Shiner	*Notropis husdonius*	Abundant
Trout-perch	*Percopsis omiscomaycus*	Common
Yellow Perch	*Perca flavescens*	Abundant
Walleye	*Sander vitreus*	Common
White Sucker	*Catastomus commersoni*	Common

Lesser Slave Lake provides important habitat for many fish species. Almost all of the fish species within the lake depend on its shallow shorelines for at least one life stage throughout their life history. Between 1994 and 1995, the Fish and Wildlife Division of Alberta Sustainable Resource Development mapped the shoreline of Lesser Slave Lake for critical fish spawning and rearing habitat (Chabaylo & Knight, 1997). During this assessment it was determined that emergent vegetation of bulrush, sedge and cattail made up approximately 50% of the shoreline, while exposed rock made up 16% and sand beaches covered 26% (Chabaylo & Knight, 1997). The west basin is primarily comprised of bulrushes and sedges at 71% followed by sand beaches at 20%, grass at 5% and rock 4% (Chabaylo & Knight, 1997). While the east basin is primarily sand beaches at 33%, followed by rock 30%, vegetated with bulrush, sedge and cattails 28% and grass at 9% (Chabaylo & Knight, 1997).

Walleye and lake whitefish require rock and gravel substrates for spawning, northern pike spawn in shallow vegetation and yellow perch attach their eggs to submerged vegetation or debris (Chabaylo & Knight, 1997). Important walleye and lake whitefish spawning areas in Lesser Slave Lake are displayed in Figure 21.

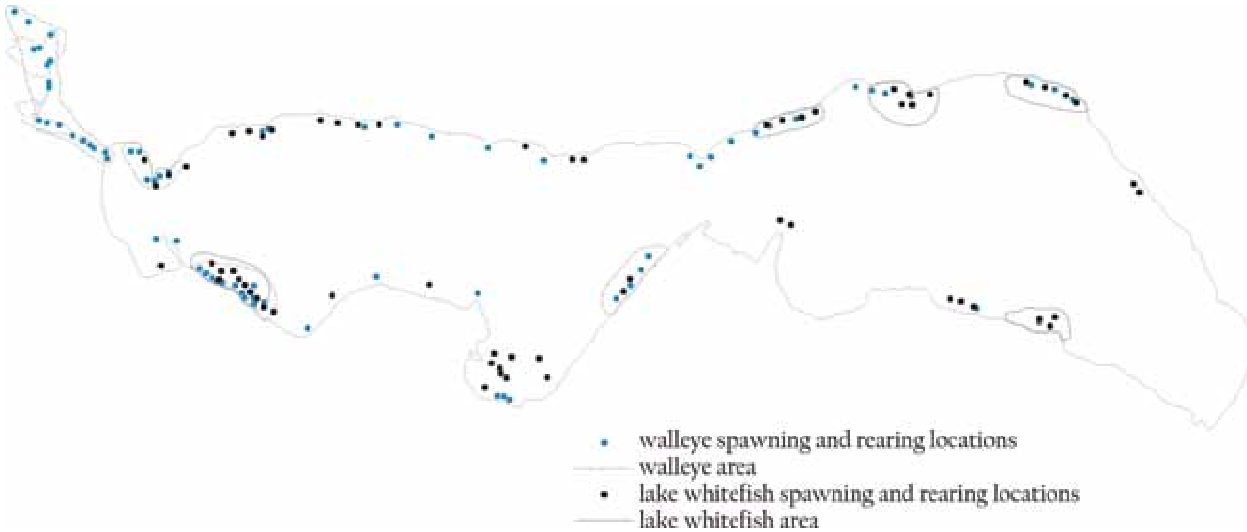


Figure 21: Important walleye and lake whitefish habitat (LSWC, 2008)

Since it is one of the best fishery lakes within Alberta, Lesser Slave Lake has experienced increased angling pressure since 1985 (Fortier *et al*, 2005). The population metrics of walleye, northern pike, lake whitefish and yellow perch were examined in the fall of 2005. Walleye was the most abundant fish caught, 43% of the total catch (Fortier *et al*, 2005). Males caught ranged from age 1-12 years and females ranged from 1-14 years, both displaying normal age distributions (Figure 22). Approximately half of the females caught reached maturitty by age 6 at a length of 450 mm; half the males reached maturity by age 5 or earlier at lengths of 400 mm (Fortier *et al*, 2005).

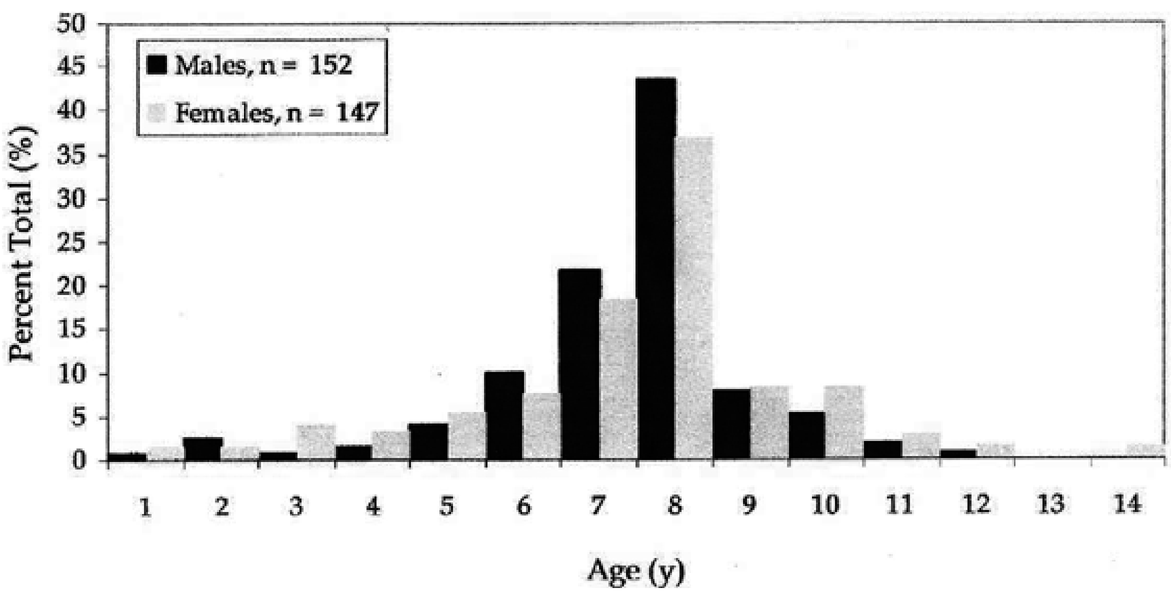


Figure 22: Age distributions of male and female walleye in Lesser Slave Lake (Fortier et al, 2005)

Total catch rate reports from anglers were compared between 1999 and 2005; rates reported were 2.045 fish/angler-hour and 3.025 fish/angler-hour, respectively (Fortier *et al*, 2005b). This seems to suggest a higher catchability or an increase in the walleye population between 1999 and 2005 however, when the same two years are compared for the total harvest rate, more fish were harvested per angler in 2005 (0.187 fish/angler-hour in 1999 and 0.291 fish/angler-hour in 2005) (Fortier *et al*, 2005b). In 2005, the estimated total catch of walleye was 870,000 fish and total harvest was 82,000 fish (Fortier *et al*, 2005b) displaying the popularity of this species of sport fish.

During the fall 2005 sampling period, Northern pike comprised 6.5% of the total catch (Fortier *et al*, 2005). Males caught ranged from 1-9 years and females from 2-11 years (Figure 23); no prominent age class was determined for either sex (Fortier e*t al*, 2005). This could be a result of the small number of fish caught. Based on the limited data available, Fortier *et al* suggested that half the males reached maturity at age 2 at lengths of 350 mm and half the females reached maturity at age 3 at lengths under 500 mm.

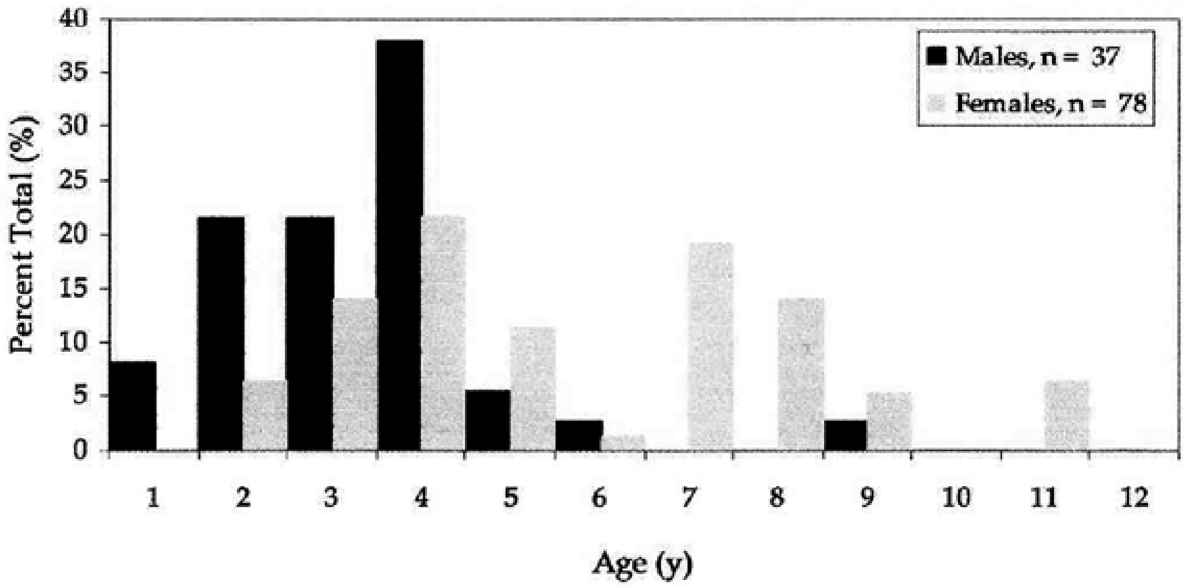


Figure 23: Age distributions of male and female northern pike in Lesser Slave Lake (Fortier et al, 2005)

Total catch rates of northern pike appear to have decreased between 1999 (0.335 fish/angler-hour) and 2005 (0.09 fish/angler-hour); total harvest rates have also decreased (Fortier *et al*, 2005b). In 2005, the estimated total catch of northern pike was 25,700 fish and total harvest was 1,060 fish (Fortier *et al*, 2005b).

Lake whitefish was the second most abundant fish at 32.7% of the total catch (Fortier *et al*, 2005). Both males and females ranged in age from 2-13 years and appear to follow normal distribution curves (Figure 24). Approximately half of the males and females sampled were mature by age 6 at lengths of 500 mm (Fortier *et al*, 2005).

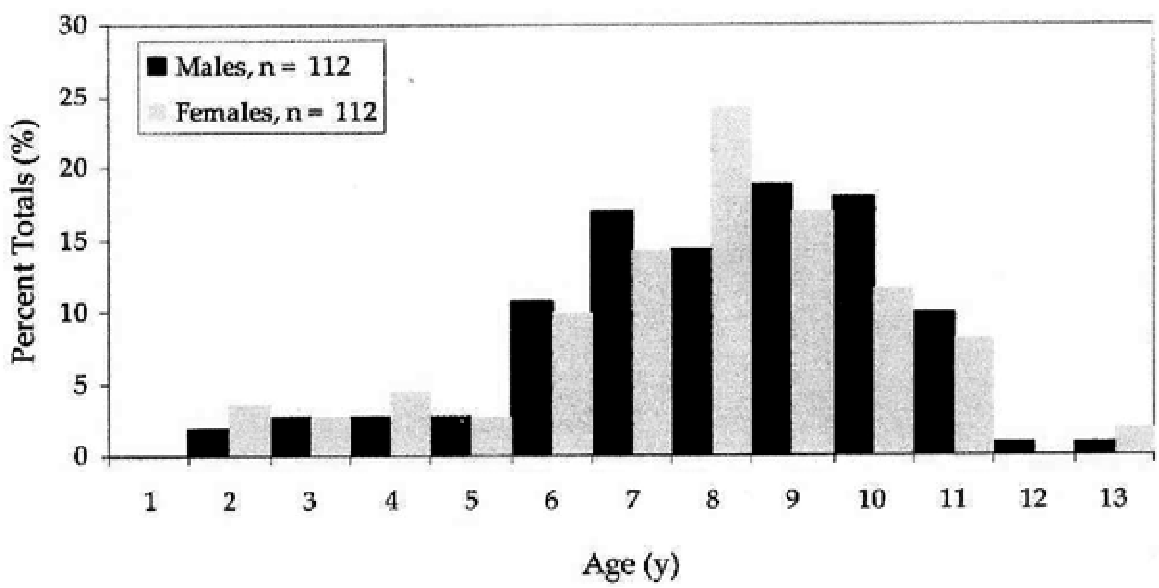


Figure 24: Age distributions of male and female lake whitefish in Lesser Slave Lake (Fortier et al, 2005)

Yellow perch made up the least percentage of fish caught at 4.2% (Fortier *et al*, 2005). The majority of yellow perch caught were females (83.1%) resulting in a small male sample size. Males ranged in age from 1-2 while females ranged from 1-10 years (Figure 25). Of the males sampled, all were mature while half the females reached maturity at age 3 with lengths of 250 mm (Fortier *et al*, 2005).

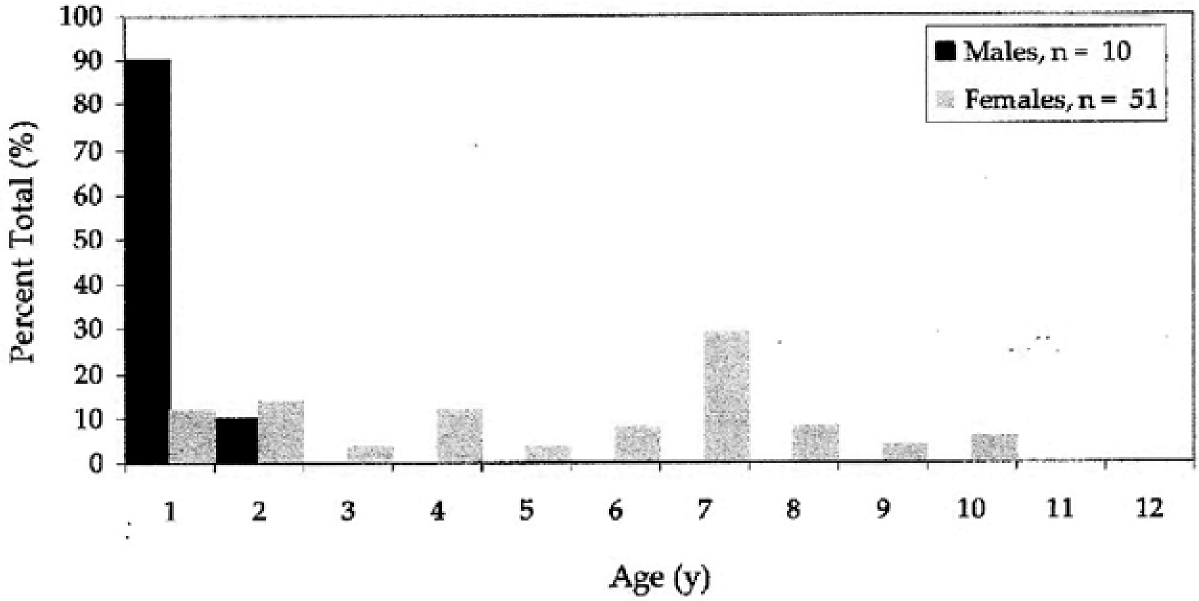


Figure 25: Age distributions of male and female yellow perch in Lesser Slave Lake (Fortier et al, 2005)

8.4.2 Blue/Green Algae Outbreaks

No detailed reports or recent data on blue/green algae outbreaks in Lesser Slave Lake was available for this report. This data gap should be addressed in the future.

However, in both 1992 and 1993, algal densities reached highs in mid to late summer and the blue-green algae, *Aphanizomenon flosaqua*, formed dense clumps in the west basin (Noton, 1998). Nessman (2003) also reports a blue-green algae bloom in 2002, although the details were not outlined. Overall, algae outbreaks are much more common in the west basin but also occur occasionally in the east basin.

9.0 Lesser Slave River Sub-basin

Sawridge Creek joining Lesser Slave River. Photo by Ron Davis.

The Lesser Slave River sub-basin is the largest within the Lesser Slave Watershed at approximately 6,507 square kilometres (km^2). Major tributaries draining the southern portion of the sub-basin are Sawridge Creek, Eating Creek, Otauwau River and the Saulteaux River, which is joined by Allan River, Donnelly Creek, Ethel Creek, Coutts River, Akuinu River and Parker Creek before its confluence with the Lesser Slave River (Figure 26). The major tributaries draining the northern portion of the sub-basin are Muskeg Creek and the Driftwood River, which is joined by the Fawcett River. There are many smaller tributaries and lakes within the sub-basin including, Mitsue Lake, Fawcett Lake, Otter Lake and Orloff Lake.

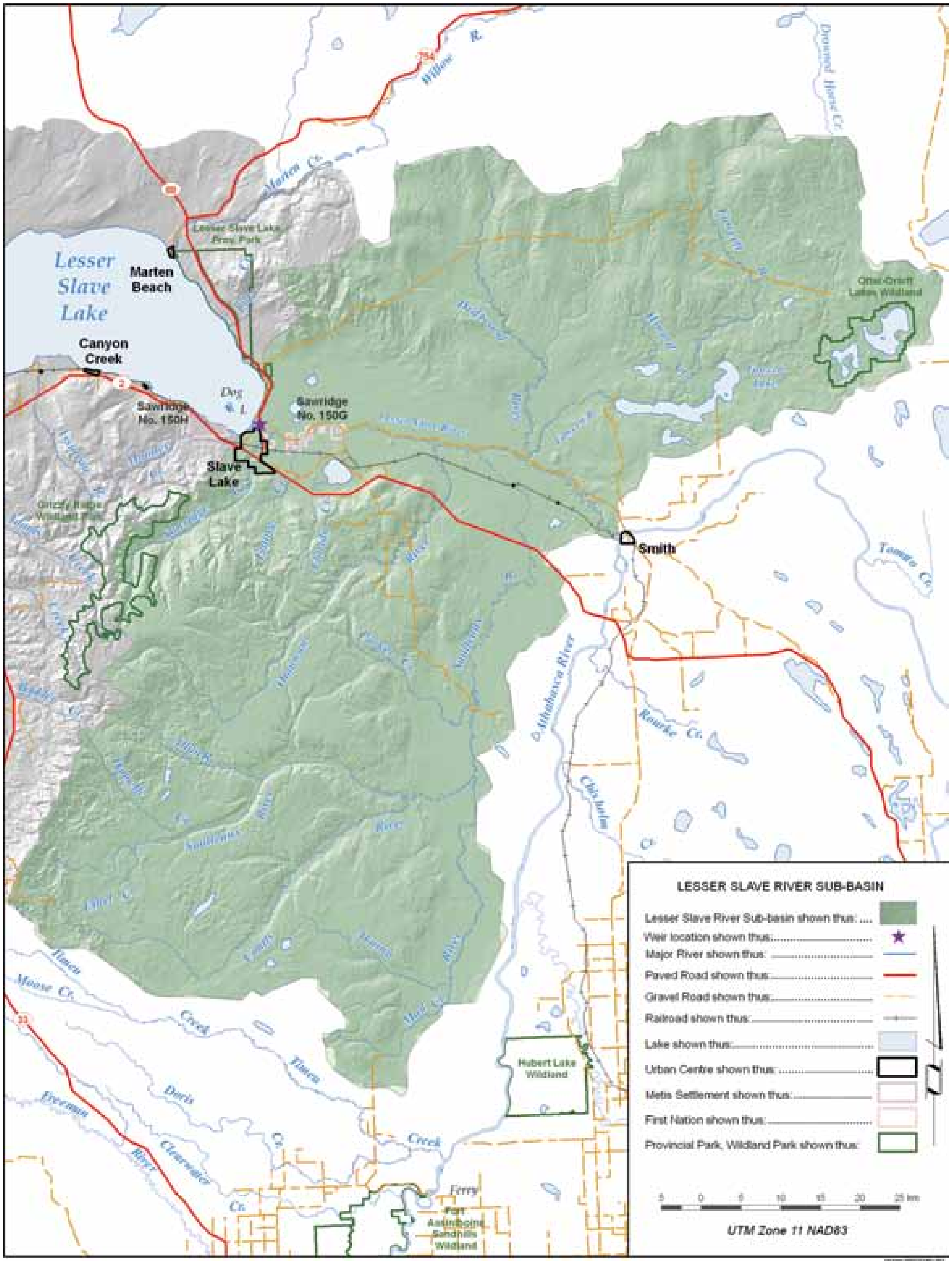


Figure 26: Overview of the Lesser Slave River sub-basin

The terrain within the Lesser Slave River sub-basin generally slopes towards the middle of the basin, the Lesser Slave River, and towards the eastern boundary. The sub-basin is within the upper foothills, lower foothills and central mixedwood natural sub-regions of Alberta (see section 3.5.1). The upper foothills occur along the boundary with the Swan River sub-basin; this area is quite steeply sloped and has predominately coniferous forests. The lower foothills sub-region extends east from the upper foothills approximately halfway across the basin as well as encompasses the northern portion of the basin; the Marten Hills and Pelican Mountains. These areas are generally rolling and undulating hills with mixedwood forests of the combination of the following species; aspen, balsam poplar, white birch, lodgepole pine, black spruce, white spruce, balsam fir and tamarack (NRC, 2006). The remainder of the sub-basin is within the central mixedwood sub-region, which is characterized by a mix of aspen dominated deciduous stands, aspen-white spruce mixedwood and white spruce or jackpine dominant stands (NRC, 2006).

Nine provincially designated environmentally significant areas (ESA's) and one internationally significant ESA occur, at least in part, within the sub-basin. The area surrounding Lesser Slave Lake and the Lesser Slave Lake Provincial Park are considered internationally significant. This is based on the areas importance as bird habitat and multiple rare plant species that occur there (Fiera, 2009). Four of the provincially significant areas within the sub-basin are concentrated along the Lesser Slave River where there are aeolian beach ridges and non-patterned horizontal fens (Fiera, 2009). The remaining ESA's of provincial significance are in the southern half of the sub-basin surrounding important headwaters, wildlife habitat and areas with northern plateau bogs (Fiera, 2009). The selection of ESA's is based on seven criteria, areas that contain conservation concerns, rare or unique landforms, habitat for focal species, important wildlife habitat, riparian areas, large natural areas and other sites of recognized significance (Fiera, 2009). ESA's are used as a "decision support tool for land use planning" within Alberta over the long term (Fiera, 2009).

There are seven parks within the Lesser Slave River sub-basin totalling approximately 115 km^2 or 1.8% of the sub-basin. Parks within the sub-basin include approximately 1/3 of Grizzly Ridge Wildland Provincial Park, Otter-Orloff Lakes Wildland Provincial Park, Fawcett Lake Provincial Recreation Area, Chrystina Lake Provincial Recreation Area, Hondo, Otauwau and Saulteaux Natural Areas.

The Lesser Slave River is the largest sub-basin within the watershed but has very few communities. The Town of Slave Lake is located near the outflow of the Lesser Slave River and about half of the Sawridge Band Reserve is situated along Sawridge Creek and Lesser Slave River.

9.1 Water Quality

AENV staff measuring water quality. Photo by Ron Davis.

9.1.1 River Water Quality Index

Alberta Environment calculated the River Water Quality Index for the Lesser Slave River sub-basin to be incorporated into this report. The Lesser Slave River has the most extensive sampling data compared to other rivers within the watershed. The index was calculated at two stations, one near the mouth of the Lesser Slave River near Lesser Slave Lake and the other at its confluence with the Athabasca River (Table 38 & Table 39). This will allow trends both over time and throughout the sub-basin to be displayed.

Table 38: River water quality index, Lesser Slave River, near Lesser Slave Lake (R. Hazewinkel, AENV, pers.)

Index Period	River Water Quality Index	Rating
1989	96	Excellent
1990-91	92	Good
1991-92	94	Good
1992-93	90	Good
1994	96	Excellent
1994-95	94	Good
1995-96	98	Excellent
1996-97	97	Excellent
1997-98	85	Good
1999-2000	98	Excellent
2000-01	94	Good
2001-02	95	Good
2002-03	90	Good
2005-06	84	Good

Table 39: River water quality index, Lesser Slave River, at confluence with Athabasca River (R. Hazewinkel, AENV, pers. comm.)

Index Period	River Water Quality Index	Rating
1989	96	Excellent
1989-1990	89	Good
1990-91	98	Excellent
1991-92	87	Good
1992-93	85	Good
1993-94	80	Fair
1994-95	86	Good
1995-96	94	Good
1996-97	86	Good
1997-98	94	Good
1998-99	80	Fair
1999-2000	78	Fair
2000-01	77	Fair
2001-02	74	Fair
2002-03	80	Fair
2003-04	83	Good
2004-05	92	Good
2005-06	95	Good

Near the outlet at Lesser Slave Lake, the Lesser Slave River has remained in 'good' or 'excellent' water quality over the last 18 years (1989-2006). Excellent water quality means that the water quality guidelines are almost always met and represents the best water quality. Good ratings represent periods when the guidelines are occasionally exceeded but threat is minimal. At the confluence with the Athabasca River, water quality is slightly less desirable and was rated as 'fair' during 1993-94 and between 1998 and 2003. The guidelines were sometimes exceeded by moderate amounts during these periods. The fair ratings experienced during the 1993-94 period can be attributed to elevated trace metal concentrations, in particular, manganese, copper, and aluminum (R. Hazewinkel, AENV, pers. comm.). High flows carrying increased loads of suspended solids likely caused the elevated trace metal concentrations. Fair ratings received between 1998 and 2003 were caused by high nutrient values, especially phosphorus (R. Hazewinkel, AENV, pers. comm.), which is usually natural in northern Alberta.

9.1.2 *Escherichia coli*

To date, there is no data on counts of *Escherichia coli* within the Lesser Slave River sub-basin. This data gap should be addressed in future water quality studies.

9.1.3 Nutrient Budget

There is no recent data on total nitrogen and phosphorus concentrations from the Lesser Slave River sub-basin. This data gap should be addressed in future water quality monitoring.

9.1.4 Sediment Contamination

Sediment load at the mouth of the Lesser Slave River is relatively small since 97% of the sediment entering Lesser Slave Lake will settle out in the lake (AMEC, 2005). Based on a sediment budget for Lesser Slave Lake and suspended sediment loads collected at the mouth of the Lesser Slave River, approximately 44,200 tonnes of sediment leave the lake and flow downstream annually (AMEC, 2005).

However, sedimentation at Lesser Slave Rivers outlet from Lesser Slave Lake is occasionally a concern. Excessive sedimentation in this location if caused by littoral drift, the movement of sediment along beaches by wave action and currents (LSWC, 2009), and the slow velocity of this segment of the Lesser Slave River, which means it cannot carry large amounts of sediment downstream. Sedimentation at the mouth of the river can lead to low flow conditions in the Lesser Slave River which pose many threats to the rivers health, as well as, impairing the water supply for the Town of Slave Lake and other industrial users along the river. On several occasions (1999, 2006 and 2009) dredging was completed at the mouth of the Lesser Slave River to maintain water flow. The Lesser Slave Watershed Council and Alberta Environment are currently working together to manage this issue (LSWC, 2009).

Sediment loading throughout the drainage (at the confluence with the Athabasca River) is unknown. However, velocities are much higher after the confluence with the Saulteaux River therefore potential carrying capacity is also much greater.

9.2 Water Quantity

The Lesser Slave River is the only outflow of the Lesser Slave Lake. Annually, approximately 1,369 million m^3 of water flow through it (Seneka, 2002), which is equivalent to approximately 38.3 m^3/second (AENV, 2010).



Siphon used in November 1999 to move water across weir. No flow over weir. Photos from AENV.

In the winter of 1999-2000, Lesser Slave River experienced extremely low flows. Flow over the weir was irregular in mid and late November and nearly stopped around November 23-24, 1999 (Noton & Seneka, 2000). Emergency temporary diversions were implemented and from late November to mid-April flow was approximately 53,200 dam^3, equivalent to a mean daily discharge of 4.2 m^3/second (Noton & Seneka, 2000).

9.2.1 Water Allocation

Within the Lesser Slave River sub-basin a total annual volume of 13,836,496 m^3 of surface water is allocated for withdrawal (AENV, 2009c). The main uses of water within the sub-basin are oilfield injection, pulp production, municipal use, industrial or commercial uses and minor amounts are allocated for recreation and agriculture (Figure 27). Four water licenses from the Lesser Slave River account for 99.8% of the total surface water allocated within the sub-basin; Penn West Energy Trust, Ranger Slave Lake Pulp Corporation, the Town of Slave Lake and the Municipal District of Lesser Slave River to provide water for the Mitsue Industrial Park (Table 40). However, not all the water withdrawn from the basin permanently leaves the system. On average over the last ten years, almost 50% of the water withdrawn by these four main users is returned to the system (Table 40).

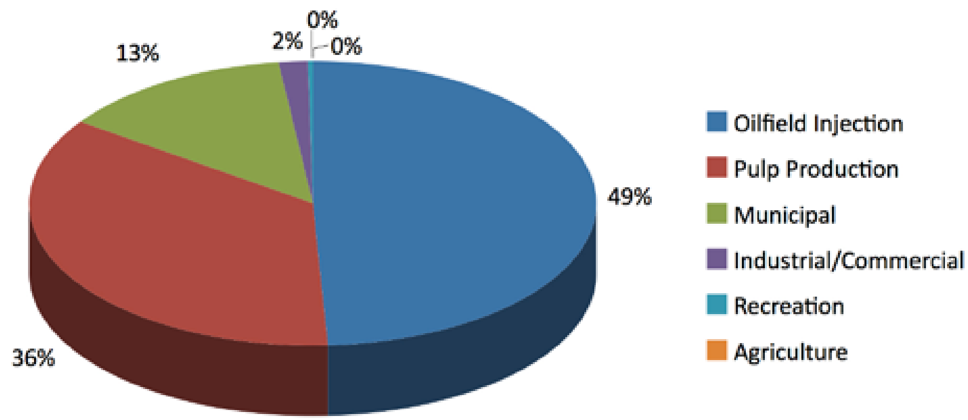


Figure 27: Lesser Slave River sub-basin surface water allocation

Table 40: Major water licenses within the Lesser Slave River sub-basin (AENV, 2009c)

Water License	Allocation (m3/year)	Purpose	Average Withdrawal* (m3)	Average Return Flow (%)
Penn West Energy Trust	6,784,170	Oilfield injection	5,682,650	11
Ranger Slave Lake Pulp Corporation	4,932,430	Pulp production	3,996,411	88
Town of Slave Lake	1,850,230	Municipal water supply	1,068,822	108**
Mitsue Industrial Park	246,700	Industrial	205,773	0

*Average data from 1998-2008 records
**Average return is greater than 100% because of groundwater seeping into the system

In addition to the surface water licenses within the Lesser Slave River sub-basin, there are 18 licenses and registries for ground water withdrawal. The total allocation for ground water is 979,684 m^3 (AENV, 2009c) and is used for oilfield injection, industrial and commercial use, wood processing, recreation and minor amounts for agricultural purposes (Figure 28).

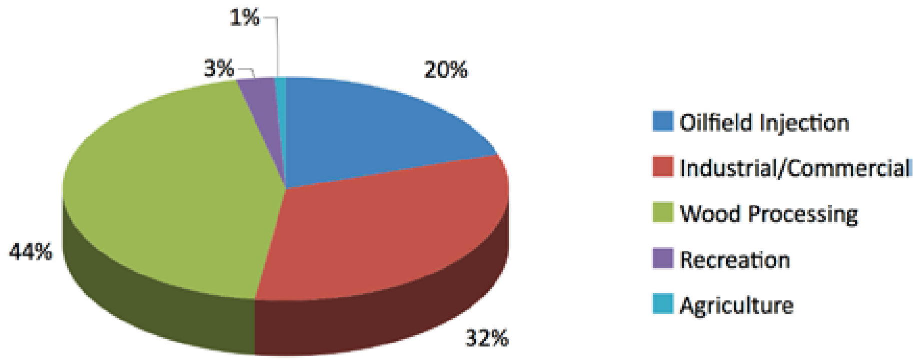


Figure 28: Lesser Slave River sub-basin ground water allocation

9.3 Land Use

9.3.1 Riparian Health

In the late 1970's when the lake regulation project was initiated a riparian assessment was completed however the data is quite old and was therefore not included in this report. There are no current studies that have been completed on the health of riparian areas within the Lesser Slave River sub-basin. This data gap should be addressed in future studies.

9.3.2 Linear Development

Linear development within the Lesser Slave River sub-basin, as a percentage of the basin area, is the highest within the entire watershed. Approximately 2.7% of the basin has been disturbed through linear development. Although the sub-basin has the highest percentage within the watershed it is still 0.3% below the 'high' rating threshold and is therefore rated 'fair'.

9.3.2.1 Stream Crossings

The Lesser Slave River sub-basin has the second highest number of stream crossings by linear features per stream kilometre than any other sub-basin within the watershed. For every kilometre of stream within the sub-basin there are 1.33 crossings, ranking it as 'medium' risk. The number and crossing type can be viewed in Table 41. The number of road crossings per stream kilometre within the sub-basin is the lowest within the watershed at 0.09 (ASRD, 2005a).

Table 41: Breakdown of linear feature stream crossings within the Lesser Slave Lake North sub-basin (ASRD, 2005a)

Linear Feature	Total	Crossings/km of Stream	Percent of Total Crossings (%)
Cutlines	7043	1.0536	79.31
Pipelines	1076	0.1610	12.12
Powerlines	132	0.0197	1.49
Railroads	13	0.0019	0.15
Roads	616	0.0922	6.94
Summary	8880	1.3284	100

9.3.3 Land Use Inventory

Land use within the Lesser Slave River sub-basin includes agriculture, parks and protected areas, forestry, oil and gas development, and other industrial development. There is very little agricultural land within this sub-basin. Small pockets are located along the north side of the Lesser Slave River and in the Eating Creek area.

Parks and protected areas make up approximately 1.8% of the sub-basin (Table 42). The majority of the protected areas are surrounding lakes, with the exception of Grizzly Ridge Wildland Park which contains the headwaters of Sawridge Creek and the Otauwau River. This area is also important habitat for Grizzly bears, a potential species at risk within Alberta (see section 3.6).

Table 42: Parks within Lesser Slave River sub-basin

Name	Provincial Designation	Size (ha)	% of Sub-basin
Grizzly Ridge*	Wildland Provincial Park	3,533.02	0.54
Otter-Orloff Lakes	Wildland Provincial Park	6948	1.07
Fawcett Lake	Provincial Recreation Area	47.83	0
Chrystina Lake	Provincial Recreation Area	26.85	0
Hondo	Natural Area	434.56	0.07
Otauwau	Natural Area	248.09	0.04
Total		11,238	1.76

*Grizzly Ridge Wildland Provincial Park is a total of 10,706.06 hectares, and was assumed to be 1/3 in the Lesser Slave River sub-basin, and 2/3 in the Swan River sub-basin.

The majority of the Lesser Slave River sub-basin in within provincial crown land held under four separate Forest Management Agreements (FMA) between industry and the province. Forest Management Unit S07 is managed by Vanderwell Contractors; FMU S17 is managed jointly by Alberta Plywood, Tolko Industries and Vanderwell Contractors. Forest Management Unit S20 is managed by Slave Lake Pulp Corporation, while FMU W11 is managed by Millar Western Forest Products. Detailed Forest Management Plans have been developed and approved for each FMA, which establish the goals and objectives of forest management, including the protection of water quality and quantity. The forest industry is also required to develop operational plans that detail how higher level objectives will be achieved during operations. A key component of the forest management planning process is continuous improvement, which requires performance monitoring, to determine if goals and objectives are being achieved, and to make recommendations on how to improve future operations.

Oil and gas activity is slightly less active in the Lesser Slave River sub-basin than elsewhere in the watershed with 405 well sites. The density of oil and gas sites within this sub-basin is one for every 327 hectares, which is the second lowest density when compared to other sub-basins within the watershed. In addition to the well site itself, there are typically associated disturbances with each site including access, pipelines and powerlines.

Other industrial development includes the Mitsue Industrial Park and the Swan Hills Treatment Centre. The Mitsue Industrial Park is located between Mitsue Lake and the Lesser Slave River. The industrial park is the location of several small businesses as well as four wood processing facilities, two gas plants, a calcium chloride production facility, and a waste/product management facility for oilfield services. The Swan Hills Treatment Centre is a waste management facility that disposes of hazardous wastes such as PCB's and dioxins (AECOM, 2009). This facility is located in the south-west corner of the sub-basin, near the Town of Swan Hills. The facility was opened in 1987 and has a current waste processing capacity of 45,000 tonnes per year (AECOM, 2009).

9.3.4 Livestock Density

No data on livestock density within the Lesser Slave River sub-basin is available.

9.3.5 Wetland Inventory

There is no recent data on the location and extent of wetland cover within the Lesser Slave River sub-basin. This data gap should be addressed in future studies.

9.4 Biological Indicators

Sawridge Creek with modified channel for erosion reduction. Photo by Meghan Payne.

9.4.1 Fish Populations

Habitat for fish within the Lesser Slave River varies from the outlet at Lesser Slave Lake to its confluence with the Athabasca River. Upstream of the Saulteaux River, the Lesser Slave River is a slow moving sand bed river with a low gradient (Golder, 2004). Important habitat in this portion of the river is the backwaters and the large oxbows created during channel straightening projects. The slope of the Lesser Slave River increases downstream of the Saulteaux River where the river is predominately gravel /cobble substrate with riffles and pools (Golder, 2004). In this section of the river, deep pools are present which create important fish habitat. As a whole, the river provides cool-water, turbid habitat for various fish species.

Electro fishing on the Salteaux River. Photo from AENV.

There are fifteen fish species that have been documented in the Lesser Slave River (Table 43); this includes seven species of sport fish, six species of small forage fish and two species of suckers (Golder, 2004). Golder (2004) identifies eight key species, chosen based on abundance and ecosystem importance that should be monitored. These include walleye, northern pike, lake whitefish, mountain whitefish, goldeye, longnose sucker, white sucker, spottail shiner and emerald shiner. In the following paragraphs the habitat and populations of each key species will be discussed based on the available data.

Table 43: Fish species documented in the Lesser Slave River (Golder, 2004)

Common Name	Scientific Name	Abundance
Arctic Grayling	*Thymallus arcticus*	Rare
Burbot	*Lota lota*	Rare
Emerald Shiner	*Notropis atherinoides*	Abundant, Insufficient data
Goldeye	*Hiodon alosoides*	Rare, Seasonal?
Lake Chub	*Couesius plumbeus*	Rare
Lake Cisco	*Coregonus artedii*	Rare
Lake Whitefish	*Coregonus clupeaformis*	Abundant
Longnose Sucker	*Catostomus catostomus*	Abundant
Mountain Whitefish	*Prosopium williamsoni*	Abundant
Northern Pike	*Esox lucius*	Abundant
Spottail Shiner	*Notropis hudsonius*	Abundant, Insufficient data
Trout-perch	*Percopsis omiscomaycus*	Rare
Walleye	*Sander vitreus*	Abundant, Seasonal?
White Sucker	*Catostomus commersoni*	Abundant
Yellow Perch	*Perca flavescens*	Rare

Walleye typically prefer large, shallow, turbid lakes and large turbid river habitats (Golder, 2004). It is unknown at this time whether the walleye population in the Lesser Slave River uses it for only portions of its lifecycle or for all life stages. Some data suggests that walleye are using the river for spawning as they make very limited use of the fishway located at the mouth of the river (Golder, 2004). Walleye spawning occurs just after ice break-up in rocky substrate in either high wave action lakes or turbulent rivers (Golder, 2004). Little data exists on fry and juvenile walleye within the river however, adult populations are quite abundant. Walleye are sensitive to light therefore sufficient cover is an important part of suitable habitat.

Northern pike prefer shallow lakes, rich in vegetation, with clear water or slow moving rivers (Golder, 2004). Data collected in the Lesser Slave River suggests that northern pike complete all of its life stages, spawning, fry, juvenile and adult, in the oxbows downstream of the lake and the slow moving portion of the river between the outflow and confluence with the Saulteaux River (Golder, 2004). Studies of the fishway at the river outlet show large numbers of pike utilizing it suggesting populations regularly migrate between the lake and river (Eco-Logic, 2000).

Lake whitefish generally prefer cool, well-oxygenated lakes and large rivers (Golder, 2004). Currently it is unknown if the Lesser Slave Rivers' population uses the river for all of its life stages, however, it is assumed that portions are completed in the lake. Lake whitefish prefer boulder, cobble and gravel substrate as spawning habitat which is usually found in lakes but based on the numbers of fish that have been captured in the river during the fall some spawning may be occurring in the river (Golder, 2004). Overwintering most likely occurs in Lesser Slave Lake and based on the available data it is unlikely that the river is used as a migration route from the Athabasca River. In other words the fish in Lesser Slave River are associated with Lesser Slave Lake (Golder, 2004).

Habitat for mountain whitefish is typically clear, cold rivers with temperatures between 8 and 14°C and in shallow lakes (Nelson & Patez, 1992). Mountain whitefish are abundant in the Athabasca River and are most abundant in the Lesser Slave River downstream of the confluence with the Saulteaux River to the Athabasca River (Golder, 2004). Spawning is completed over gravel shallows in lakes or streams in temperatures between 0 and 12°C (Nelson & Peatz, 1992). Historically it was thought that spawning of mountain whitefish did not occur in the river, however, recently pre-spawning and spent specimens were found in the river suggesting spawning was occurring there (Golder, 2004). Little is known about fry individuals in the Lesser Slave River but juveniles are fairly common downstream of the Otauwau River (Golder, 2004). Adults are abundant in the lower reaches of the river but overwintering remains unknown.

Goldeye usually prefer large turbid rivers and smaller lakes, ponds and marshes that are connected to them (Golder, 2004). Angler catch reports suggest that the Lesser Slave River may be an important feeding zone for adult goldeye during the summer months (Golder, 2004). Goldeye spawn in the spring in muddy backwater ponds and lakes; no data is available with evidence of spawning in the river, however there is some speculation that it does occur. No information is available on fry, juvenile or overwintering activity in the river. Based on the limited data, goldeye may use the river seasonally, entering in the spring and leaving in the fall (Golder, 2004).

Longnose suckers typically prefer deep lakes with depths greater than 10 meters and are most successful in cold (10 to 15°C) oligotrophic lakes with sufficient vegetative cover (Golder, 2004). In Lesser Slave River, longnose suckers are most abundant downstream of the Otauwau River confluence. Spawning usually occurs in riffles over gravel, cobble substrates and it is suspected that Lesser Slave Rivers tributaries are important spawning locations for the longnose sucker (Golder, 2004). Fry have been collected in portions of the river but little data is available, however, juvenile longnose suckers have been collected throughout the Lesser Slave River. It is unknown whether or not longnose suckers overwinter in the river but there is evidence that they use the fishway to enter the lake (Golder, 2004).

White suckers are most abundant in the Lesser Slave River between the weir and the confluence with the Saulteaux River (Golder, 2004). This species prefers cover (woody debris and shade) and can be found in rivers and both shallow and deep lakes (Golder, 2004). Studies suggest that white suckers utilize tributaries of the Lesser Slave River for spawning. Based on the data available, it is not known whether the fry life stage or nursery habitat is represented in the river. Most juveniles collected have been captured near the weir but data is very limited (Golder, 2004). Adults have been collected throughout the river and are most abundant upstream of the bridge, just north of the Mitsue Industrial Park. There is potential for overwintering in the river but this has not been confirmed and studies have shown that white suckers do frequent the weir (Golder, 2004).

Emerald shiners are quite widespread within Alberta and can be found in all of Alberta's major rivers and in numerous lakes (Golder, 2004). In the Lesser Slave River adults have been collected around the weir but further knowledge of their presence n the river is unknown (Golder, 2004). Emerald shiners can spawn over a large range of substrates during the summer months (June to August) however; spawning information in the river is lacking (Golder, 2004). Furthermore, no data exists on fry, juveniles or overwintering within the river. A study completed in 2000, suggests that only adult emerald shiner can ascend the weir and it may act as a barrier for juveniles (Eco-Logic, 2000).

Multiple studies on fish habitat and community inventories have been completed in the Lesser Slave River, however many are seasonally focused concentrating in particular on spring data (summer data is lacking) and cover only a portion of the river. The most complete data has been collected near the pulp mill (Slave Lake Pulp Corporation) and the weir (Golder, 2004).

The Driftwood River, a tributary to the Lesser Slave River, historically has held Arctic grayling populations (Lucko, 1987). However, in more recent sampling no sport fish, including Arctic grayling, were found (Osokin, 2004). The absence of Arctic grayling in this drainage may be attributed to angler pressure and poor stream crossings. During habitat assessments of the drainage for Arctic grayling potential, 6% of sites assessed were rated high and 34% rated as moderate for spawning; 43% were rated high for rearing juveniles and overwintering sites were lacking (Osokin, 2004). A breakdown of the fish species collected during this assessment is included in Table 44.

Table 44: Fish species present in the Driftwood River Drainage (Osokin, 2004)

Species	Scientific Name	Total	Percent of Total Catch (%)
Lake chub	*Couesius plumbeus*	42	43
Longnose dace	Rhinichthys cataractae	2	2
Pearl dace	Margariscus margarita	2	2
Brook stickleback	Culaea inconstans	20	21
Longnose sucker	*Catostomus catostomus*	3	3
White sucker	*Catostomus commersoni*	28	29

In recent years, fish sampling and habitat assessments have been completed on the Sawridge Creek drainage, a tributary to the Lesser Slave River. Historically, there is very little data on this drainage. Five permanent sample plots were established in the Sawridge Creek drainage to determine the presence/absence of Arctic grayling within the mainstem and the importance of its tributaries; locations were sampled between 2000 and 2003 (Osokin, 2004). Based on this study it was determined that the main tributary to the Sawridge Creek, near its headwaters, is important Arctic grayling habitat for spawning and rearing juveniles. Throughout the study period the following sport fish were collected; arctic grayling, northern pike and burbot; non-sport fish included lake chub, longnose dace, pearl dace, longnose sucker, white sucker, trout-perch and spoonhead sculpin (Osokin, 2004). Fish populations and fish habitat within the Sawridge Creek drainage are limited by low flows. When flows are higher there is moderate rearing and spawning potential within the stream based on diverse cover and an abundance of aquatic invertebrates (food source), however, overwintering potential is low (Osokin, 2004).

Although there are no recent published reports for the Otauwau River drainage, some sampling was completed in the summer of 1987 (ASRD, 2009a). During the 1987 sampling season arctic grayling, longnose sucker, lake chub and yellow perch were caught at multiple locations; a few sites contained longnose dace, northern pikeminnow, spoonhead sculpin and burbot (ASRD, 2009a). Similarly, no published reports are available for the Saulteaux River drainage; but sampling occurred at multiple sites during the summer of 1987, summer of 2001, and fall of 1998, 2000 an 2001. Species collected are similar to the Otauwau River with the exception of burbot , which has not been collected in this river. Furthermore, brook stickleback appears to be quite abundant in the upper reaches of this drainage (ASRD, 2009a).

Chrystina Lake, near the headwaters of Coutts Creek, which joins the Saulteaux River, has been stocked with brook trout for a number of years to expand fishing and harvest opportunities. Brook trout are a common stocking fish and can withstand lower oxygen concentrations than other trout species (ASRD, 2009h). The Fish and Wildlife Management Information System (FWMIS) contains stocking records of the lake from 2000 to 2007; between 2,000 and 2,300 fish were added each year. Brook stickleback, white sucker and yellow perch are also present in the lake (ASRD, 2009a). Tea Lakes, just east of Chrystina Lake, is stocked with rainbow trout. Records are available for 2001, 2004 and 2007; 10,050 fish were introduced the first year, with 6,000 in both years after that.

Fawcett Lake and Mink River, in the northeast corner of the sub-basin, have limited collection information. Lake whitefish, walleye and burbot are present in the lake and northern pike and walleye have been found in the river (ASRD, 2009a). In 2006, walleye stock status for Fawcett Lake was assessed; the walleye size structure was truncated at 43 cm indicating growth over-fishing (J. Tchir, F&W, pers. comm.). In response to this the regulations were adjusted to allow walleye to grow for several more years before being harvested (J. Tchir, F&W, pers. comm.). Orloff Lake, also located in the northeast corner of the sub-basin, was assessed for sport fish populations in 2004 (Patterson, 2005). Between 1999 and 2004, the walleye population in the lake was considered vulnerable. Fishing regulations relating to the number of walleye harvested, maximum bag limit and minimum size limit were adjusted accordingly to ensure recovery of the walleye population (Patterson, 2005). During the 2004 assessment, the population seems to have recovered with moderate densities of age 3, 4, 6, 7, 9, 10, 11 and 12 walleye being caught (Patterson, 2005). Furthermore, all fish sampled were mature. Between 1999 and 2004, the northern pike population in Orloff Lake was described as stable (Patterson, 2005). During the 2004 sampling a broad age class was caught but densities were low (Patterson, 2005).

10.0 Recommendations

The Lesser Slave Watershed is a large and diverse system making up 3% of Alberta's landbase. While the population in the watershed is relatively small, there is a large amount of industry in the area including oil and gas, forestry, electrical utilities as well as agriculture and urban areas. The increases in development over the last forty years have put increased pressure on the health of the watershed. Data gaps and areas for improvement are outlined below.

Water Quality

Water quality data is severely lacking within the Lesser Slave Watershed. This does not mean that there are water quality issues but we do not have a current snapshot of the water quality within the watershed. For most tributaries and the Lesser Slave Lake the most recent water quality data is 10-20 years old. Increased consistency and regular water quality assessments of Lesser Slave Lake and its tributaries are highly recommended. The data collected during these assessments should be complete enough in order to calculate the Alberta River Water Quality Index for all major tributaries. This will allow an easily understood and comparable index that corresponds to a rating system of water quality used throughout Alberta.

Currently, there are no permanent water quality monitoring stations within the watershed. The installation of a permanent water quality monitoring station in the Lesser Slave River is recommended.

Treated sewage waste from some communities enters the Lesser Slave Watershed. Concentrations of *Escherichia coli* should be monitored as a means of measuring contamination by human and/or agricultural populations within the Lesser Slave Lake and its tributaries.

Water Quantity

Throughout the majority of the watershed, water quantity has not been an issue, but flows of the major tributaries within the system should continue to be regularly monitored. The amount of water allocated for municipal use, agriculture, industry, commercial use and recreation is a very small percentage of the total volume of water in the system. Within the Lesser Slave Lake drainage basin only 0.001% of the total volume is allocated for use and within the Lesser Slave River 1.3% of the total volume is allocated. However, licence holders should continue to evaluate their water use and reduce the volume wherever possible.

The Lesser Slave River has experienced low flow problems in the past to the point where emergency measures had to be implemented. Regular flow in the Lesser Slave River is extremely important for the health of the ecosystem including healthy fish populations and riparian areas as well as providing the water needed for municipal and industrial use. During low flows dissolved oxygen and an increase in metal concentrations can become an issue. The completion of an instream flows needs (IFN) study is recommended. In addition, computer modelled IFN studies should be completed as a minimum on all the other major tributaries within the watershed.

Land Use

While recent riparian assessments have been completed on the Lesser Slave Lake shoreline and the lower portions of the South Heart and West Prairie Rivers little is known about the remaining riparian areas. Riparian studies should be completed on the rest of the tributaries within the watershed. Aerial videography assessments to assess conditions on a large scale should be coupled with on the ground assessments.

Based on the assessments that were completed, the riparian areas of the South Heart and West Prairie Rivers are in fairly poor condition, 25% and 27% respectively. This is mainly due to erosion issues, clearing of riparian vegetation for farming, unrestricted livestock access and intensive agricultural practices along river banks. Remediation work on riparian areas with poor health should be implemented. Increased public education about the importance of riparian areas is also very important for the maintenance of healthy riparian areas and the remediation of deteriorated areas.

Linear development affects all of the sub-basins within the watershed. Efforts should be concentrated on the density of linear features, especially in sensitive areas. The construction of new roads should be limited and cross-industry sharing of existing road systems should be encouraged. Road crossings can have a negative impact on streams through increasing sediment entering streams, preventing fish passage, and disrupting water flow. GIS work that is already being completed by the Fish and Wildlife Division of Alberta Sustainable Resource Development should continue; quantifying the number of stream crossings by linear feature per kilometre of stream. This should be coupled with on the ground assessments of crossings to ensure proper installation and maintenance of crossings is being achieved. Furthermore, new crossings should be minimized wherever possible.

Detailed assessments of the land base should be completed to determine a more accurate inventory of land use within the watershed. This will allow the area affected by each land use category to be quantified. Over time, changes in land use can be tracked and used as a management tool.

Increasing our knowledge of the numbers of livestock species within the watershed in order to calculate livestock density should be completed. Of particular importance is determining the density of livestock close to watercourses and riparian areas. Efforts to educate landowners on the detrimental effects livestock can have especially when in close proximity to watercourses and water bodies should be continued.

Current wetlands within the watershed should be mapped using aerial or satellite imagery. This will establish a baseline of comparison for future wetland gain, maintenance or loss.

Biological

Currently the majority of data collection on fish populations within the watershed is within Lesser Slave Lake and the Lesser Slave River. Data collection efforts should be expanded into the remaining lakes and rivers along with their tributaries. It is also important to increase the times of year that data is collected to gain a better understanding of the habitat used by each life stage of the fish species that occur in the watershed.

Data should be collected on the frequency of blue/green algae outbreaks within each basin of Lesser Slave Lake. This will allow duration and frequency of outbreaks to be tracked overtime. Increases in the duration or frequency of such outbreaks can indicate changes to water quality in the system.

Throughout the process of compiling this report it became quite clear that communication and integration between industry, various branches of government and other organizations is extremely important for the successful management of the watershed. Efforts should be made to collaborate and work together to achieve common goals.

11.0 Stewardship

Grade 5 kids learning about wetlands in Lesser Slave Provincial Park. Photo by Meghan Paynee. Photo by Ron Davis.

Stewardship is an extremely important component of watershed health. There are multiple active groups within the Lesser Slave Watershed that are devoted to its health and sustainability. The following paragraphs will provide a brief background of each of these organizations and outline projects that each has completed and are currently working on within the watershed.

Alberta Conservation Association (ACA)

The Alberta Conservation Association (ACA) formed in 1997 as a not-for-profit organization and is a registered charity. The majority of funding is provided through license levies of hunters and anglers in Alberta as well as corporate partners, which have increased over the years (ACA, 2010). The Board of Directors is made up of multiple stakeholders including representatives from hunting, trapping, fishing and naturalist groups; government, First Nations, industry, members of the public, as well as representatives from the academic community (ACA, 2010). The ACA's mission is to conserve, protect and enhance fish, wildlife and habitat for all Albertans to enjoy, value and use (ACA, 2010).

The ACA puts more than $10 million per year towards conservation efforts across the province in the form of various projects, services and programs (ACA, 2010). Within the Lesser Slave watershed the ACA has completed numerous projects over the last 10 years including the following (T. Johns, ACA, pers. comm.):

- Stream crossing assessment in the Swan River sub-basin
- Angler and test netting surveys in Lesser Slave Lake
- Cooperative fisheries inventory of sub-basins surrounding Lesser Slave Lake
- South Heart River walleye radio telemetry project
- Aerial videography assessment of the Lesser Slave Lake shoreline
- Aerial videography assessment of the South Heart & West Prairie Rivers
- Working jointly with the High Prairie Riparian Action Team and landowners to complete on the ground riparian enhancement projects.

Currently, the ACA is continuing its work with the High Prairie Riparian Action Team completing riparian enhancement projects. In addition, the ACA plans to work with the Lesser Slave Watershed Council (LSWC) to complete and aerial videography assessment of the Swan River in the summer of 2010 (T. Johns, ACA, pers. comm.).

Volunteers are required occasionally to assist with one-day projects or programs. For more information visit the website, www.ab-conservation.com.

Lesser Slave Lake Bird Observatory** and **the Boreal Centre for Bird Conservation

Photo by Ron Davis.

The Lesser Slave Lake Bird Observatory was established by a group of volunteers in 1994 as the northernmost monitoring station for bird migration in Canada (LSLBO, 2009). The mission of the LSLBO "is to gain knowledge, understanding and appreciation of boreal birds by monitoring their populations and participating in research; to produce scientifically defensible data; to deliver education programs that foster appreciation of birds and their habitat needs; and to generate awareness/support of the LSLBO within the Lesser Slave Lake region and throughout Canada" (LSLBO, 2009). Recently the Boreal Centre for Bird Conservation was opened, which focuses on education of birds and conservation issues for persons of all ages.

The LSLBO and BCBC have participated in multiple research and monitoring projects both solely and joint with other organizations including (BCBC, 2006):

- The Canada Warbler Project – study on the breeding populations of the species
- The Owl Monitoring Project – monitoring of long term population trends of Saw-whet owls
- Migration Monitoring – as part of an international effort to track the migration of landbirds
- The Christmas Bird Count – participation in annual collection of data across Canada, United States and Latin America to contribute to an ongoing database of distribution and populations of North American birds
- Project Feederwatch – tracking of winter bird populations across North America
- Monitoring Avian Productivity and Survivorship (MAPS) – monitoring of population dynamics of over 120 species of North American landbirds

Individuals who are interested in becoming a member can inquire on either website, www.lslbo.org or www.borealbirdcentre.ca.

Ducks Unlimited Canada (DUC)

Ducks Unlimited Canada (DUC) is a non-profit organization that has been in operation for over 70 years (DUC, 2009). DUC is committed to the maintenance and protection of wetlands across Canada (DUC, 2009).

Conservation efforts of Ducks Unlimited Canada include (DUC, 2009):

- Wetland and waterfowl research by scientists
- Encouraging policy changes in favour of wetland conservation when necessary
- Providing education to the public about wetlands and their importance

Individuals who are interested in becoming a member can inquire on the website, www.ducks.ca.

High Prairie Riparian Action Team (HP RAT)

Unhealthy riparian area in 2007, after riparian health improvements by HP RAT in 2008. Photo by Cows and Fish.

The High Prairie Riparian Action Team (RAT) was formed in 2001 by a group of individuals from both government and non-government conservation organizations involved in riparian area and agricultural programs (M. Heckbert, F&W, pers. comm.). Currently members are from the following organizations Ducks Unlimited Canada, SARDA, Alberta Sustainable Resource Development, Alberta Environment, Peace Country Beef Producers, Department of Fisheries and Oceans Canada, PFRA Canada, Alberta Conservation Association, Municipal District of Big Lakes and Cows and Fish (M. Heckbert, F&W, pers. comm.).

Projects are chosen based on the following priorities (M. Heckbert, F&W, pers. comm.):

- Sites on the Lesser Slave Lake shoreline
- Sites along watercourses that flow into Lesser Slave Lake
- Sites on the shores of other wetlands
- Sites on land with willing landowners

To date, riparian health improvements have been made on approximately 800 acres of riparian areas within the Lesser Slave Watershed (M. Heckbert, F&W, pers. comm.). Improvements vary between sites but most include establishing an off-site watering source for livestock and decreasing grazing pressure in riparian areas.

Regional Environmental Action Committee (REAC)

The Regional Environmental Action Committee (REAC) was established in 1992 by a group of concerned citizens and now contains more than 200 members (J. Asterisk, REAC, pers. comm.). At its inception, recycling was a major focus of the committee; since then the organization has provided recycling bins for High Prairie, Joussard, Faust and Kinuso. Over the years the committee has strived to represent the public on other potential environmental issues including treatment of hazardous waste, contaminated sites, and air, water and forest management. REAC's mission involves both public education about and activities supporting responsible waste management, sustainable energy production, sustainable resource development, airshed and watershed protection in the region (J. Asterisk, REAC, pers. comm.).

REAC has created a video series focusing on recycling; 'My Life as a Plastic Bottle' and 'My Life as a Tire' are now part of the curriculum for Grade 4 and 6 students across the country (J. Asterisk, REAC, pers. comm.). Other recent work that has been completed within the watershed includes an investigation of water quality in the tributaries to Lesser Slave Lake.

Currently, REAC is working with the Boreal Centre for Bird Conservation to install a set of solar panels and bird and bat friendly wind turbines to promote the use of renewable energy systems. The main goals of the project are to reduce the use of conventional energy of the centre and provide an educational platform regarding alternate energy to the public (J. Asterisk, REAC, pers. comm.). The project is presently in phase 1, design and fundraising, with completion of the demonstration project anticipated for the fall of 2010.

Individuals seeking additional information about REAC or who are interested in joining the committee should direct their inquiries to asterisk@telusplanet.net.

Smoky Applied Research and Demonstration Association (SARDA)

The Smoky Applied Research and Demonstration Association (SARDA) is a non-profit organization focusing on research related to agriculture and has been in operation since 1986 (SARDA, 2009). SARDA initially worked within the MD of Smoky River but has since expanded into other regions including the Lesser Slave Watershed (S. Gerbig, SARDA, pers. comm.). SARDA's goal is to "facilitate the transfer of agricultural related ideas and product information between research institutions, government departments, other organizations, industry and local producers" (info sheet).

Some recent projects include (S. Gerbig, SARDA, pers. comm.):
- Regional variety trials
- Wood ash and fertilizer comparisons for crop growth
- Seeding dates for silage
- Pest monitoring
- Industry products

SARDA also works in conjunction with other organizations within the Lesser Slave Watershed, for example, the High Prairie Riparian Action Team.

Individuals seeking additional information about SARDA or who are interested in becoming a member can inquire on the website, www.areca.ab.ca/site/sarda.

Lesser Slave Lake North Country Community Association (LSLNCCA)

The Lesser Slave Lake North Country Community Association (LSLNCCA) is a group of interested members of the public from all across Alberta, the majority of which live in the Lesser Slave Lake area. Many of the members are involved because of an interest in land management as well as the North Country Fair, a music festival that coincides with the summer solstice held annually on a parcel of land south of Driftpile. The organizations main goals are to manage cattle at the North Country Fair site, in particular protecting the riparian areas along the Driftpile River and planting and maintaining native tree and plant species at the site (Markus .E, LSLNCCA, pers. comm.).

Since 2000, the LSLNCCA has worked to repair and maintain the riparian area along the Driftpile River that flows through the fair site and the adjacent land, totalling nine quarter sections (Markus, E. LSLNCCA, pers. comm.). Damage to the riparian area was mainly caused by cattle but is also very sensitive to human disturbance. The project has included transplanting numerous local tree and shrub species from the area including white spruce, paper birch, saskatoon, river alder, trembling aspen, and wild rose. Alberta Sustainable Resource Development also donated some white spruce trees to the project. This year the association is working to secure funding to plant shrubs in the low lying areas, old oxbow lakes that occur over the site to increase habitat for ungulates and birds (Markus. E, LSLNCCA, pers. comm.).

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R. Davis, Alberta Environment (AENV). December 8, 2009.

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S. Gerbig, Smoky Applied Research and Demonstration Association (SARDA). January 22, 2010.

R. Hazewinkel, Alberta Environment (AENV). December 10, 2009.

M. Heckbert, Alberta Sustainable Resource Development, Fish and Wildlife Division. January 25, 2010.

I. Johnston, Alberta Sustainable Resource Development. January 18, 2010.

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J. Tchir, Alberta Sustainable Resource Development, Fish and Wildlife Division. January 19, 2010.

14.0 Map Information

NOTES:

- Topographic 250K mapping (NTDB) provided by Her Majesty The Queen In Right Canada [April, 2007]
- Provincial base mapping provided by AltaLIS Ltd, agent for Spatial Data Warehouse Ltd. [March, 2008]
- Watershed basin boundaries, modified from Environment Canada, PFRA Watershed project, Version 8 [March, 2008]
- Wetland classification – Anthropogenic Influenced, forested – based on imagery from 1999-2002.
- AVI data provided by FMA holders – Spring, 2009 (Alberta Plywood, Vanderwell, DMI, Millar Western)
- Note: data did not include details on how current data is from each company.
- Class E wildfires – ASRD Lesser Slave Area office [November, 2009]
- Digital Elevation Model 9DEM)/Bathymetry surface – AENV [DEM 2003, Bathymetry 1977]
- Natural Sub-regions – AB Tourism, Parks and Recreation [2005]

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