UPPER FISH CREEK

STATE OF THE WATERSHED REPORT

FOREWARD: THE VALUE OF THE FISH CREEK WATERSHED

Most people reside in quiet acceptance that the place where they live is simply their present surroundings that have little to do with their health or well-being. But I believe that where we live greatly influences how we view life, our general health and our mental well-being. Humans need contact with the natural world to feel healthy and content.

Little of the natural world is easier to access for people than a creek or a stream. Even in the city natural flowing water is accessible to everyone and riparian areas and waterways are generally public places. The proximity of the Fish Creek watershed to a large city like Calgary is a valuable resource to its people. The natural flowing water of this watershed provides one of the primal elements that are essential for our well-being and mental health.

Like fire, natural flowing water gives people a special feeling when in its presence. Everyone has experienced the joy that young people exhibit when they are around a campfire or fishing, or just boating in natural moving water. I think this is because these experiences existed as essential and spiritual experiences for our ancestors, and the exhilaration people feel today is an instinctual feeling gained in the past that tells us that these elements are necessary for our survival. Life has changed so much over time that these instincts are less vivid now and people are caught up in what they think are other essential activities. I think that this lack of awareness in our natural world is starting to contribute to physical and mental "unwellness" in our culture. I think that increased knowledge and increased activity in natural areas in this watershed is something that benefits everyone.

We may take for granted the value natural running water provides, but we only need to look a short distance east, to the vast prairie landscape that has little running water to see that the Fish Creek watershed provides economic, recreational and life sustaining benefits. This watershed also blesses us with great biodiversity that is becoming increasingly rare. People thrill to see the wildlife, birds, and plant life that exists just minutes from the City Limits.

With the 2013 flood still in recent memory, the Fish Creek Watershed Association (FCWA) hopes to better understand how a healthy watershed and intact riparian zones and wetlands along the creek function to minimize flooding events. The FCWA would like to determine whether this area is healthy enough to reduce flooding damage in the Calgary area or whether it is contributing to the damage because of its deteriorated health.

Urbanization and infrastructure development, as well as resource extraction, are pressures in this area that have to be well planned by all stakeholders considering the benefits that the watershed provides before decisions are made. A strong group of people who understand the value of a healthy watershed is an essential voice in these discussions.

The value of a watershed to the people that live in its surroundings is subtle, as subtle as quiet, natural running water, subtle enough to be overlooked or even forgotten. But the Fish Creek watershed is a valuable resource to Alberta, by creating the forests found in it, but also as a recreation and tourism resource for people from far and wide. It's valuable resource to the City of Calgary, not only in providing flood mitigation, and domestic water quality and quantity, but by maintaining the natural areas in the watershed. It becomes an ever increasingly valuable mental health resource to all people that want to access it.

We can't expect this land to remain healthy and continue to supply these many benefits unless it is understood, protected and managed. And as such, the FCWA's sponsorship of the ongoing "watership study" is both valuable and timely to our community.

- By Peter Swann, Treasurer, FCWA

UPPER FISH CREEK
STATE OF THE WATERSHED REPORT

Prepared by Palliser Environmental Services Ltd.

For the Fish Creek Watershed Association

September 2021

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Disclaimer: Data was compiled from multiple sources within the available budget to complete this report. Palliser Environmental Services Ltd. makes no assurances on the quality of the data received.

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ACRONYMS

AAF Alberta Agriculture and Forestry

ABMI Alberta Biodiversity Monitoring Institute

AEP Alberta Environment and Parks

AER Alberta Energy Regulator

AVI Aquifer Vulnerability Index

AWWID Alberta Water Well Information Database

FCWA Fish Creek Watershed Association

GIS Global Information System

GOA Government of Alberta

GW Groundwater

KID Kananaskis Improvement District

IO Instream Objective

OHV Off-Highway Vehicle

PLUZ Public Land Use Zone

SOW State of the Watershed Report

SSRB South Saskatchewan River Basin

SW Surface Water

TDL Temporary Diversion Licence

TSS Total Suspended Solids

USEPA United States Environmental Protection Agency

WCO Water Conservation Objective

WSC Water Survey of Canada

USEFUL CONVERSIONS

Multiply	by	To Obtain
Length		
cm	0.394	inches
m	3.2808	ft
km	0.6214	miles
Area		
acres	0.004046856	km^2
hectares	2.471	acres
hectares	0.01	km^2
km^2	247.1	acres
km^2	100.0	ha
Volume		
acre-ft	1234.0	m^3
acre-ft	1.234	dam^3
dam^3	0.810713182	acre-ft
m^3	0.000810713	acre-ft
m^3	0.001	dam^3
m^3	35.32	ft^3
Yield		
kg/ha	0.892	lb/acre
lb/acre	1.12	kg/ha
Discharge		
ft^3/s	0.028	m^3/s
m^3/d	0.152756420	Igpm
m^3/s	35.32	ft^3/s

1.0 INTRODUCTION

1.1 Fish Creek Watershed Association

The Fish Creek Watershed Association (FCWA) is a non-profit organization that was established in December 2020. The FCWA is interested in the stewardship of the Upper Fish Creek watershed.

Vision: Fish, Priddis and Whiskey creeks and their watershed have excellent quality and quantity of water to ensure human and agricultural needs, healthy riparian areas and fish habitat.

Mission: This citizen-led association is committed to protecting the Fish Creek watershed through citizen action for prevention of adverse impacts, education, monitoring and advocacy to sustain water quality and quantity in perpetuity.

Five strategies were identified to support the FCWA's vision for Fish, Priddis and Whiskey creeks:

1. Host educational forums to understand the trends in water quality and quantity
2. Educate and engage the community in citizen science to increase understanding of water quality and quantity
3. Fund research and periodically report on the state of the watershed
4. Facilitate collaborative planning to manage watershed resources
5. Participate in restoration activities that improve and sustain watershed health

The FCWA has hosted community meetings to increase awareness about watershed resources and stewardship opportunities, and better understand community concerns about the watershed. Water supply and availability, water quality, fisheries and headwaters management were among the top priorities based on a preliminary review. Until now, these issues have not been well described in a comprehensive way.

1.2 State of the Watershed Report

The Upper Fish Creek State of the Watershed (SOW) Report summarizes existing data to assess the current understanding and state of water quantity, water quality, riparian areas and wetlands, biodiversity and land use in the watershed. Indicators of watershed health and function were used to measure and assess conditions using established targets and thresholds where possible.

The SOW Report identifies gaps in current understanding of watershed resources, and recommends next steps that may be taken by the FCWA with respect to watershed management planning, monitoring and stewardship activities.

The Upper Fish Creek SOW Report will:

- Improve understanding of how natural features and processes influence watershed conditions
- Provide insights into the linkages between watershed health and past and current land and water uses
- Identify sensitive, at-risk areas
- Create a common understanding among all stakeholders to effectively identify issues and develop a plan of action
- Provide direction on watershed priorities, and the basis for future watershed planning

The Upper Fish Creek watershed or the "headwaters" is the focus of this report (upstream of the Hamlet of Priddis). However, the FCWA's interests and future initiatives span from this headwaters area downstream to The City of Calgary Limit near the 37 St. Bridge (Map 1.1, inset).

1.2.1 *Indicators*

Indicators are used throughout the Upper Fish Creek SOW Report to evaluate social and environmental factors that contribute to the health and function of the watershed (Table 1.1). For some indicators it was possible to describe conditions using values that range from poor to excellent. For other indicators, a trend was established and the indicators were reported as increasing, stable, or decreasing. Data was not available for all themes, thus data gaps were identified where present.

Table 1.1. Indicators used to determine watershed condition in the Upper Fish Creek watershed.

Theme	Indicator	Measure	Significance
Water Quantity	**Water Supply and Demand**	Streamflow volume (deviation from natural condition)	Streamflow should reflect a normal range of condition and support channel processes (erosion/bank building), aquatic life, and riparian areas and vegetation.
		Percentage of time streamflow meets instream objectives and/or Water Conservation Objectives	Instream Objectives and Water Conservation Objectives are established to maintain a minimum flow in creeks to support aquatic life.
		Water allocation and use	Withdrawals of water for human use (consumption, livestock watering, irrigation) can impact water availability for aquatic life and downstream users.
Water Quality	**Water Quality (e.g., dissolved oxygen, nutrients, sediment, bacteria, other)**	Deviation from baseline/normal concentration or load	Deviation of quality from baseline conditions suggests a degrading (or improving) trend. Surface water quality should support a variety of uses.
		Number of parameters and frequency that parameters exceed established guidelines or objectives	
Riparian Areas and Wetlands	**Riparian function**	Riparian health scores	Functioning riparian areas contribute to water supply, water quality, river channel stability, and biodiversity.
	Wetland cover	Percentage of watershed area	
		Wetland loss	
Biodiversity	**Fish, Wildlife and Vegetation**	Species composition Population estimates	Aquatic and upland systems that support a diverse group of fish, wildlife, and plant species are more resilient to ecological adversity or changes to environmental condition.
		Regulated invasive plants, disturbance and rare plants	
		Land cover (anthropogenic footprint)	
Land Use	**Change to human footprint**	Percentage change in land use cover (agriculture, forestry, oil and gas, urban development)	Monitors land use changes in the watershed, and quantifies cumulative impacts of multiple land uses in watersheds.
	Population	Number of people	High road densities can impact fish through increased sedimentation, impassable culverts that prevent upstream migration and increased harvest due to improved accessibility.
	Access	Road Density; traffic counts	

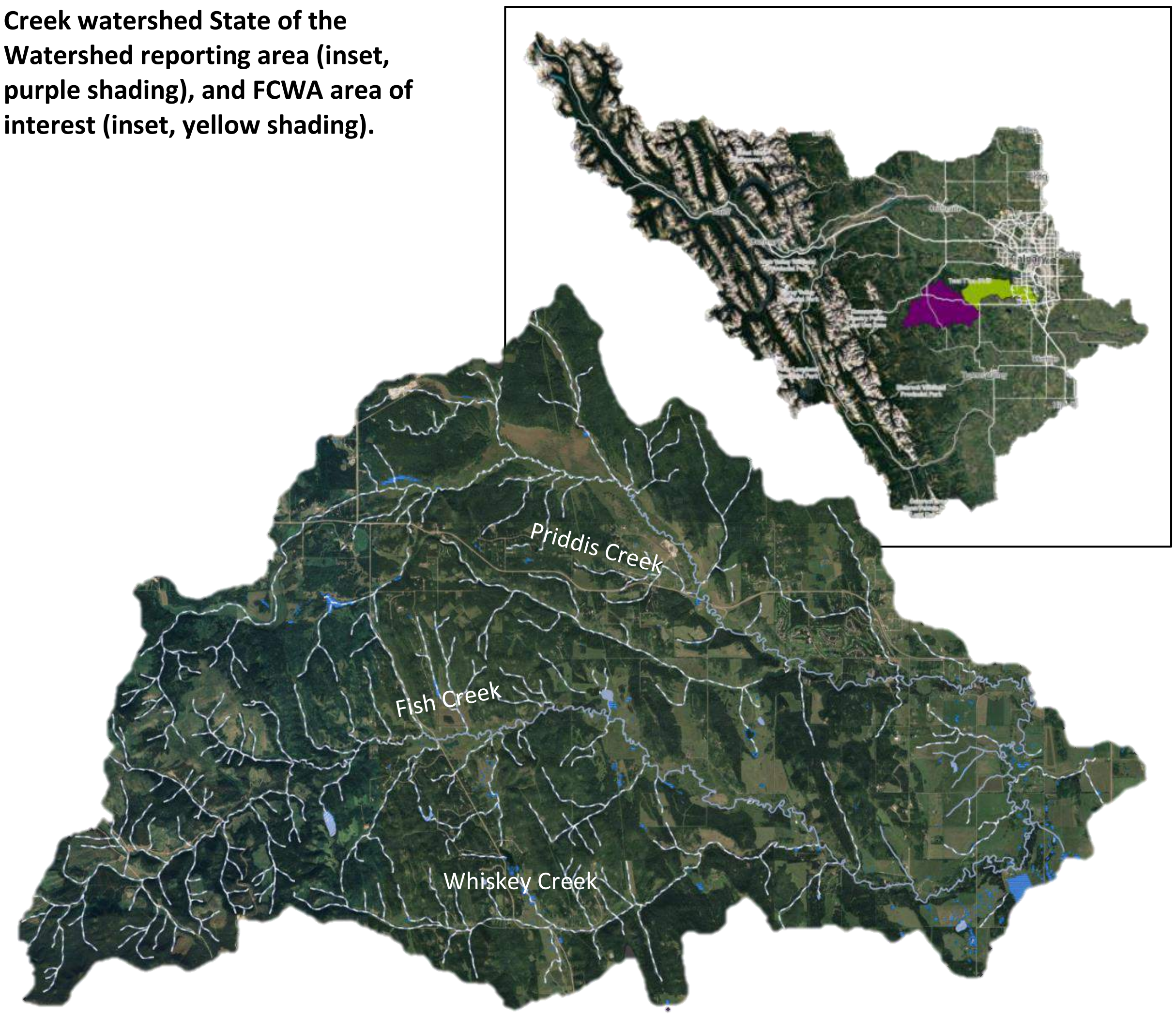
2.0 THE UPPER FISH CREEK WATERSHED

The upper Fish Creek watershed is located west of Calgary and spans an area of about 262 km^2. The watershed is comprised of Fish Creek, and its two main tributaries, Priddis Creek and Whiskey Creek (Map 2.1). Fish Creek rises in the Montane natural subregion, and flows about 55 km before it is joined by Priddis Creek at the Hamlet of Priddis. Whiskey Creek flows northward and joins Fish Creek upstream of the Hamlet of Priddis.

The headwaters of Fish Creek rise in the Kananaskis Improvement District (KID), within the McLean Creek Public Land Use Zone. This area is heavily used for recreation, particularly the use of off-highway vehicles. Forestry activity is present and harvest activities are easily visible. The KID also supports livestock grazing. Downstream, there is a mix of agricultural lands and country-residential developments that have established along Hwy 762.

At the lower reach, higher-density country-residential developments predominate, situated north and south of Hwy 22, and bordering Priddis Creek and Fish Creek. The Priddis Greens Golf Course (which has two 18-hole courses) and the community of Priddis are also located in this reach.

Map 2.1. Map of the Upper Fish Creek watershed State of the Watershed reporting area (inset, purple shading), and FCWA area of interest (inset, yellow shading).



2.1 Geography

Alberta's natural regions are defined by the topography, climate, and the natural vegetation and soils that are present in an area. Two of Alberta's natural subregions are represented in the Upper Fish Creek watershed. The western part of the watershed is characteristic of the Montane natural subregion, and the eastern part reflects the Foothills Parkland natural subregion (Natural Regions Committee 2006).

2.1.1 Topography

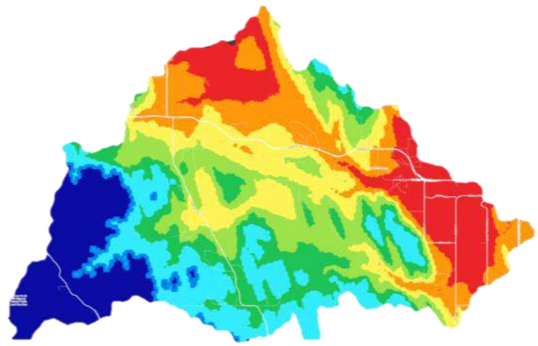
The highest elevation in the Upper Fish Creek watershed is 1,793.7 m a.s.l. and is located in the MacLean Creek PLUZ. The lowest elevation is located near the Hamlet of Priddis (1,182.1 m).

2.1.2 Climate

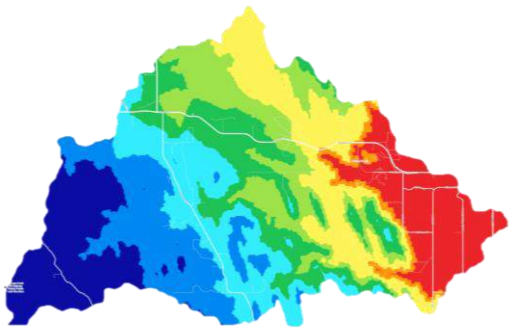
Annual precipitation averages 457 mm/year, and ranges from about 400 mm/year in the north and eastern part of the watershed, to about 486 mm/year in the west (Map 2.2; Stelfox 2020).

Average annual air temperature is about 1°C in the western part of the watershed and 2.8°C in the east (Map 2.3; Stelfox 2020).

Map 2.2. Annual Average Precipitation (mm)			
	476-486		439-446
	461-476		424-439
	453-461		413-424
	446-453		Min-413



Map 2.3. Annual Average Air Temperature (°C)			
	Min-0.98		2.41-2.55
	0.98-1.51		2.55-2.64
	1.51-2.18		2.64-2.74
	2.18-2.41		2.74-2.81



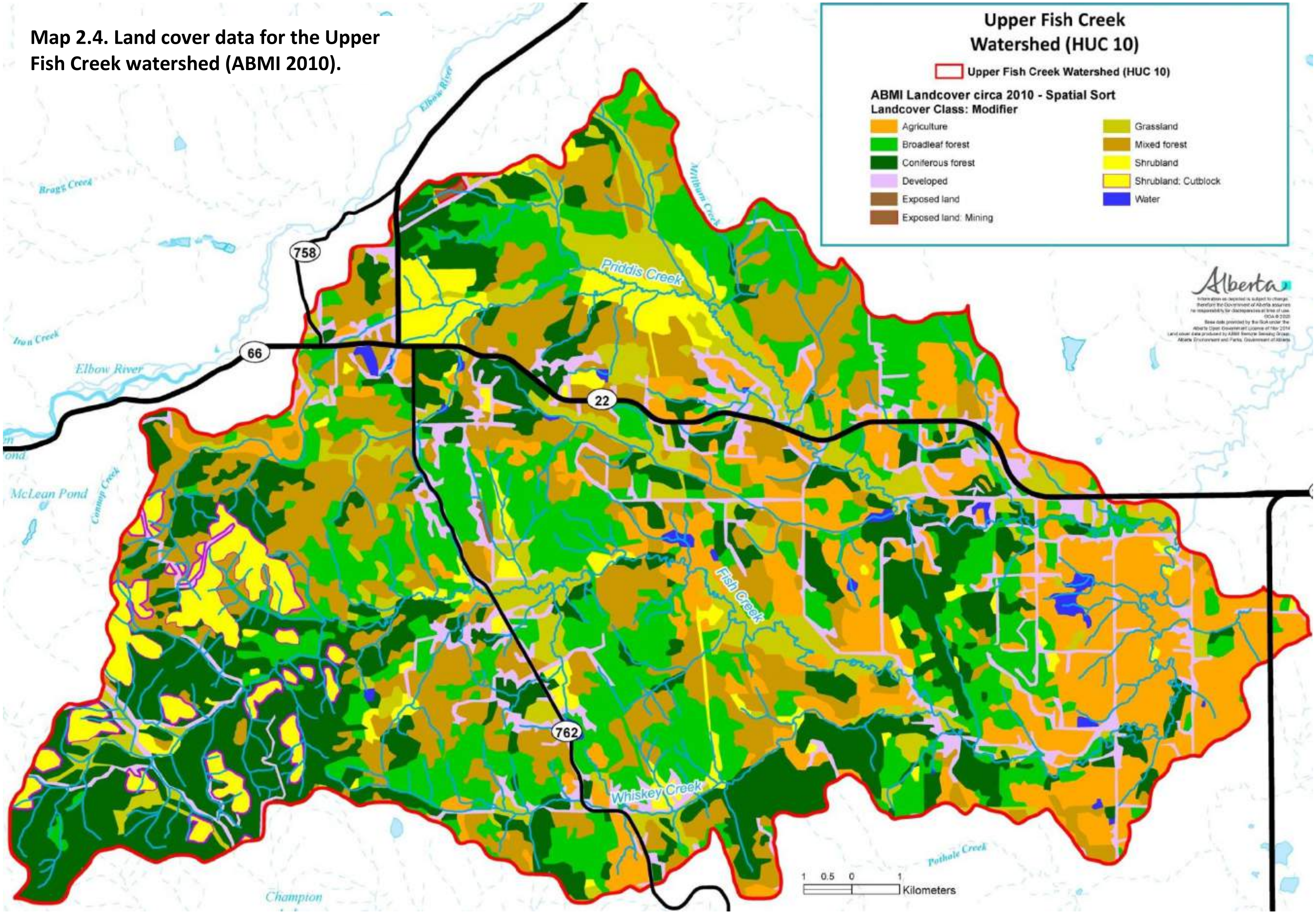
2.1.3 Land Cover

The Upper Fish Creek watershed is characterized by dense coniferous, deciduous and mixed forests that border Fish Creek. Forested areas cover about 60% of the watershed (Map 2.4). Shrubland covers about 7% of the watershed. Shrubs have encroached on previously harvested areas in the headwaters, and are also a dominant feature in the Priddis Creek sub-basin.

Native grassland covers about 8% of the watershed, and is also used for agricultural grazing land.

Although the ABMI land cover map shows the area adjacent to Priddis Creek as shrubland, the Alberta Merged Wetland Inventory (and other wetland GIS data sources), indicate that these areas are likely wetlands (Section 5.2; Map 5.1). From aerial or satellite imagery, these wetlands can look very similar to terrestrial land. Open water covers under 1% of the watershed area.

Map 2.4. Land cover data for the Upper Fish Creek watershed (ABMI 2010).



2.2 Settlement, Population and Administration

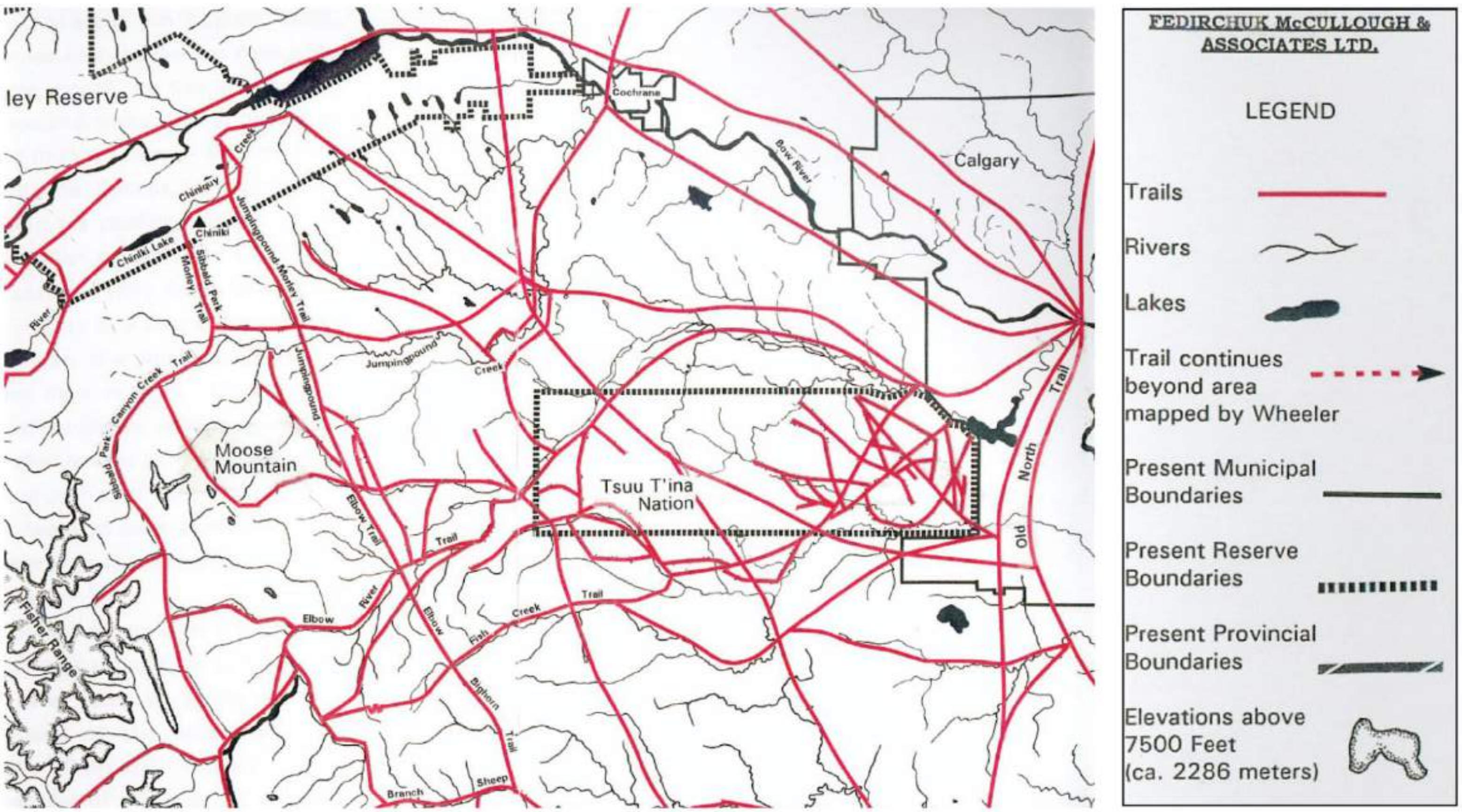
2.2.1 First People

The Upper Fish Creek watershed resides in Treaty 7 and is the traditional lands of Tsuut'ina Nation. The Tsuut'ina are thought to have travelled to the region about 600 years ago. Early written records kept by fur traders in the 1700s indicate Tsuut'ina's association with the foothills and eastern slopes.

Trails were established historically along Jumpingpound Creek, Elbow River, Fish Creek and Priddis Creek (Map 2.5). These trails provided access to important areas such as Moose Mountain.

The name Tsuut'ina comes from the Athabaskan (Dene) meaning "many people."

Map 2.5. Historic trails in the region of Upper Fish Creek watershed (Tsuut'ina Nation and Husky Oil 1995).



2.2.2 European Settlement

European settlers arrived with the construction of the Canadian Pacific Railway. Mr. Charles T. Priddis was one of the first to homestead in the area. He was born in 1844 in London, England, and arrived in Calgary with a C.P.R. crew. In 1883, he settled at the NE 1/4 22-22-3-W5. Charles made many contributions to the area that are still recognized today. He donated the land for the Priddis School, as well as for the Priddis Farmers and Ranchers Hall, and the St. James Church. He passed away in 1921 (SAPD 2021).

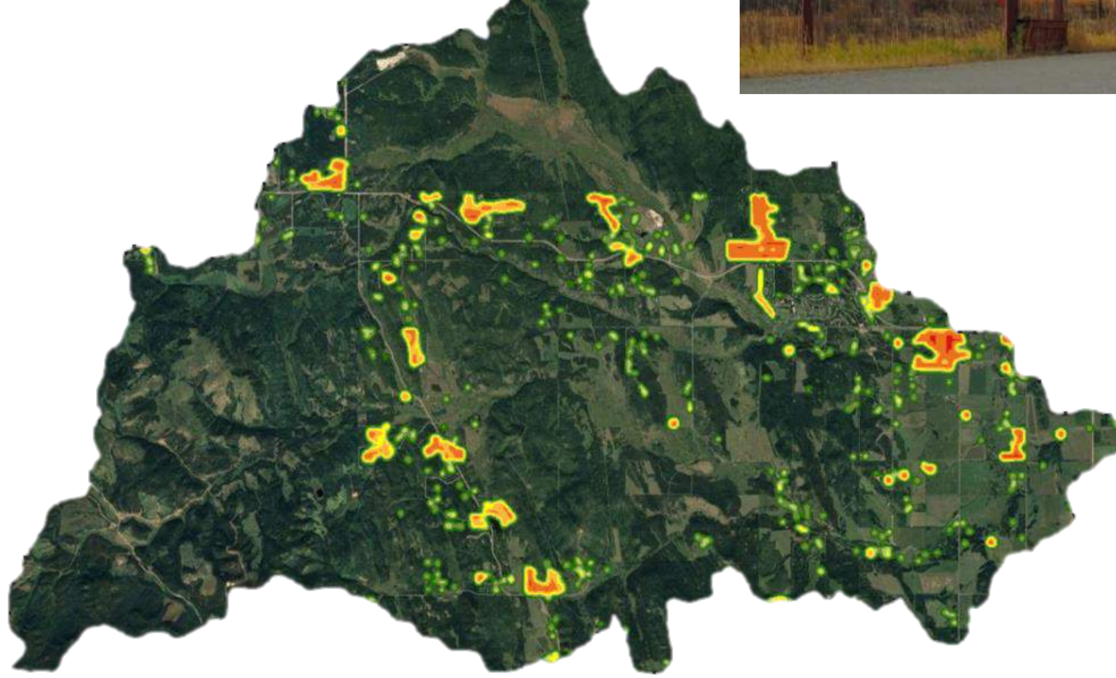
2.2.3 Population

Today, about 9% of the Upper Fish Creek watershed is considered developed (Map 2.4). Most of the population in the watershed is concentrated in the communities situated near Priddis, north and south of Hwy 22x, and the Hwy 762 corridor (Map 2.6).

Near Priddis (and south of Hwy 22x) there are about 286 homes represented in the communities of Hawks Landing, Priddis Greens Golf Course, and the Hamlet of Priddis. Further west, and including north of Hwy 22x there are about 115 homes. There are about 186 homes adjacent to Hwy 762, including the community of Fish Creek Ranch.

As of 2019, the population in the watershed was estimated to be 2,229 residents (8.5 people/km^2). There are about 2,169 residents in the area represented by Foothills County (Foothills County, pers. comm.), and about 60 residents in Rocky View County (Rocky View County, pers. comm.).

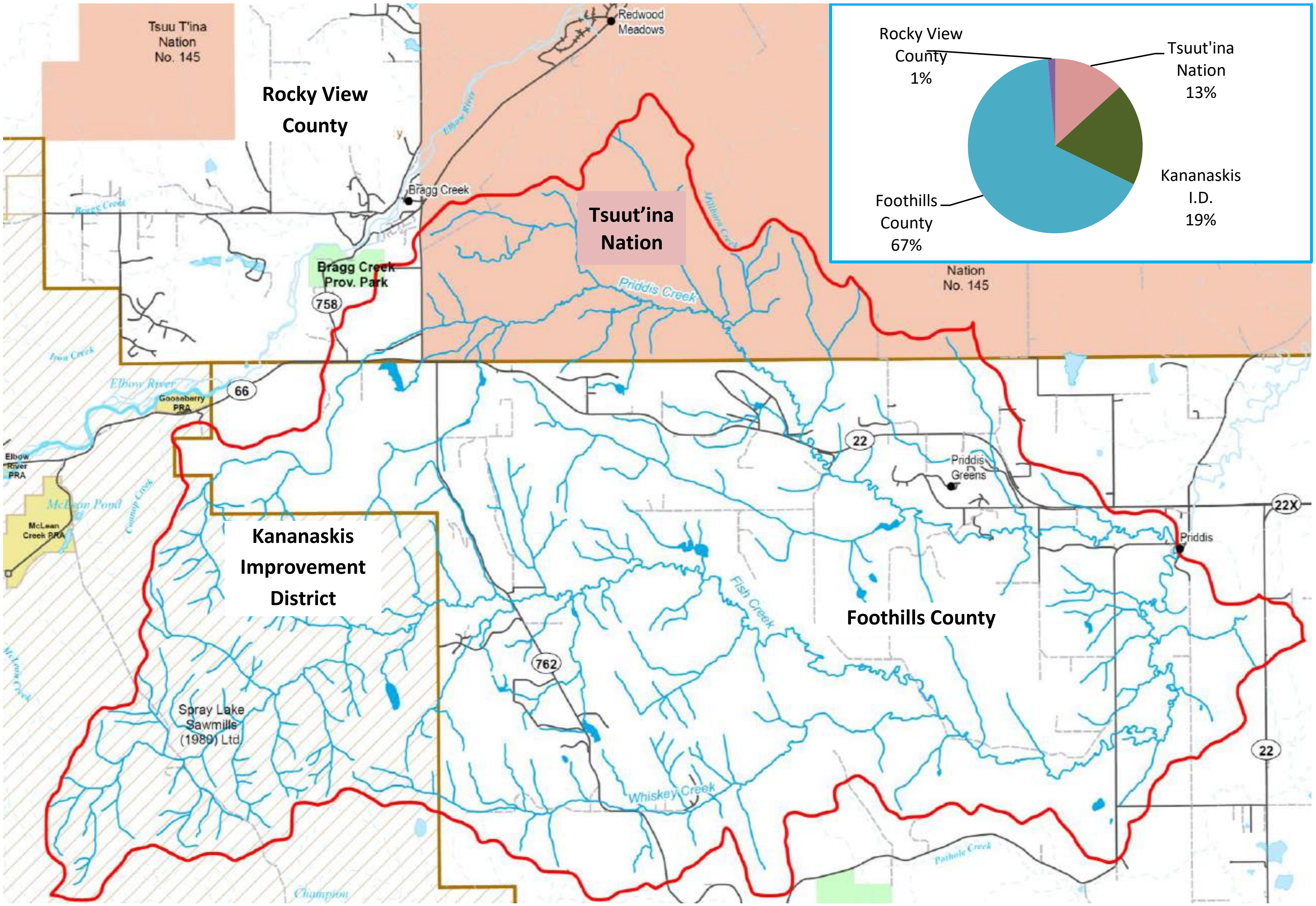
Map 2.6. Population distribution in the watershed (Stelfox 2020).



2.2.4 Administration

The Upper Fish Creek watershed is administered by Tsuut'ina Nation (13%) and Rocky View County (1%) in the northern part of the watershed, Kananaskis Improvement District (19%) in the south-west, and Foothills County (67%) in the central, southern and eastern regions (Map 2.7).

Map 2.7. Administrative boundaries in the Upper Fish Creek watershed.



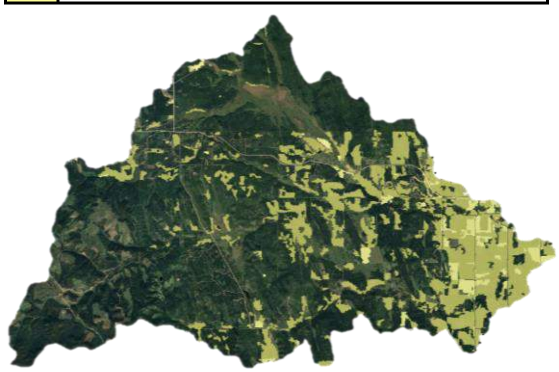
2.3 Land Use & Development

2.3.1 Agricultural Industry

Agricultural lands are comprised of annual and perennial croplands (tame pasture), which cover about 15% of the watershed. Grassland covers about 8% of the watershed and contributes to grazing lands. Cultivated crops are predominantly found in the eastern part of the watershed, with some isolated fields in the forested area (Map 2.8).

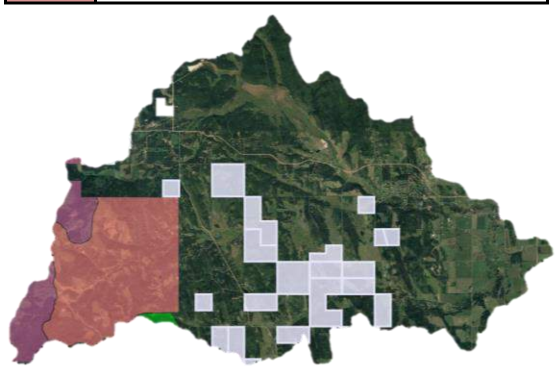
Hay and green-feed forage crops are the main crops grown in the watershed. Due to a generally short growing season, grain crops only reach maturity occasionally (P. Swan, pers. comm.).

Map 2.8. Agricultural lands.	
	Pasture
	Cropland



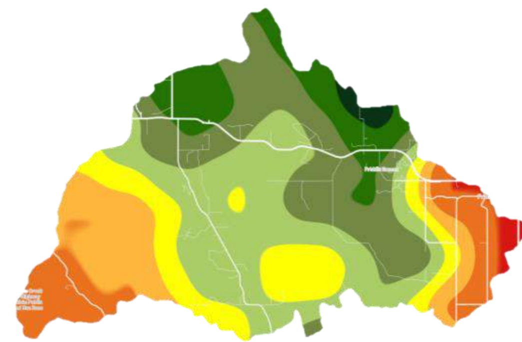
There are 22 grazing dispositions in the watershed that cover an area of about 76 km^2 (Map 2.9). Of the disposition types, there are 18 Grazing Leases (26 km^2), 1 Grazing Permit (<1 km^2), and 3 Forest Reserve Grazing Allotments (50 km^2).

Map 2.9. Grazing dispositions.	
	Grazing Lease
	Grazing Permit
	Forest Reserve Grazing Allotment



Livestock distribution was estimated as number of head per km^2 and is shown in Map 2.10. Higher livestock densities are generally found in the upper watershed, in the McLean Creek PLUZ, and in the most eastern part of the watershed (Map 2.10) It was estimated that there are about 2,300 head of cattle in the watershed.

Map 2.10. Estimated livestock density (head/km^2)			
	0.000		3.584
	0.355		7.684
	1.332		15.711
	2.268		>20.639



2.3.2 *Oil and Gas Industry*

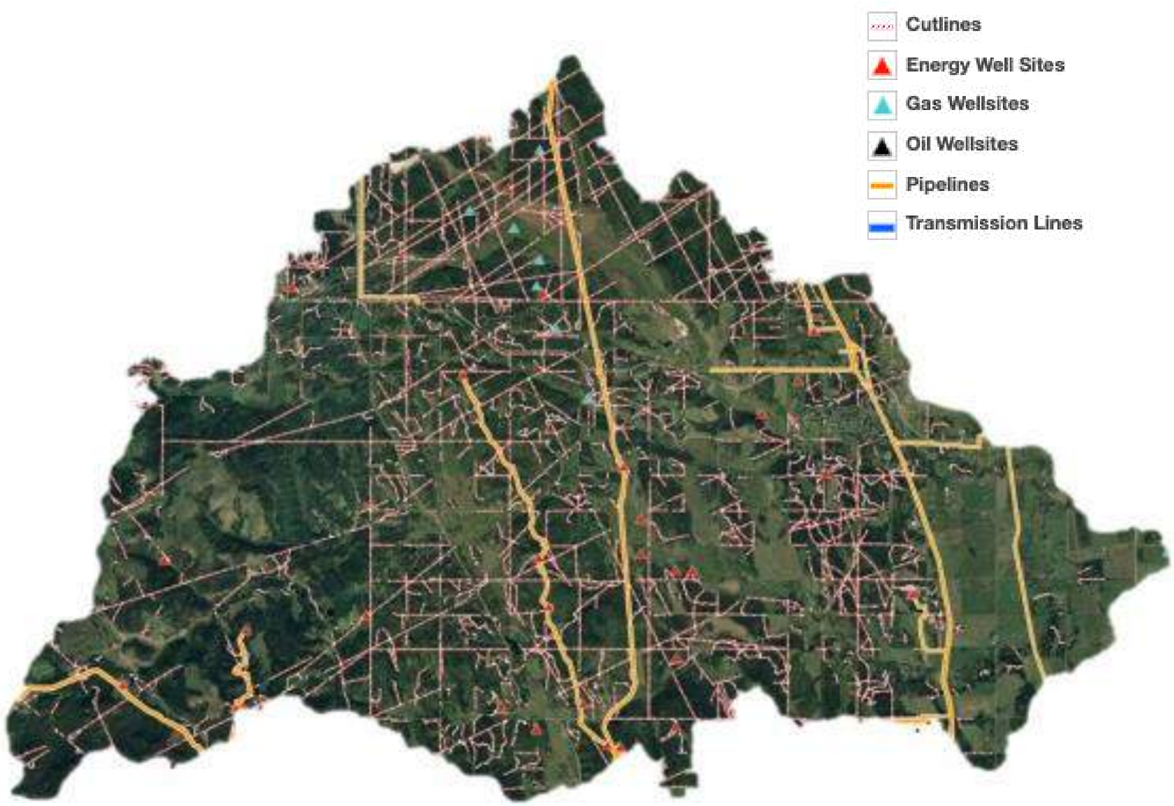
The oil and gas footprint is approximately 4.6 km^2 or 1.8% of the watershed (Map 2.11). Most of the footprint is associated with linear disturbances such as seismic lines and pipelines.

Little information was readily available to report on for this sector. However, according to the Alberta Energy Regulator (AER) (2021), there are 27 abandoned oil and gas wells listed in the Alberta Abandoned Wells Database that are owned by 20 different companies.

2.3.3 *Sand and Gravel*

Foothills County operated a gravel pit in the vicinity of Priddis Greens Estates from about 1992 to 2017. It is the only sand and gravel pit in the watershed. The gravel pit is no longer active and is scheduled to be reclaimed (S. Oel, pers. comm.).

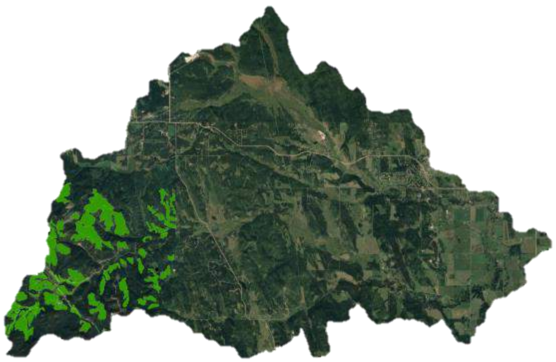
Map 2.11. Oil and gas sector footprint in the Upper Fish Creek watershed (Stelfox 2020).



2.3.4 Forest Industry

Forestry activity occurs in the headwaters of Fish Creek. Previously harvested areas cover an area about 14.8 km^2 or 5.7% of the watershed (Map 2.12; Stelfox 2020).

Map 2.12. Previously harvested areas (Stelfox 2020).



Spray Lakes Sawmills currently operates in the Upper Fish Creek watershed under Forest Management Agreement 0100038 in the McLean Creek Compartment. The operational areas extend beyond the boundary of the Upper Fish Creek watershed. General harvest plans are set for the period 2021 to 2025, and include harvests in the McLean Creek Compartment during the 2021/2022 and 2022/2023 seasons (SLS 2021).

Watershed protection is considered during forestry planning and operational stages. Watershed protection standards and guidelines have been defined for road construction and harvesting activities that specify the requirements for establishing crossing structures, road locations, machine-free zones, and stream buffers. Watercourses ranging from ephemeral streams to rivers and lakes are classified for protection according to provincial guidelines (SLS 2021).

Site-specific assessments are completed before harvest plans are developed. The assessment information is used to plan access routes and boundary locations to minimize watershed disturbance. All operations must be planned and conducted in compliance with provincial & federal regulations and Operational Ground Rules (SLS 2021).

2.3.5 Tourism and Recreation

The Upper Fish Creek watershed is a popular recreation area for many local residents and visitors. The MacLean Creek Public Land Use Zone (PLUZ), in particular, is a popular destination for hiking, fishing, camping and off-highway vehicle (OHV) use.

Based on registration data (self-registrations and more recent Reserve Alberta Parks information) the number of people using the McLean Creek PLUZ has been increasing annually, from 12,760 registered campers in 2012 to 15,993 registrants in 2020 (an increase of 25%) (B. Johnston, pers. comm.).

While the objective of Alberta's PLUZ are to protect the environment while allowing responsible and sustainable use of the land, it can be challenging to manage the cumulative impact of multi-users in headwater systems.

The cumulative impact of recreation activities, in addition to other activities (e.g., forestry, livestock grazing and oil and gas activity) can be large when users do not heed trail signs or bridges placed to reduce impacts and preserve ecosystem functions.

Generally, unmanaged use can have large impacts on the headwaters of small creek systems like Fish Creek. Loss of fish habitat and poor water quality can result when recreation vehicles repeatedly drive through wetlands and streams.

There has been little work completed to understand the impact of multi-use areas on Upper Fish Creek.

Stewardship Effort in the McLean Creek PLUZ: Rocky Mountain Dirt Riders Association

Local OHV clubs are working to encourage better stewardship of trail networks in the headwaters of Fish and Priddis creeks. The Rocky Mountain Dirt Riders Association (RMDRA) is helping to re-define stewardship on the trail through signage and structures that mitigate damage in sensitive areas and at watercourse crossings (P. Adams, pers. comm). Some initiatives taken by the RMDRA encourage single track riding in wet areas (see photos).

The Alberta OHV Association (AOHVA) also has a 4-point plan for environmentally responsible OHV use to ensure that past damage is corrected and not repeated in the future. Part of the 4-point plan includes working in collaboration with government and other users to promote environmental stewardship (AOHVA 2021).

2.3.6 *Access*

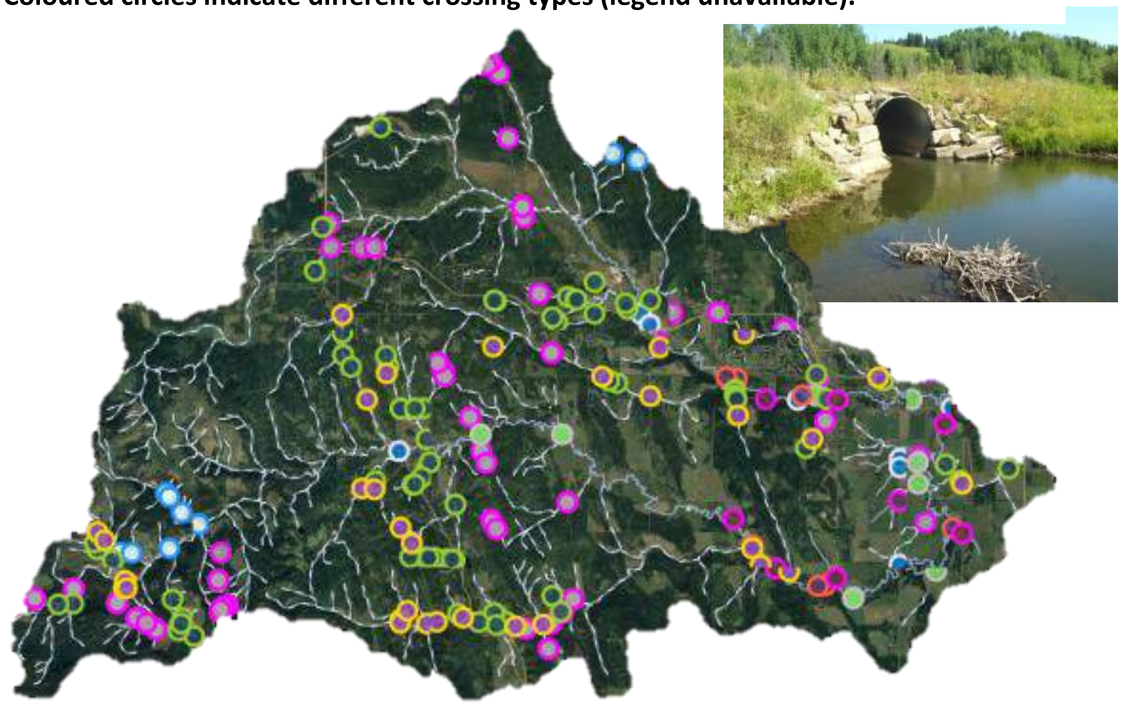
The cumulative effects of land use can best be reported by linear developments (including roads and pipelines) that contribute to cumulative effects. In the Upper Fish Creek watershed, there are about 345 kms of road surface that is divided among private roads (including driveways) (102 km), gravel roads (162 km) and paved roads (81 km).

Stream Culverts and Crossings

A preliminary assessment of stream crossings identified a number of crossing locations in the Upper Fish Creek watershed (Stelfox 2020). More than 172 major crossing locations were identified related to pipelines, truck trails and roads (Map 2.13) (Stelfox 2020).

Studies have found that as the number of stream crossings increase, fish habitat tends to degrade. Stream crossings can isolate fish communities when habitat is fragmented or made inaccessible through improperly placed or maintained culverts. Streams impacted by stream crossings tend to have poor water quality and increased sedimentation.

Map 2.13. Stream crossings in the Upper Fish Creek watershed (Stelfox 2020). Coloured circles indicate different crossing types (legend unavailable).

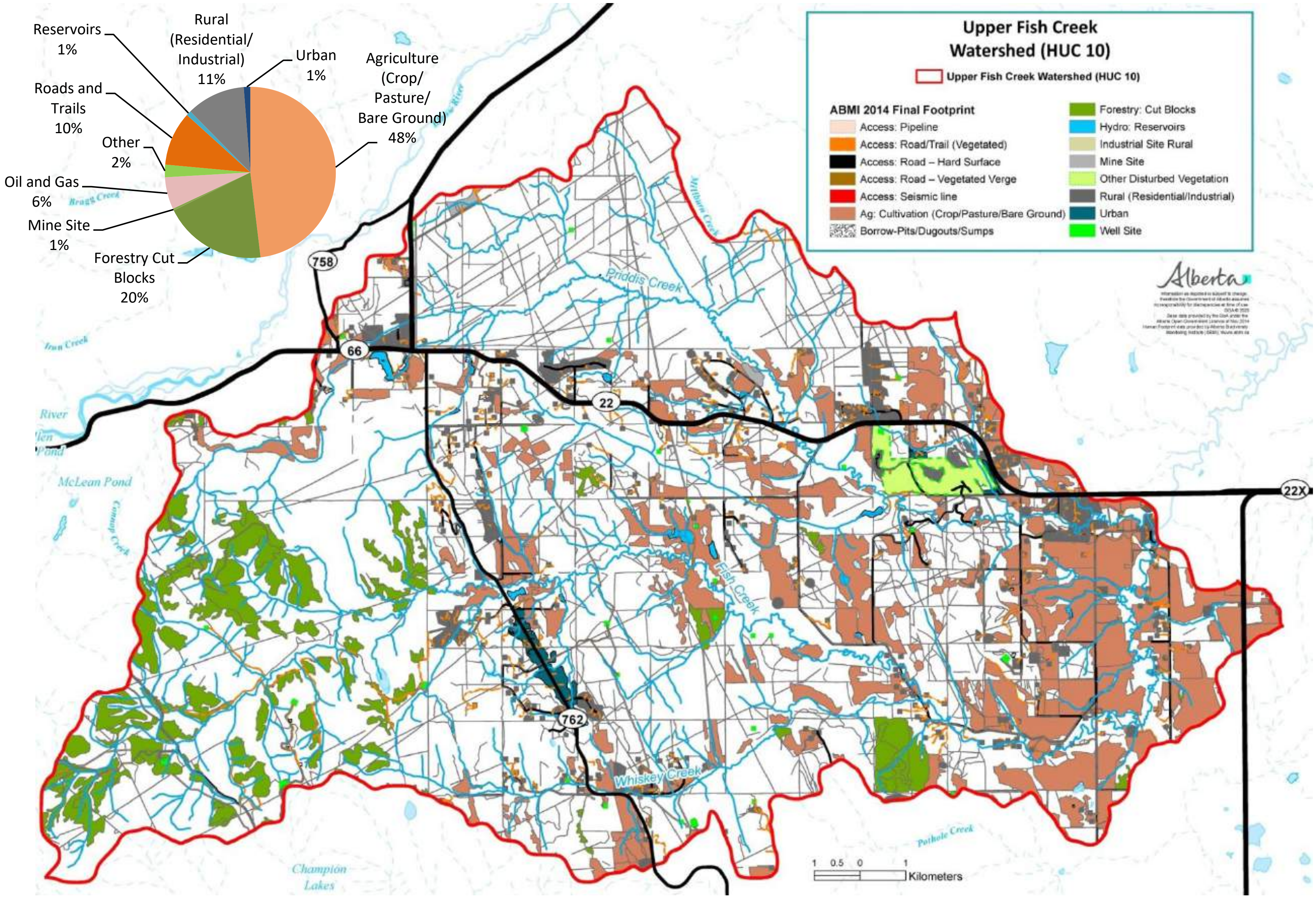


2.3.7 *Cumulative Impacts*

The Upper Fish Creek watershed is a relatively small watershed that is under pressure from population growth and the impacts of multiple land uses in the watershed. The human footprint is a measure of land use and development (Map 2.14). Multiple uses can impact the natural hydrologic and ecological functions of watersheds when activities are planned and managed independently. The human footprint in the watershed is estimated to be 75.7 km^2 or 29% of the watershed area.

It is important to understand how the human footprint impacts on the natural environment. The following sections describe what is known about environmental conditions in the watershed as they relate to water quantity (including availability and supply), water quality, riparian health and biodiversity.

Map 2.14. Human footprint in the Upper Fish Creek watershed. The pie chart shows the percentage contribution of land use to the total footprint.



3.0 WATER QUANTITY

3.1 Water Supply

3.1.1 Surface Water

Fish Creek and its two main tributaries Priddis Creek and Whiskey Creek form an important hydrologic network that supplies water from the headwaters, through wetlands and shallow groundwater aquifers, downstream to support aquatic life, and to serve as community water supplies. Water quantity is an interest to many residents in the Upper Fish Creek watershed who rely on stable surface water and groundwater supplies for drinking water, irrigation water, recreation, and to support aquatic life. The following discusses water supplies at Fish Creek and Priddis Creek, the history of water management in Alberta, and water allocation and use.

Fish Creek

The Water Survey of Canada measures streamflow in Fish Creek at the gauging station "Fish Creek near Priddis" (Station 05BK001). This station was operated annually from 1908 through 1916, and seasonally from March through October since 1956 (Figure 3.1). The long period of record for this station indicates that average seasonal streamflow in upper Fish Creek ranged from a low of 0.20 m^3/s in 1984 to a high of 4.12 m^3/s in 2005. The three highest average seasonal flows were recorded in the last 15 years, in 2005, 2013 and 2011, while the lowest seasonal flows were recorded in 1976, 1984 and 1988 (Figure 3.1). Hydroconsult (2003) reported that Fish Creek flow decreased to less than 0.25 m^3/s more than 50% of the time in September-October, and to less than 0.1 m^3/s more than 50% of the time during December to February. Zero flow has been recorded for the entire month in September, and January to March (Hydroconsult 2003).

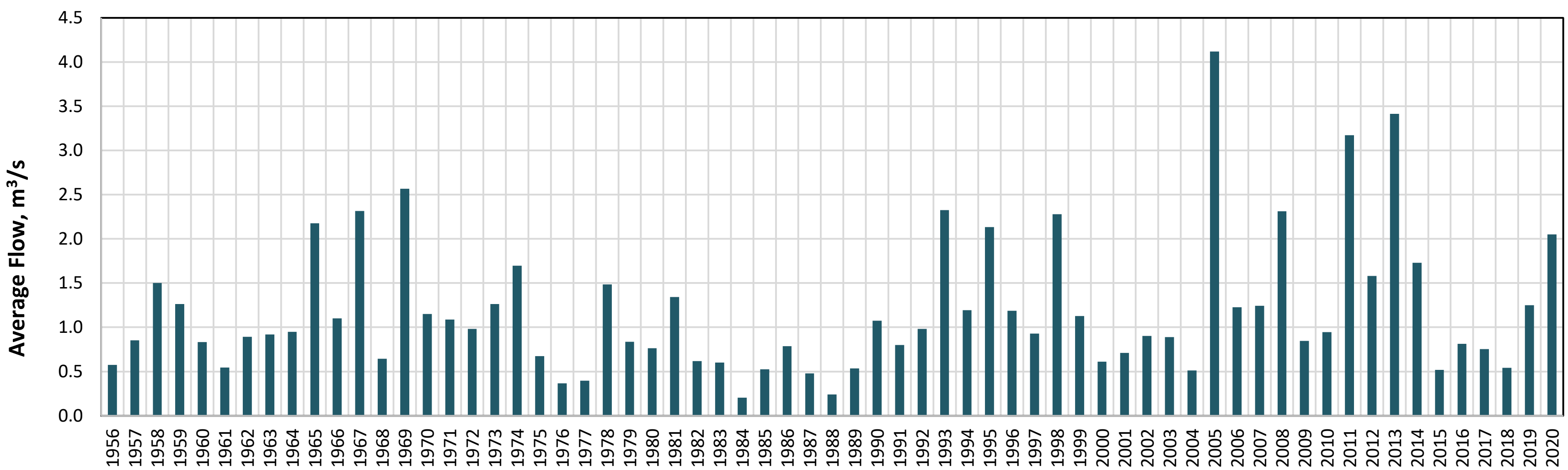
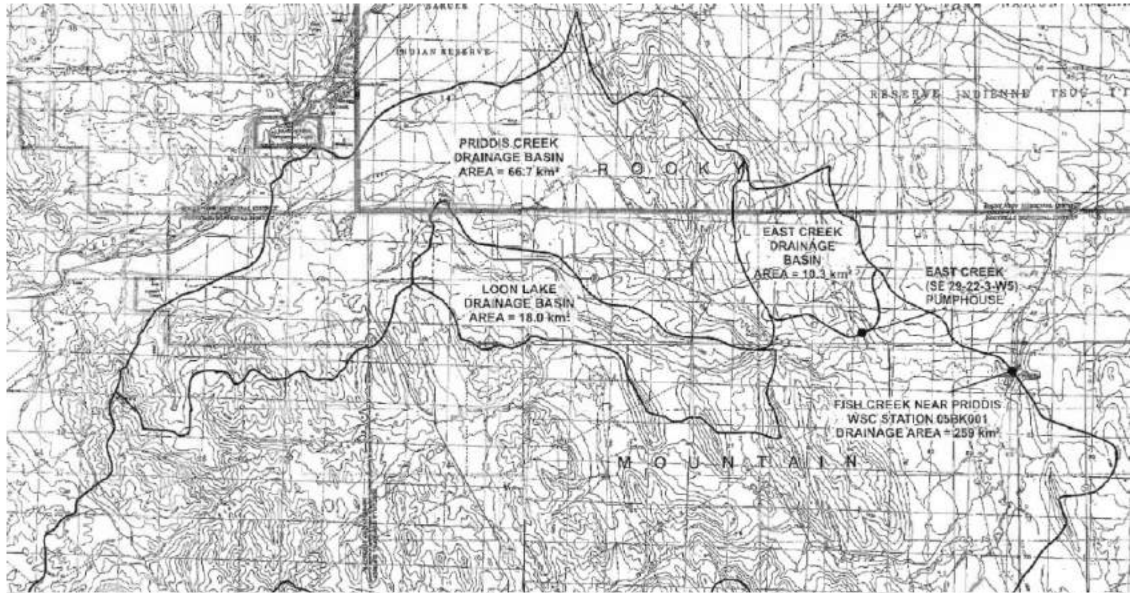


Figure 3.1. Average seasonal flow (March-October) at Fish Creek near Priddis (05BK001), (Water Survey of Canada 2020).

Total daily streamflow volume was determined from daily streamflow measurements. Figure 3.2 shows total daily volume discharge for Fish Creek near Priddis. The historic discharge record that was set in 1916 (greater than 17,000 dam^3) was equalled in 2013, nearly 100 years later (Figure 3.2).

Priddis Creek

Weekly streamflow measurements (Jan-Dec) were collected at Priddis Creek from 2008 to 2020 by an independent contractor (Foothills County 2020). The station is located about 10.5 kms upstream of the confluence with Fish Creek (as measured in creek kms).



Map 3.1. Delineation of the Priddis Creek, Loon Lake and East Creek sub-basins in the Upper Fish Creek watershed.

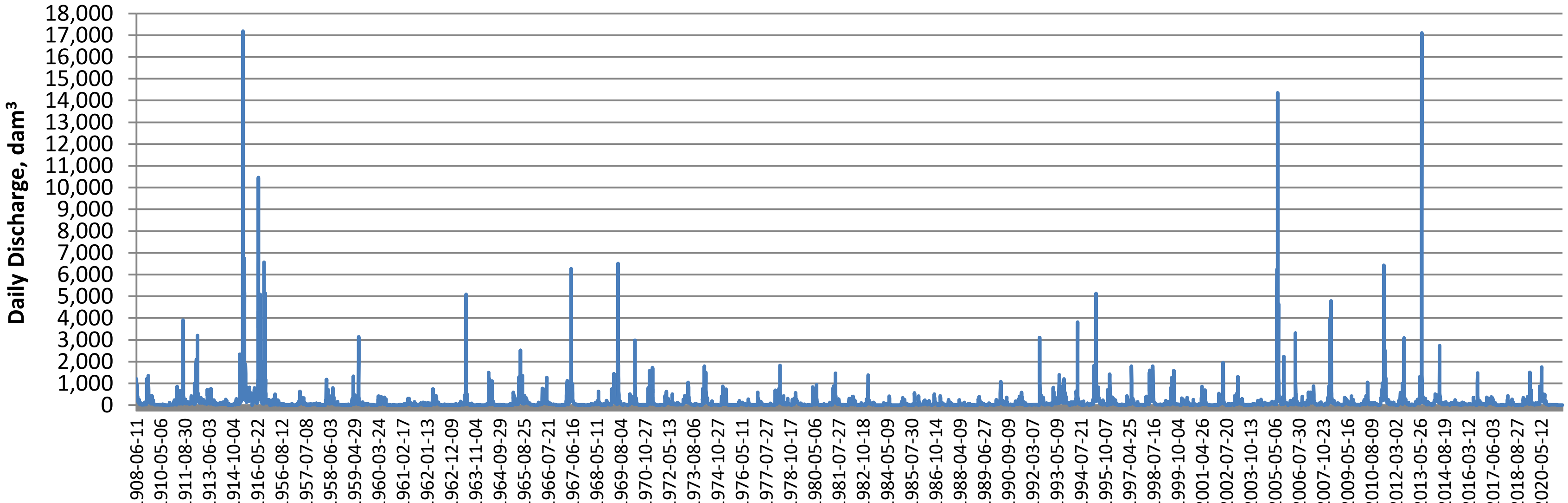


Figure 3.2. Daily discharge volume (dam^3) for Fish Creek near Priddis (Station 05BK001) (1908-16; 1956-2020) (https://rivers.alberta.ca/).

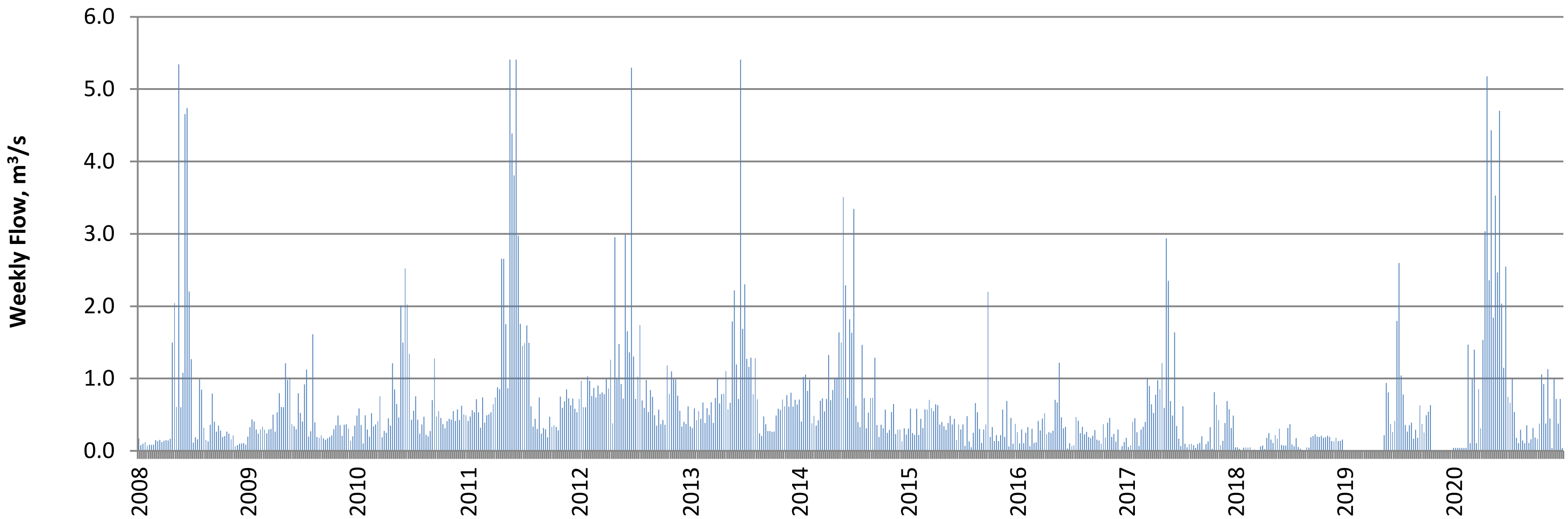


Figure 3.3. Weekly streamflow measurements at Priddis Creek, 2008 through 2020 (Foothills County 2020).

Weekly streamflow measurements in Priddis Creek (2008 to 2020) ranged from a low of 0.007 m^3/s in July 2018 to greater than 5.407 m^3/s in May and June 2011, and June 2013 (Figure 3.3).

The highest average flow for the open-water season (Mar-Oct) was recorded in 2011 (1.365 m^3/s), while the lowest average flows occurred in 2015, 2016, 2018 and 2019, with 2018 being the lowest (0.132 m^3/s) (Figure 3.4).

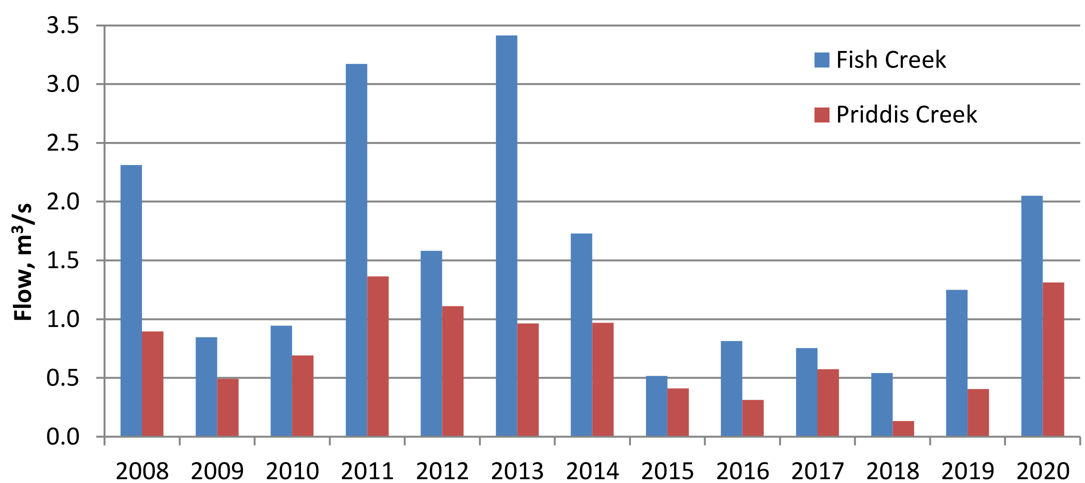


Figure 3.4. Comparison of average open-water flow (March to October) at Priddis Creek and Fish Creek (Station 05BK001), 2008 to 2020. Note average flow in 2020 represents the period mid-April to October for Fish Creek only.

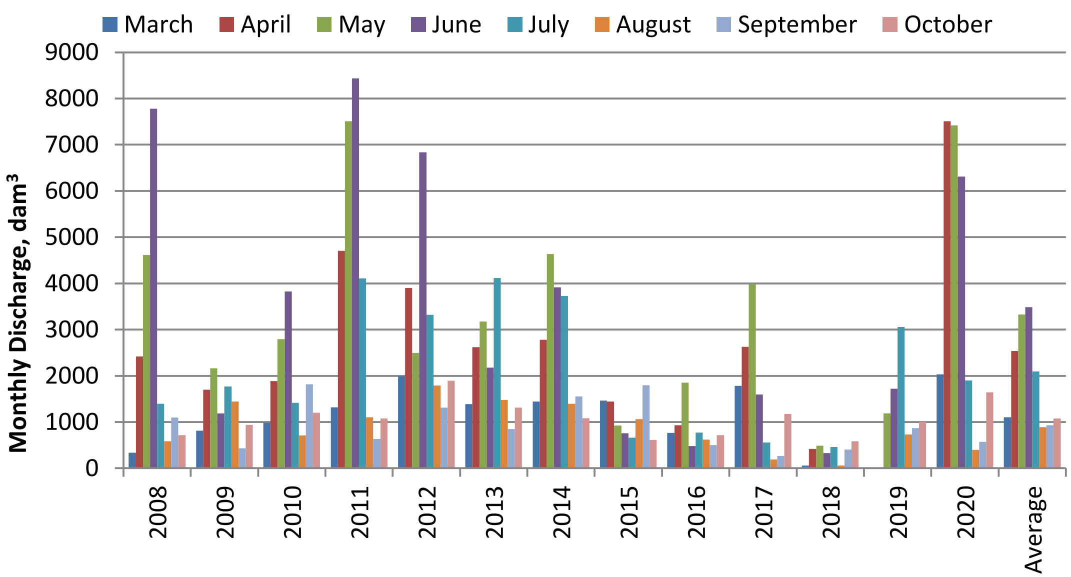


Figure 3.5. Monthly discharge during the open water season at Priddis Creek, 2008-2020.

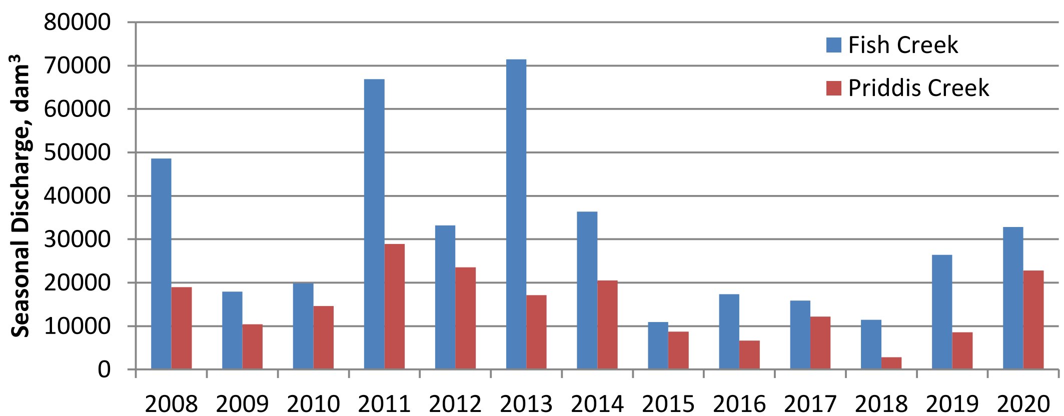


Figure 3.6. Comparison of total open-water season discharge (Mar-Oct) at Fish Creek and Priddis Creek, 2008-2020. Note discharge for 2020 represents the open water season from mid-April to October for Fish Creek and Priddis Creek for equal comparison.

During the open-water season, total discharge tends to vary considerably between months and years. On average, monthly discharge (2008-2020) at Priddis Creek ranged from about 889 dam^3 (August) to 3,488 dam^3 (June) (Figure 3.5). Total discharge (Mar-Oct) was lowest in 2018 (2,802 dam^3) and highest in 2011 (28,891 dam^3) and 2020 (27,778 dam^3) (Figure 3.5). In 2018, Priddis Creek was nearly dry during the months of March and August 2018 when flow was about 60 dam^3. In 2020, higher flows volumes were observed in April, May and June, while flow volume in August and September was substantially lower.

From 2008 to 2020, Priddis Creek contributed an estimated 23% to nearly 80% of the total discharge volume measured at the 'Fish Creek near Priddis' gauging station (Figure 3.6). Similarly, in a review of hydrology at Priddis Creek, Hydroconsult (2003) estimated that Priddis Creek contributed about 25.8% of the flow at 'Fish Creek near Priddis'. The Loon Lake inflow was expected to account for 6.9% of the flow, and East Creek (see Map 3.1 for locations) was expected to account for an additional 3.2% of the flow, with all three sources contributing 35.9% of the flow at Fish Creek near Priddis (Hydroconsult 2003).

3.1.2 Groundwater

Groundwater is an important contributor to water supply in the upper Fish Creek watershed. Groundwater is replenished in "recharge areas", and contributes water to streams and lakes in "discharge areas". Shallow groundwater often interacts with surface water, whereas deep groundwater aquifers are usually confined between impermeable rock layers at greater depth. Previous studies in the watershed have shown that groundwater is found in shallow floodplain gravels that are likely recharged by precipitation, and influenced by surface water (McCann and Associates 1986).

Water well information was extracted from the Alberta Water Well Information Database (AWWID). The AWWID contains roughly 1,476 water well records for the Upper Fish Creek watershed, with the first record dating back to 1938 (Figure 3.7). The majority (58%) of wells drilled were for the purpose of domestic use (Figure 3.8). About 9% of the wells drilled were dry. A number of wells were drilled for the purpose of water chemistry (further discussed in Section 4.0).

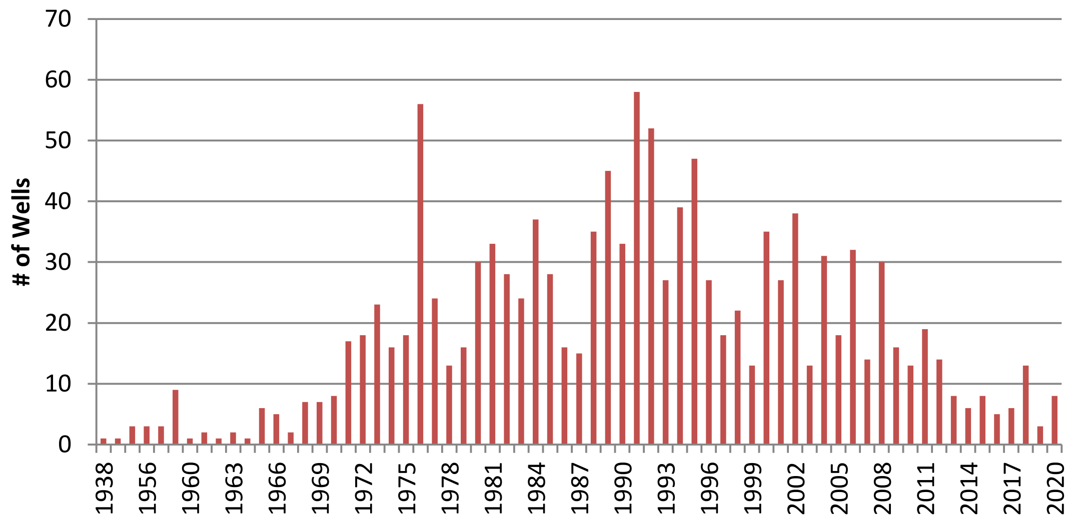


Figure 3.7. Wells drilled in the Upper Fish Creek watershed by year, 1938 to 2020. Note the break in time sequence from the 1930s to 1950s.

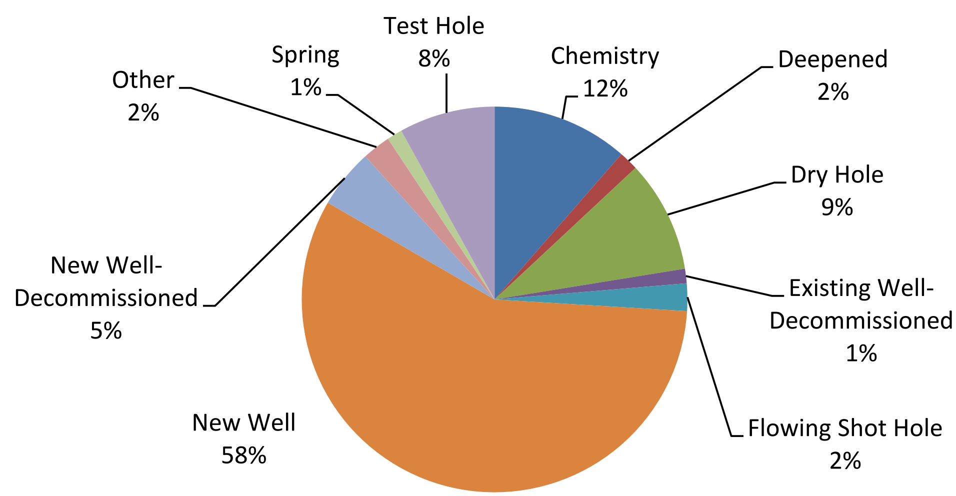


Figure 3.8. Summary of well purpose, AWWID (as of 2020).

In 1979, test wells were drilled to investigate groundwater availability to supply the proposed Priddis Greens development. Preliminary findings indicated that groundwater was not found in sufficient supply to support both irrigation and residential development. These wells were developed in the shallow floodplain gravels and were considered to be "water table" wells, or wells completed in an unconfined aquifer (McCann and Associates 1986).

In 1980, additional drilling was undertaken to find a deeper gravel aquifer with no success. In 1986, an assessment of the original two wells capacity (named TW 1 and TW 2) was undertaken to support development of Priddis Greens (McCann and Associates Ltd. 1986). The aquifer assessment included an assessment of drawdown and recovery rates using an estimated pumping rate of 393 m^3/day to meet the estimated water demand of 96 homes. Gravels were reported as clean and coarse at TW 1, while gravels surrounding TW 2 had higher fines content.

The floodplain gravels in this area were reported to be underlain by till, which in turn were underlain by bedrock. The majority of the wells in the area were reportedly completed in bedrock aquifers which are not in direct hydraulic contact with the floodplain aquifer. However, there were several domestic wells completed in the floodplain gravels upstream and downstream from the development. The long-term yield estimated for TW 1 was about 240 m^3/d (if operated singly) and 70 m^3/d for TW 2 (McCann and Associates 1986). It was suggested that Phase I (half of the project) could be developed using TW 1, but that additional, properly developed wells, would be required to meet the demand of the full build-out (McCann and Associates Ltd. 1986).

Springs

Springs form where groundwater emerges to the surface. Springs have been defined as "a place where…water flows from a rock or soil upon the land or into a body of surface water" (in Borneuf 1983).

There are eight spring locations identified in the watershed that are contained in provincial data sets, although more springs are likely known locally (Section 4.2.1, Map 4.2).

In most cases, the flow regime (e.g., discharge volume and timing) of springs is unknown (Borneuf 1983). However, of the few studies that focused on groundwater-surface water interactions, including at Jumpingpound Creek, the contribution of groundwater discharge to baseflows can be substantial (e.g., 68% of measured streamflow) (AMEC 2009; Westerbrook 2020).

In addition to important contributions to baseflows and water supplies, springs can be important sources of water for fish in winter.

3.1.3 Flood and Drought

Flood

In 2019, Alberta Environment and Parks completed the Priddis Flood Study. The study included a hydrological assessment and flood frequency analyses of Fish and Priddis creeks, the creation of a hydraulic model, and a high level investigation of channel stability (GOA 2020). Flood profiles for thirteen different sized open water floods, from the 1:2 to the 1:1000 flood, were generated (Figure 3.9). Flooding in the Priddis area typically occurs because of high river flows in spring or summer.

Drought

Water shortage advisories are reported on Alberta Environment and Parks “River Basins” interactive web page, including Fish Creek near Priddis (Station 05BK001). Advisories are not reported for a particular station, but are posted for water management areas. For Fish Creek, advisories are posted for the Fish Creek basin.

For the Fish Creek watershed, low flow advisories were posted on Alberta River Basins website for the years 2015, 2016, 2017, 2018 and 2020 (S. Tanzeeba, pers. comm.).

Advisories were in effect mainly in the summer months but in some years came into effect earlier or ended later depending on the low flow situation in different years. These low flow water advisories stated that no further Temporary Diversion Licence (TDL) applications were accepted in the basin and existing TDLs were suspended for the period.

Water licensees were advised to review the conditions of their licence to be in compliance with water conservation objectives or instream objectives where they have been applied (S. Tanzeeba, pers. comm.).

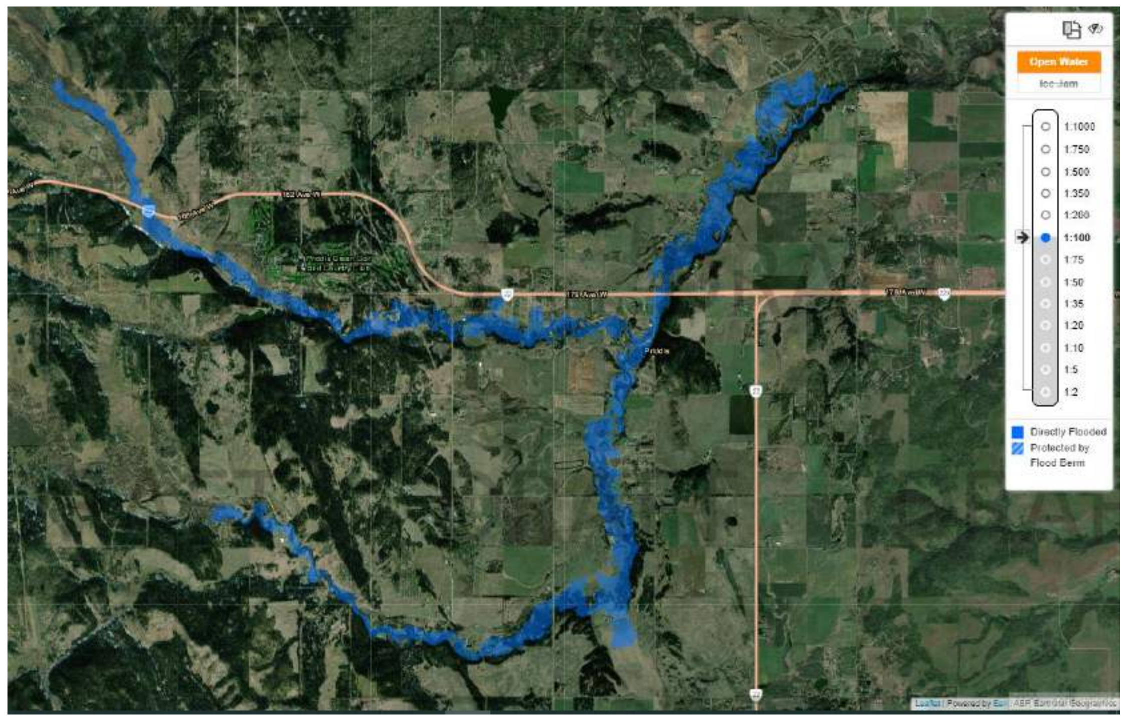


Figure 3.9. Aerial image showing the 1:100 flood prediction for Fish Creek and Priddis Creek, GOA 2020; Alberta Floods Portal).

3.1.4 Discussion

Watershed hydrology is an important aspect of ecosystem health. Persistent high streamflows can alter morphological characteristics of a watercourse, increase erosion and sediment deposition, and cause flooding. Prolonged low streamflows can stress aquatic life, and result in water shortages for communities. Streamflow varies naturally, and is influenced by many factors that include climatic conditions, local weather patterns, groundwater interactions, geomorphology, surficial and bedrock geology, riparian condition, and human alterations (e.g., stormwater inputs and water withdrawals). At Fish Creek and Priddis Creek, peak discharge generally occurs during snowmelt and with larger precipitation events in May/June. Low streamflow occurs during late summer, fall and winter when precipitation tends to be lowest.

During summer months, water losses occur through natural processes like evaporation from the water's surface, and from the transpiration of plants (i.e., riparian vegetation). The impact of vegetation cover on regional water balance has been studied for semi-arid areas. Yang et al. (2009) found that in extremely dry or extremely wet environments, the regional annual water balance is controlled entirely by the climate with no relation to vegetation conditions. For normal climates, however, the regional water balance changes with climate (dryness index) and landscape conditions (Yang et al. 2009). Observations at Bighill Creek, north of the Town of Cochrane, AB, showed that streamflow fluctuated by about 0.02 m^3/s to 0.03 m^3/s during the day time when riparian plants were actively drawing water for photosynthesis (Hayashi 2016). This could represent between 15% and 30% of the flow at Fish Creek near Priddis in dry years (Section 3.1.1).

Climate change is expected to significantly alter hydrology in southern Alberta's watersheds. Model predictions for the Bow River basin indicated that an increase in mean monthly flows from December to May and decreased flows from June to September are expected (Golder Associates 2010). An increase in the intensity of these patterns is expected; that is, drier periods will become drier and wetter periods more extreme. The potential effects of climate change were assessed recently as part of a hydrology and flood risk assessment (GOA 2020). The study found that the effect of climate change on Fish Creek and Priddis Creek flows is uncertain. Increased precipitation intensity may lead to higher flood peaks but this may be off-set by reduced snowpack and drier antecedent moisture conditions due to higher temperatures (GOA 2020). Sound water management and drought planning, particularly for dry years, will be critical to maintaining healthy aquatic ecosystems while balancing community needs in the Upper Fish Creek watershed.

Groundwater is likely hydrologically connected to surface water in some areas of the watershed, depending on local surficial and bedrock geology. Groundwater can contribute a substantial amount of water to streams, particularly in periods of drought (e.g., late summer and winter). At Jumpingpound Creek, south of Cochrane, AB, a study found that groundwater contributed about 68% of baseflow to Jumpingpound Creek (AMEC 2009). In the same watershed, studies have shown that intact wetlands that have water storage functions can maintain baseflows in tributaries to Jumpingpound Creek during drought (Westerbrook 2020).

In addition to the natural influences on streamflow, water management for human purposes (withdrawals for human use and discharges of water to streams) can alter small-stream hydrology. Water allocation and use at Fish and Priddis creeks is discussed further in the following Section 3.2.

3.2 Water Management, Allocation and Use

3.2.1 Water Management

The use of water has been regulated in Alberta before it became a province. Water is regulated by Alberta Environment and Parks (AEP) through the administration of the *Alberta Water Act*. Water licences are issued for the diversion and use of all water, except for small quantities for individual household use and for watering domestic animals from a source of water that is on or under land the user owns. From Jan 1, 1999 to Dec 31, 2001, traditional agricultural use could be registered that allowed a water user to obtain a priority number for the use of up to 6,250 m^3 of water annually for the watering of domestic livestock and/or application of pesticides on crops.

In Alberta, the principle of “first in time, first in right” is followed, where older licences that were allocated water first have seniority in water-short years. In the Upper Fish Creek watershed, the most senior surface water licence dates back to 1956 with the point of withdrawal located on a tributary to Priddis Creek.

The South Saskatchewan River Basin Water Management Plan (SSRB WMP) was completed in 2005. The plan specifies how much water can be used from major rivers in the basin. A Water Conservation Objective (WCO) of either 45% of the natural rate of flow or an existing instream objective (IO) increased by 10%, whichever is greater at any point in time, was set for the Bow River, and applies to main tributaries to the Bow River, including Fish Creek. IOs are defined for 52 weeks of the year for Fish and Priddis creeks (Section 3.3). After May 2005, water licences include requirements to meet the WCO.

In 2007, the Bow, Oldman and South Saskatchewan River Basin Water Allocation Order came into effect (known as the Boss Order). The Bow River Basin was closed to new surface water licences to address the over-allocation of water. Although water licences can currently be transferred through sale, no new licences can be issued with a few exceptions (e.g., First Nations use). A conservation holdback of up to 10% of the water volume transfer can be retained by the Director under the *Alberta Water Act* to protect the aquatic environment, or to implement a WCO.

Water Licence A licence under Alberta's *Water Act* is required to divert and use surface water and groundwater. The licence identifies the water source, location of diversion site, volume, rate and timing of water to be diverted, priority of the "water right" established by the licence, and conditions the diversion must adhere to.

Traditional Agriculture Use Registration Allows for the continued diversion of water for the raising of animals or applying of pesticides to crops. Registrations are given priority dating back to the water’s first use.

Water Conservation Objective (WCO) The amount and quality of water established by the Director, based on information available to the Director, to be necessary for the protection of a natural water body or its aquatic environment, or any part of them, protection of tourism, recreational, transportation or waste assimilation uses of water, or management of fish or wildlife, and may include water necessary for the rate of flow of water or water level requirements. WCOs are important to meeting minimum flows required for fish, and to ensure adequate water supply for recreation, industry and downstream users. WCOs are determined as a percentage of real-time streamflow and vary according to streamflow conditions (e.g., annual and seasonal changes).

Instream Objective (IO) IOs represent minimum flows in the water body that need to be met before a licensee is able to divert water from that water body (AEP 2010). Licensees are not permitted to withdraw water when streamflows fall below the specified IOs that are typically established as a set flow requirement for 52 weeks of the year. IOs may be specified as conditions attached to some water licences.

3.2.2 Water Allocation

Surface Water

As of 2020, a total of 913,567 m^3 of water is allocated in the Upper Fish Creek watershed through 42 surface water licences (825,855 m^3), 45 surface water registrations (25,522 m^3), 10 groundwater licences (43,493 m^3), and 20 groundwater registrations (18,697 m^3) (Table 3.1). The volume of water licenced from Priddis Creek (542,312 m^3) is more than double the volume that has been allocated from Fish Creek (209,390 m^3) (Figure 3.10). Water licence and registration information can be viewed online at http://waterlicences.alberta.ca/ .

The total surface water volume allocated at Fish Creek (209.4 dam^3) accounted for an average of 0.9% (range: 0.4% to 1.9%) of the seasonal volume of water (Mar-Oct) for the period 2008-2020 as measured at 'Fish Creek near Priddis' gauging station (Water Survey of Canada 2020). The total surface water allocation at Priddis Creek (542.3 dam^3) accounted for an average of 5.2% (range: 1.9% to 19.4%) of the estimated seasonal water volume during the same period.

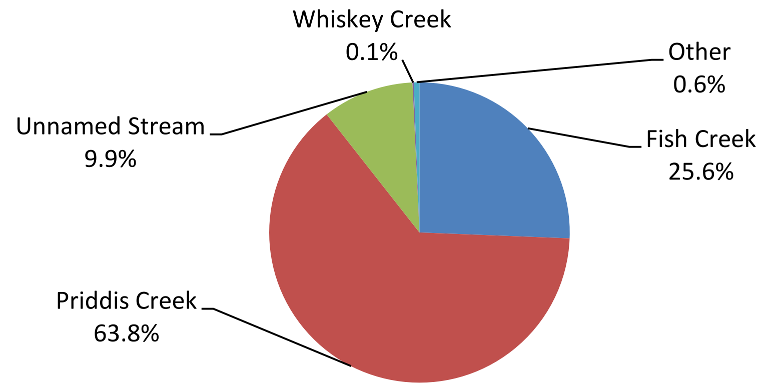


Figure 3.10. Percentage of total surface water licence and registration allocations by source in the upper Fish Creek watershed, 2020.

Temporary Diversion Licences
A Temporary Diversion Licence (TDL) provides authority to divert and use surface water or groundwater on a temporary basis up to a maximum period of one year. This licence identifies the source of water supply, location of the diversion site, allocation of water allowed from the source (s) and the conditions under which the diversion and its use must take place.

Temporary diversion licences have been issued in the Upper Fish Creek watershed to accommodate the short-term diversion of water for a variety of purposes. In the last 20 years, 27 TDLs have been issued for the temporary use of water from Fish Creek, Priddis Creek and Whiskey Creek, an Unnamed Lake and surface runoff. The total volume allocated to TDL's ranged from 50 m^3 for "Other" and "Construction" purposes to 271,366 m^3 of water from Fish Creek for "Oil/Gas" purposes (2004/05). In 2020, 45,000 m^3 of water was issued through a TDL from an Unnamed Lake. "Other" purposes include activities like dust control, abattoirs, bridge washing and hydro-seeding.

Table 3.1. Summary of surface water and groundwater licence allocations and registrations in the upper Fish Creek watershed (AEP 2021).

Source	# of Licences	Volume (m^3)	PURPOSE								
			Subdivision	Crop	Water Conservation Objective	Stockwater	Fish Ponds, Fish Farms Hatcheries	Golf Course	Wetlands	Recreation	Other
Surface Water											
Fish Creek	18	209,390	23,660	98,678	11,841	69,044	6,167	-	-	-	-
Priddis Creek	19	542,312	133,837	-	-	39,673	151,721	201,050	3,701	-	12,330
Unnamed Stream	4	73,846	-	-	-	-	-	63,915	-	9,931	-
Whiskey Creek	1	307	-	-	-	307	-	-	-	-	-
Total SW Licences	**42**	**825,855**	**157,497**	**98,678**	**11,841**	**109,024**	**157,888**	**264,965**	**3,701**	**9,931**	**12,330**
Total SW Registrations	**45**	**25,522**	-	-	-	-	-	-	-	-	-
Groundwater											
Unnamed Aquifer	11	43,493	27,140	1,230 (GRDN)	-	4,023	-	-	-	-	11,100 (INSTIT)
Total GW Licences	**11**	**43,493**	**27,140**	**1,230**	**-**	**4,023**	**-**	**-**	**-**	**-**	**11,100**
Total GW Registrations	**20**	**18,697[a]**	-	-	-	-	-	-	-	-	-
SW and GW Licences and Registrations											
Total	**118**	**913,567**	-	-	-	-	-	-	-	-	-

[a]The majority of groundwater registrations apply to unnamed aquifers. One registration is applied to surface runoff (583 m^3).

Groundwater

Groundwater makes up about 6.8% of the total water volume allocated in the upper Fish Creek watershed (Table 3.1). Eleven groundwater licences having a total volume of 45,172 m^3, and 20 groundwater registrations totalling 18,697 m^3 have been issued.

3.2.3 Water Use

Surface Water

The largest volume of surface water was allocated for golf courses (32.1%), followed by subdivisions (19.1%), fish ponds (19.1 %), stockwater (13.2%), and crops (11.9%) (Figure 3.11). A water licence was also issued for a water conservation objective at Fish Creek in 2017, which makes up about 1.4% of the surface water allocated.

Licenced water use at Fish Creek differs from use at Priddis Creek (Figure 3.12). About 80% of the licences issued at Fish Creek are for agricultural use (i.e., crop irrigation and stockwater), and just 11% of the water used is for subdivisions. At Priddis Creek, nearly 45% of water is used for a golf course community (turf irrigation), and 22% of water use is for subdivisions. Twenty-five percent of water

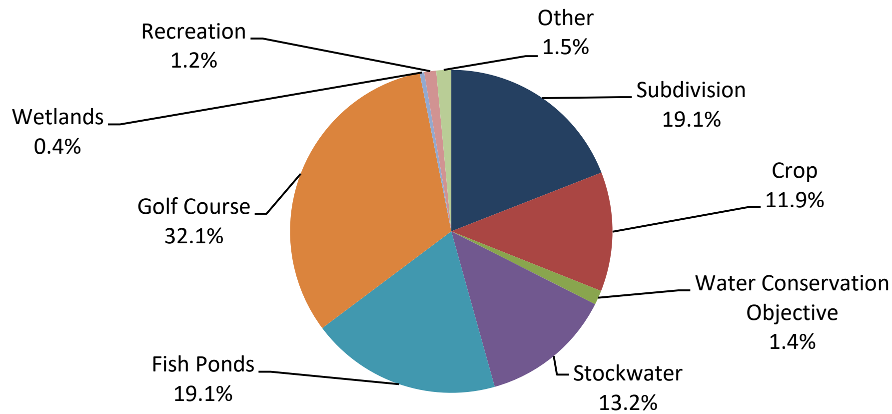


Figure 3.11. Surface water licence allocation by purpose in the Upper Fish Creek watershed, 2020.

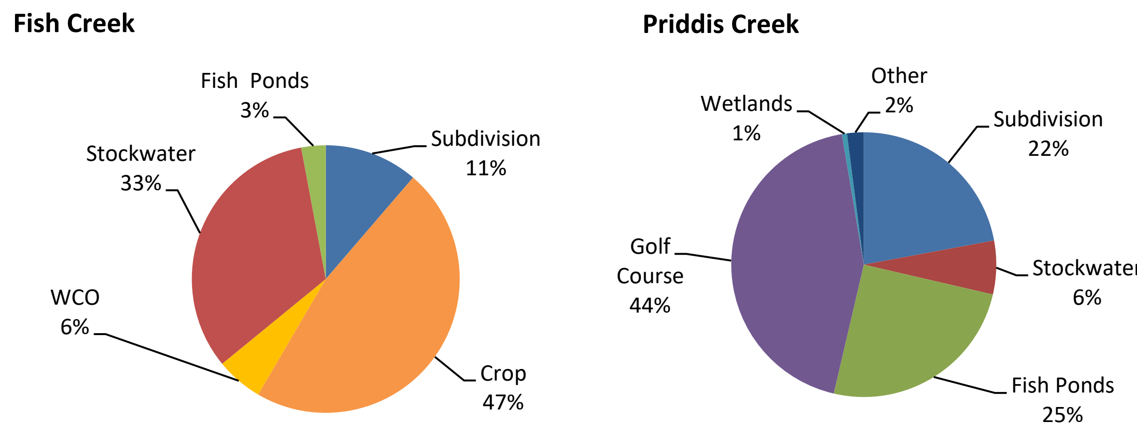


Figure 3.12. Comparison of surface water licence allocations by purpose at Fish Creek and Priddis Creek, 2020.

allocated is also for fish ponds at Priddis Creek.

Groundwater

Of the groundwater licences issued in the watershed, 84% are for the purpose of subdivisions and institutions (noted as domestic supply on actual licence), and 9% are for stockwater (Figure 3.13). Although a number of groundwater registrations were issued, the potability of the groundwater supplies is questionable, particularly along the Hwy 762 corridor. Many residents do not use their groundwater wells, rather people in this area generally have water supplied by truck to fill cisterns (D. Weston, pers. comm.). The volume of water trucked to residents is currently unknown. Quality of groundwater supplies is further discussed in Section 4.2.

3.2.4 Water Allocations vs Actual Use

Water licences and registrations are allocated to water users based on expected water use requirements. However, the actual volume used may vary annually based on precipitation, current streamflow conditions (instream objectives must be met prior to withdrawal), and other factors that are difficult to predict and account for. AEP manages an online water use reporting system to help regulate and monitor water use, however, not all licences have a requirement to report. Reporting requirements are specified as conditions in water licences.

There are reporting requirements for water use at Priddis Creek. A preliminary review of reported surface water and groundwater use indicated that an average of 32% to 89% of the surface water allocated from Priddis Creek to four unique licences was actually used during the reporting period 1987 to 2020. Water use increased to an average of 36% to greater than 100% of licenced volume in the last four years (suggesting use greater than the licensed allocation). In contrast, an average of 28% of licenced groundwater volume was used between 1983 and 2020; use has remained generally the same during the last four years (24% usage of allocation).

3.3 Water Quantity Condition

As described in Section 3.1, AEP established water conservation objectives (WCOs) and/or instream objectives (IOs) for many streams in the South Saskatchewan River basin (SSRB) as part of the SSRB Water Management Plan. The following sections compare recorded streamflow with set WCOs and IOs for Fish Creek and IOs at Priddis Creek.

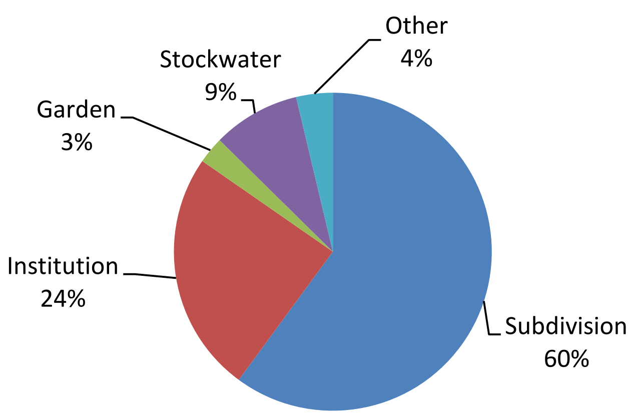


Figure 3.13. Groundwater licence allocation by purpose in the Upper Fish Creek watershed.

3.2.5 Indicators: Water Conservation Objectives and Instream Objectives

Fish Creek

In 2010, a desktop hydrology review of upper Fish Creek was completed by AEP. Daily streamflow data from the Water Survey of Canada (WSC) gauging station (05BK001 Fish Creek near Priddis) was used to naturalize flows for upper Fish Creek (AEP 2010) (Figure 3.14). The WSC gauging station has recorded daily flow since 1912 to present, with the most comprehensive and continuous data available for the period 1957 to 2008. Natural flows are present in the creek when there are no diversions, water storages and/or return-flows (unused water returned to a creek). Naturalized flow data is essential to determine water availability for projects and to assess inherent risks to water availability from water developments (AEP 2010). Natural flows for upper Fish Creek were estimated using the project depletion method, the same method used to estimate the historical natural flows at various locations in the South Saskatchewan River Basin (SSRB) (AEP 2010). Figure 3.14 shows that median natural flow is approximately equal to the median recorded flow.

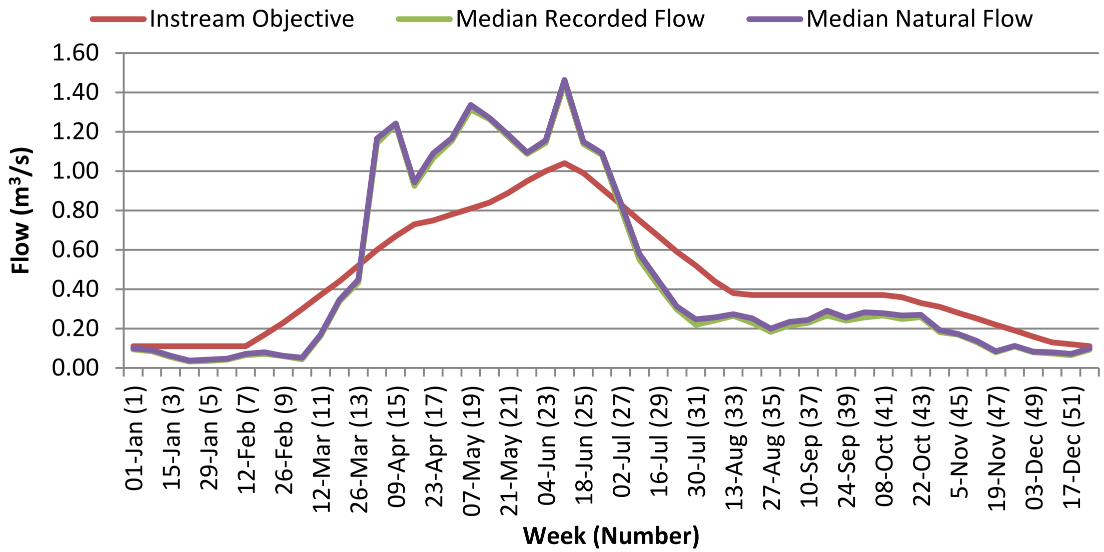


Figure 3.14. Weekly median natural and recorded flow hydrograph and instream objectives for Fish Creek at WSC gauging station 05BK001 (Fish Creek Near Priddis) (AEP 2010).

As part of a hydrological review, the adopted WCOs and IOs for Fish Creek near Priddis were evaluated (AEP 2010). Based on data from 1912-2008 recorded at Station 05BK001, it was determined that WCOs were not met an average of 59.5% of the time (AEP 2010) (Figure 3.15). IOs were compared to more recent recorded streamflow using seasonal data for the period 2009 to 2020 (PESL 2020). Similar results were observed as previously reported; streamflows did not meet the IOs an average of 50% of the time, ranging from 17-100% of the time (Figure 3.16).

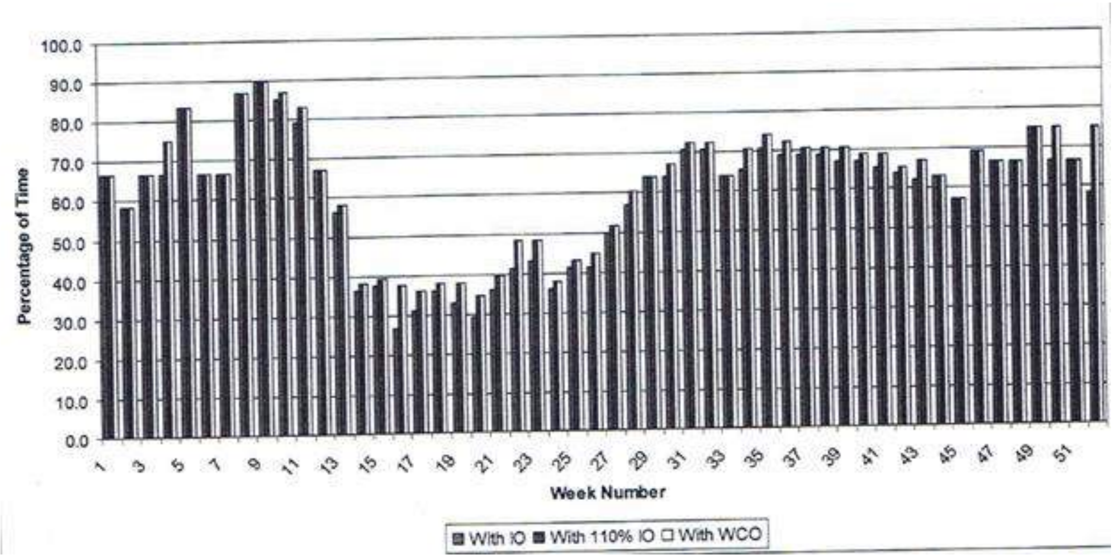


Figure 3.15. Percentage of time the IO and WCO have not been met (1912-2008) historically at Fish Creek near Priddis (05BK001) (AEP 2010).

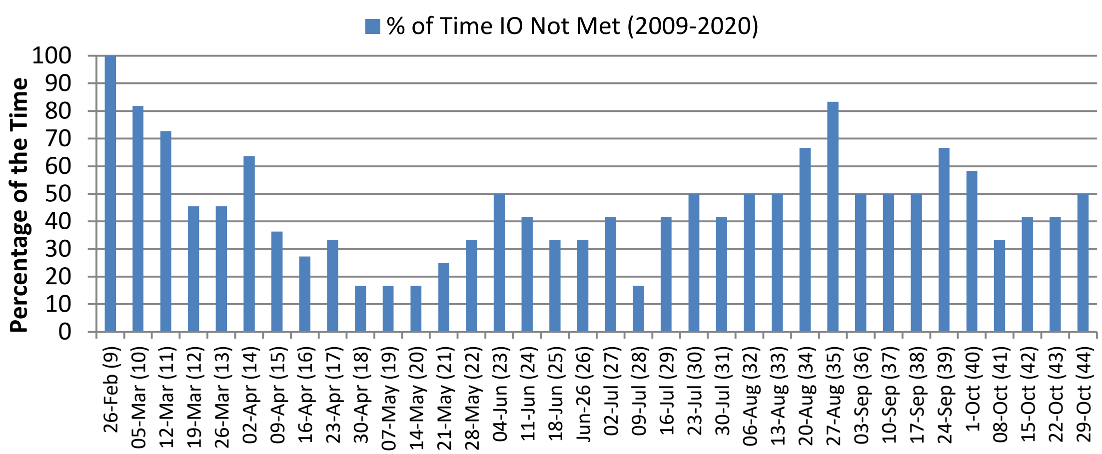


Figure 3.16. Percentage of time the IO was not met (2009-2020) at Fish Creek near Priddis (05BK001). Based on median streamflow for each week. Weeks are noted in (brackets on the horizontal axis).

WCO graphs for 1912-2008 (Figure 3.15) and 2009-2020 (Figure 3.16) are not directly comparable. For the 1912-2008 plot, natural flow was estimated to calculate the WCO. For the 2009-2020 plot, natural flow for each year was not estimated. In addition, actual water use and return flow in the system may have changed through time (e.g., between the two periods 1912-2008 and 2009-2020).

Figure 3.14 shows that recorded and natural median flows are approximately equal indicating that allocations are not affecting the median flow. This implies that water use is not the driving factor for not meeting IO/WCO thresholds during the year at Fish Creek. The 'IO, WCO not met' is mostly driven by the natural variability of stream flow. Fish Creek naturally has low flow in summer, fall and winter months and therefore sometimes is below the IO/WCO threshold values during those periods. The IO/WCO values are flow thresholds below which there is a potential of adverse effect to the aquatic environment. IOs/WCOs are attached to licences as conditions to restrict diversion of flow in low-flow situations. When the stream flow is naturally below the IO/WCO thresholds, additional cumulative water diversions place further stress on the aquatic environment.

Licensees with IO or WCO licence conditions must restrict water diversion during these low flow periods. A similar concept is applicable for Priddis Creek.

Priddis Creek

Unlike Fish Creek, there is no Water Survey of Canada gauging station at Priddis Creek. To establish instream objectives at Priddis Creek, streamflows were estimated using recorded flows at the Fish Creek near Priddis station (05BK001) (S. Tanzeeba, pers. comm). The Tennant-Tessman Desktop Method was then used to create monthly instream objectives[1]. The resulting monthly time-steps were then modified to weekly time-steps using methods of linear interpolation for use in Alberta. The natural flow of Priddis Creek has not been determined.

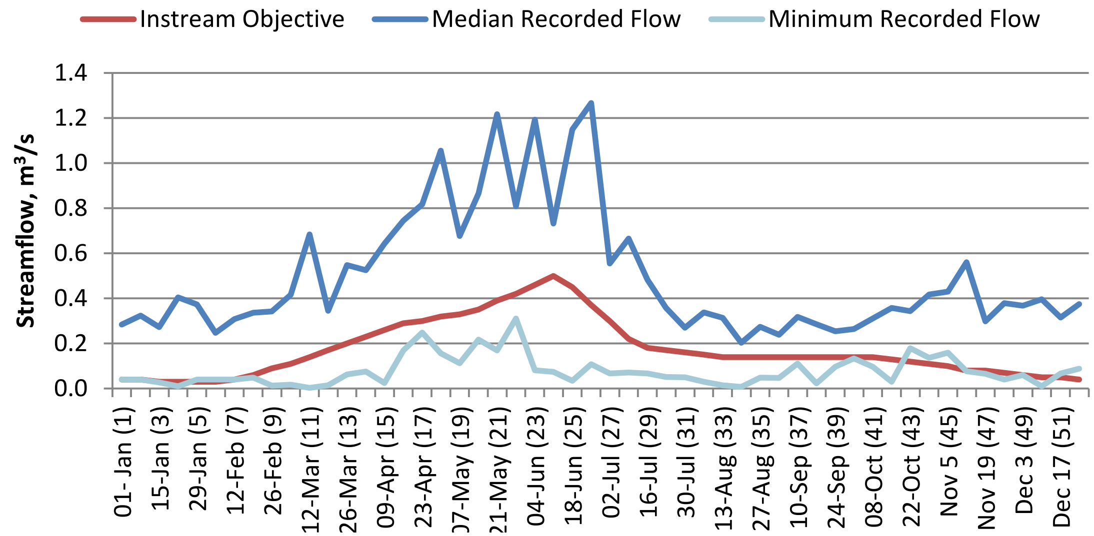


Figure 3.17. Weekly median recorded flow hydrograph and Instream Objectives for Priddis Creek, 2008-2020.

Figure 3.17 shows the median and minimum weekly recorded flow for the period 2008 to 2020, and the instream objectives set for Priddis Creek. Flows were estimated for iced covered periods. Median recorded flows were above the established instream objective in all weeks. Minimum recorded streamflow was occasionally above the IO in October and November.

Recorded flows did not meet the IOs at Priddis Creek an average of 15% of the time (range: 0% to 39%) for the period 2008-2020 (Figure 3.18). Recorded streamflows did not meet the established IOs most frequently during the summer months (mainly June-August). Figure 3.19 shows that the times the IO was not met increased as streamflows decreased. The year 2018 was a particularly dry year and flows were less than the IO for about 56% of the weeks.

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[1] Tennant-Tessman Desktop Method Equation; Note: MMF = Mean Monthly Flow and MAF = Mean Annual Flow

IF 40% MMF > 40% MAF, then the IO recommendation is 40% MMF.

IF MMF < 40% MAF, then the IO recommendation is the MMF.

IF 40%MMF < 40% MAF and MMF > 40% MAF, then the IO is 40% MAF.

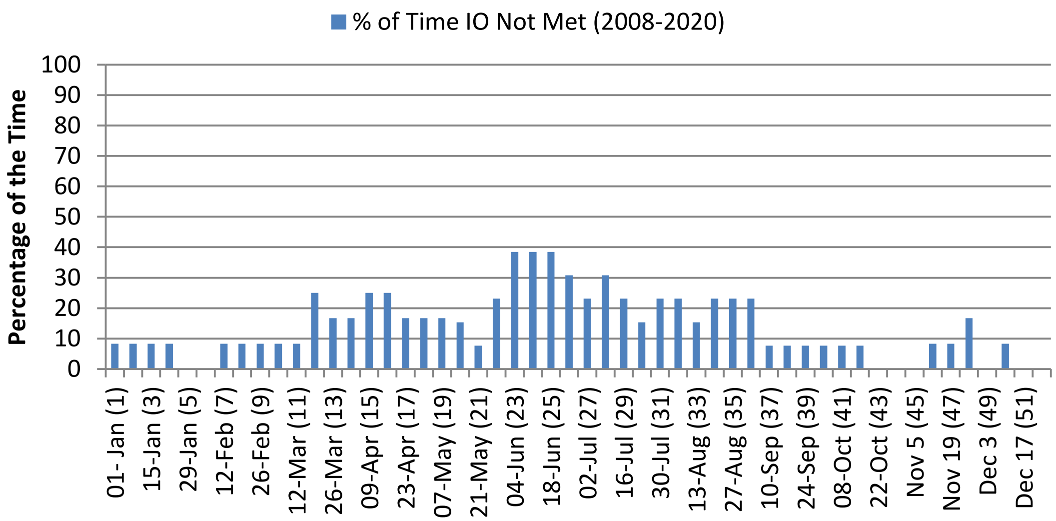


Figure 3.18. Average percentage of time the IO was not met at Priddis Creek, 2008-2020.

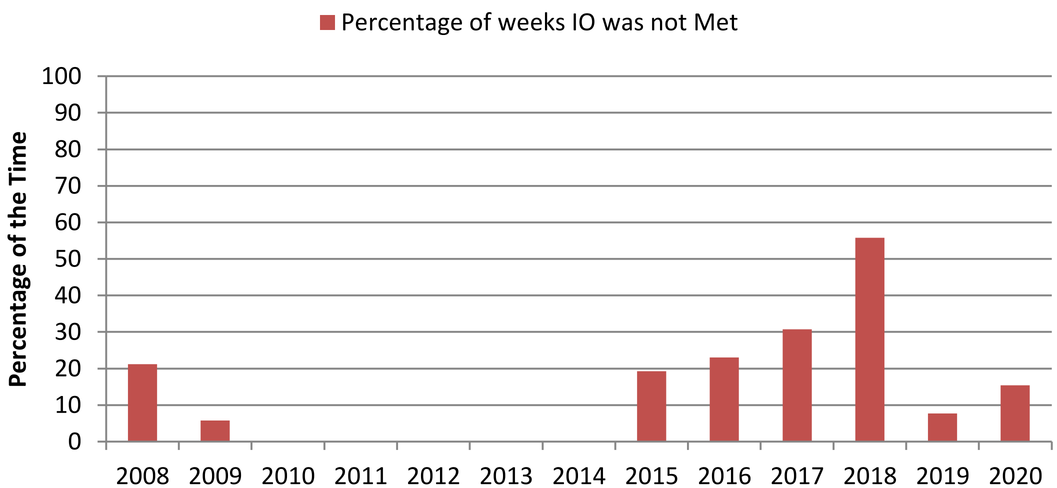


Figure 3.19. Percentage of weeks the IO was not met at Priddis Creek, 2008-2020. Note: Based on available streamflow data, the IO was met during the period 2010-14.

In their assessment of supply vs. demand, Hydroconsult (2003) surmised that adequate flow at Priddis Creek may be available on an annual volume basis. However, from flows recorded at Fish Creek near Priddis, and historical observations of ice-cover conditions on Priddis Creek, it was evident then that extended periods of no flow to insignificant flow are available for withdrawal from Priddis Creek above the Loon Lake tributary. The authors also noted that the infiltration gallery exceeded its annual licence withdrawal of about 45,000 m^3 in 1994 which was an extremely hot and dry summer (Hydroconsult 2003). Hydroconsult (2003) concluded that an off-stream storage pond, or Loon Lake, is required to provide a guaranteed source of supply water during low flow and winter ice-cover periods.

3.3 Condition Assessment

Streamflow rates and volumes at Fish Creek and Priddis Creek vary seasonally and annually based on local weather patterns, changing climate, and human use. At Fish Creek, recorded flows are considered to be reflective of natural flow (Figure 3.14). During the past 10 years, streamflow has not met established IOs about 50% of the time, depending on season and annual precipitation patterns. In recent years, the percentage of time the IO was not met increased to about 80% in August at Fish Creek. With climate change, flows at Fish Creek may increase in wet periods (spring), but decrease further during dry periods. Similarly at Priddis Creek, streamflows did not meet established IOs an average of 15% of the time (ranging from 0% to 56% of the time) from 2008 to 2020. The number of times streamflow did not meet IOs increased substantially in “dry” years (i.e., in 2018 the IO was not met 56% of the time).

A preliminary review of actual water use in the upper Fish Creek watershed suggests that licenced surface water volume has not been used to full capacity. However, in recent years an increasing trend in surface water use was observed. The timing of water withdrawals is critical to avoid degradation of the fish habitat and water quality during periods of low flow, particularly in August and September. In order to understand and manage Fish Creek and Priddis Creek, a water balance model is needed that quantifies precipitation (snowmelt, rainfall), losses (evaporation/transpiration), groundwater recharge and discharge, and human uses (water withdrawals/discharges) at the watershed scale.

A review of the IO established for Priddis Creek is also warranted (Figure 3.20). The review should determine if the IO is adequately protecting aquatic life in light of increasing water use and climate change impacts.

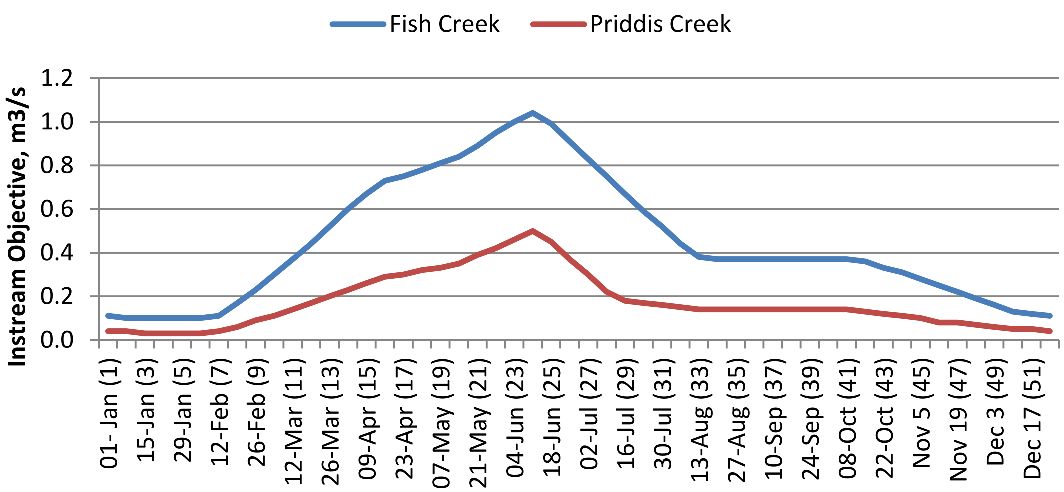


Figure 3.20. Comparison of weekly IOs established for Fish Creek and Priddis Creek.

4.0 WATER QUALITY

4.1 Surface Water

Good water quality is important to support natural systems and to meet the needs of aquatic life, upland wildlife, and for a variety of human uses, such as treated drinking water, domestic animals, irrigation agriculture and contact recreation.

4.1.1 Water Quality Studies

The Friends of Fish Creek Provincial Park Society (the Friends) conducted a volunteer-driven water quality sampling program in Fish Creek between 2007 and 2013 (Parker 2012; Wisby 2015). Water samples were collected monthly, from May through October, at five consistent locations within park boundaries. Water samples were also collected in the Fish Creek headwaters located at the extreme west end of the creek, and at the Priddis - Tsuut'ina First Nation boundary from 2010 to 2012. The water monitoring program was implemented to investigate background water quality conditions and potential stressors upstream of Fish Creek Provincial Park.

Currently, the Fish Creek Watershed Association is monitoring water quality in collaboration with CreekWatch, through a citizen science-based program. Monitoring began in 2019 at two sites on Fish Creek. One site is located approximately 1 km upstream of the hamlet of Priddis, and a second site is located at Fish Creek at Coalmine Rd. about 11 km upstream of Priddis. Seven parameters are analysed, including water temperature, pH, total dissolved solids, ammonia, and ortho-phosphorus.

4.1.2 Water Quality Condition

Water Temperature

Water temperature has an important role in aquatic systems as it regulates the growth rate of microorganisms, and therefore governs biological activity responsible for decomposition of organic matter and nutrient cycling (e.g., uptake and removal mechanisms). Water temperature also regulates the survival of bacteria, including fecal coliform bacteria, by inhibiting growth rates at colder temperatures and promoting growth when water temperatures are warm.

Water temperature is an important indicator for fish and will influence the species of fish that are present in streams. Trout species, such as the Brook Trout, and Rainbow Trout found in upper Fish Creek and Priddis Creek, prefer summer water temperatures between 13 and 18^{o}C (Nelson and Paetz 1992).

There is little to no water temperature data available for Fish, Priddis and Whiskey creeks. Continuous data collected at the Fish Creek near Priddis gauging station by the Water Survey of Canada from 2004 to 2008 indicates that recorded

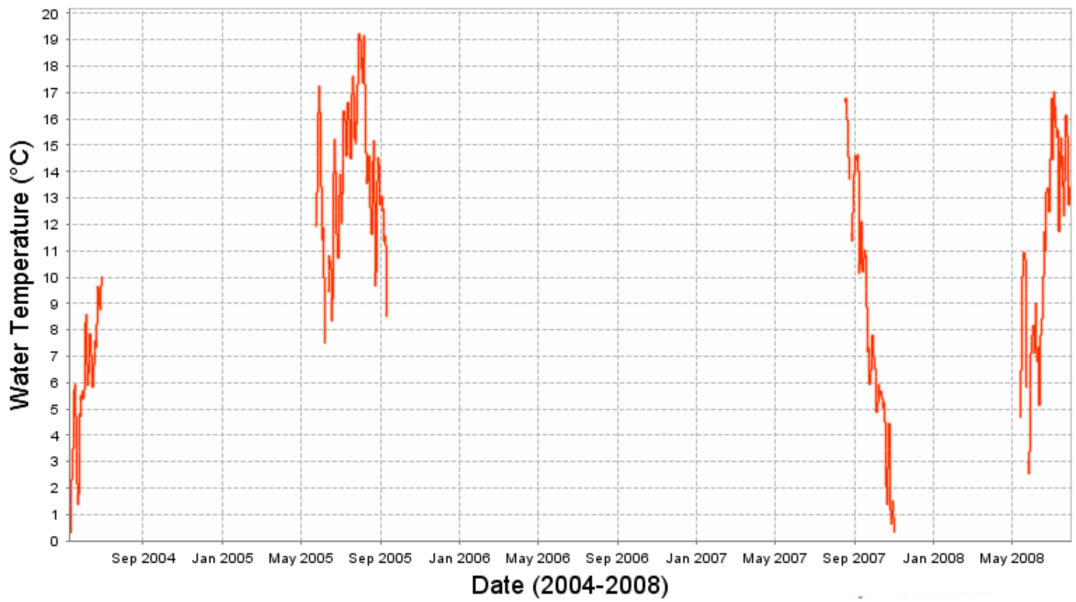


Figure 4.1. Continuous water temperature data for Fish Creek near Priddis (Station 05BK001), 2004 to 2008 (Water Survey of Canada).

water temperature did not exceed 20°C (Figure 4.1). However, the data is incomplete and may not be representative of summer mid-day conditions when temperatures tend to be highest. Recent monitoring at Fish Creek near Priddis recorded a mid-day water temperature of 20.4°C in June and 22.4°C in July (PESL 2021, unpublished).

Dissolved Oxygen

Dissolved oxygen is vital to freshwater organisms. Oxygen is soluble in water and the solubility increases with decreasing water temperature (i.e., cold water holds more oxygen). Oxygen enters the water directly from the atmosphere or by aquatic plant/algae photosynthesis. Oxygen is removed by the respiration of animals and plants and by organic decomposition. The provincial oxygen guideline for the protection of freshwater aquatic life is ≥ 5.0 mg/L (acute: 1 day minimum) and ≥ 6.5 mg/L (chronic: 7 day mean). The federal cold water biota oxygen guideline for the protection of freshwater aquatic life ranges from ≥ 6.5 mg/L (other life stages) to 9.5 mg/L (early life stages) (AEP 2018).

In 2020, the few samples analysed for dissolved oxygen at Fish Creek near Priddis, Fish Creek at Coalmine Rd. and Priddis Creek all met the chronic dissolved oxygen guideline (≥6.5 mg/L) (CreekWatch 2021).

Conductivity

Electrical Conductivity (EC) is the measure of minerals (e.g., sodium, chloride, magnesium, potassium) dissolved in water or the salinity and is expressed as micro Seimens per centimeter (µS/cm) (USEPA 1978; Cole 1994).

In 2020, the maximum conductivity recorded at 'Fish Creek near Priddis' (460 µS/cm) and 'Priddis Creek' (480 µS/cm) were well below the safe irrigation guideline of 1,000 µS/cm (AEP 2018). No conductivity data was collected at the site 'Fish Creek at Coalmine Rd.' in 2020.

Phosphorus

Phosphorus is the limiting nutrient in freshwater that controls plant growth. In excess, it leads to increased productivity known as "eutrophication". Excessive phosphorus in freshwater can increase the growth of algae and aquatic plants. In some circumstances, increased plant abundance can change the chemistry of the water, affect oxygen concentrations (through photosynthesis/respiration and decay of organic matter), affect aesthetics and affect the physical movement of water.

Sources of phosphorus can include animal manure (e.g., livestock, waterfowl), commercial inorganic fertilizers, sewage treatment plants and domestic sludge, food processing plants, urban runoff, atmospheric deposition, and natural levels found in soils and bottom sediments.

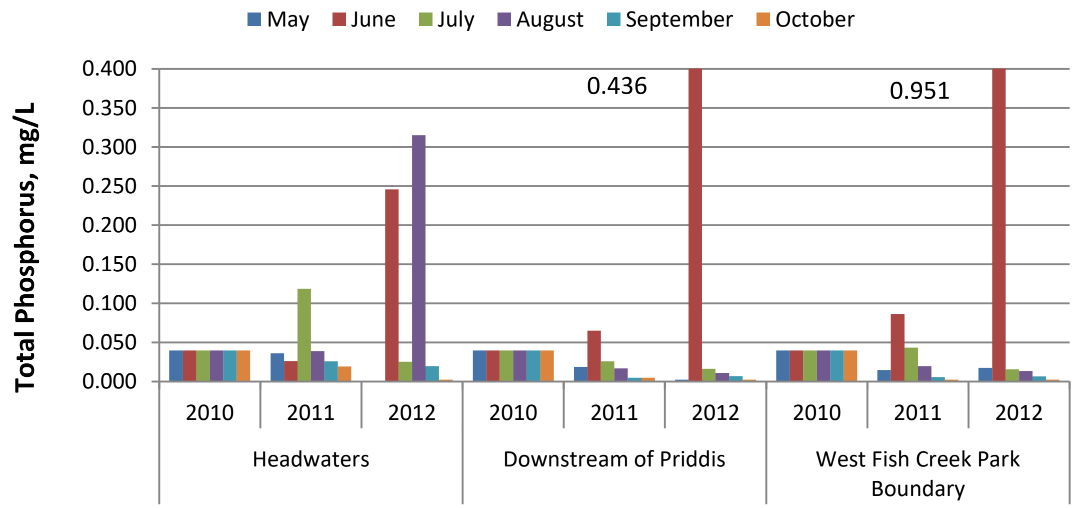


Figure 4.2. Total phosphorus concentrations at upper Fish Creek, 2010-12 (modified from Wisby 2015).

There is currently no provincial water quality guideline established for total phosphorus, beyond the narrative statement:

"*For surface waters not covered by specific guidelines, nitrogen (total) and phosphorus concentrations should be maintained so as to prevent detrimental changes to algal and aquatic plant communities, aquatic biodiversity, oxygen levels, and recreational quality. Where priorities warrant, develop site-specific nutrient objectives and management plans*. " (AEP 2018).

The historic guideline for total phosphorus was 0.05 mg/L. At upper Fish Creek, total phosphorus concentrations were generally below the historic guideline, except in June (2012) at all sites, July (2011) and August (2012) at the headwaters site (Figure 4.2) (Wisby 2015).

In 2020, the median "ortho-phosphorus" (a fraction of total phosphorus) recorded at 'Fish Creek near Priddis' was 0.04 mg/L, 0.02 mg/L at Fish Creek at Coalmine Rd., and 0.04 mg/L at 'Priddis Creek'. Note that the methods used for analysis are not directly comparable to those used historically.

Total Suspended Solids

Total Suspended Solids (TSS) is a measure of the suspended particles such as silt, clay, organic matter, plankton and microscopic organisms which are held in suspension in water. Total suspended solids concentrations are expressed as milligrams per litre (mg/L) of water (USEPA 1978). TSS should not increase by more than 10 mg/L above background to protect aquatic life (AEP 1999).

Suspended solids can transport nutrients and contaminants downstream and may be aesthetically undesirable. Excessively high TSS in irrigation water can cause the formation of crusts on top of the soil which can inhibit water infiltration, and plant emergence and impedes soil aeration. The formation of films on plant leaves can reduce sunlight and impede photosynthesis. TSS residues can reduce the marketability of some leafy crops such as lettuce. High TSS can interfere with the treatment of drinking and industrial process water. High concentrations of suspended and deposited sediment can reduce benthic invertebrate abundance and species richness. Deposited sediment can fill in deep pools and bury spawning gravels leading to reduced survival of fry fish. Sub-lethal effects on fish can include avoidance/re-distribution, reduced feeding/growth, respiratory impairment, reduced tolerance to disease and increased physiological stress. In very high concentrations, suspended sediment can result in mortality of fish (Waters 1995).

Figure 4.3 shows total suspended solids concentrations at upper Fish Creek, 2010-2012. Total suspended solids concentrations were generally highest during the spring runoff and rain events.

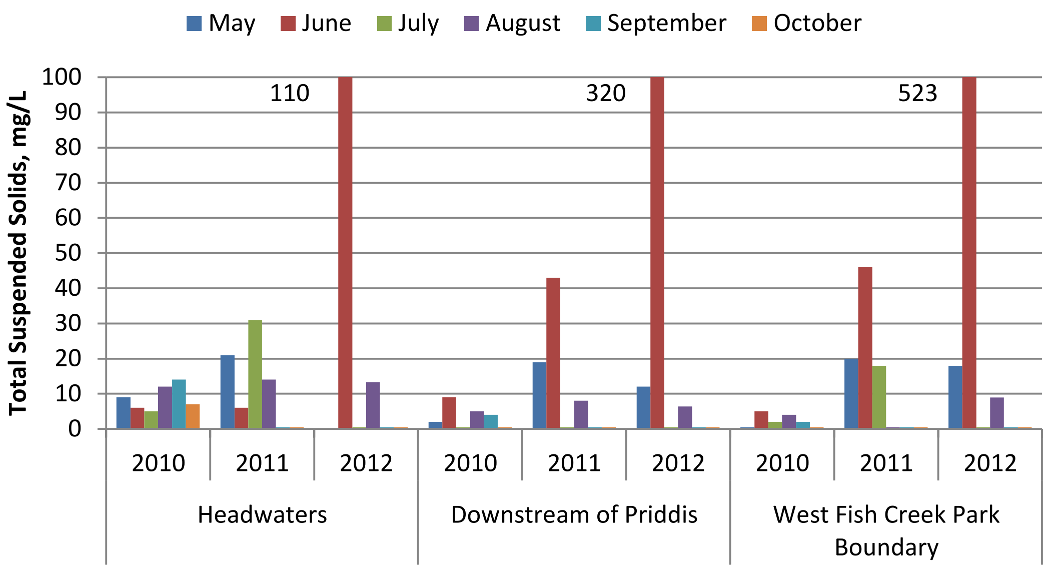


Figure 4.3. Total Suspended Solids concentrations at upper Fish Creek, 2010-12 (Wisby 2015).

Escherichia coli

Escherichia coli (*E. coli*) is found in the intestines of all mammals and is commonly used as an indicator of fecal contamination. *E.coli* may enter surface water through wildlife, runoff from fields grazed by domestic livestock or fertilized with manure, leaky septic fields and sewage lines, treated effluent, and urban runoff. Although most strains of *E.coli* bacteria are harmless, certain strains may cause illness in humans (Centers for Disease Control and Prevention 2014). E. coli should be $\leq$100 cfu/100 mL (geometric mean) or $\leq$320 cfu/100 mL (statistical threshold - no more than 10% of samples should exceed over a 30-d interval) (AEP 2018).

Figure 4.4. shows *E. coli* counts at sites monitored at upper Fish Creek from 2010-2012. Generally counts were below the guideline of 100 cfu/100 mL (for irrigation) in 2010, 2011 and 2012 at the Headwater and Priddis sites. Wisby (2015) reported that the majority of exceedances for individual sample events occurred during the months of May, June, and July. In June of 2012, high *E. coli* counts were detected at all locations excluding the headwaters. Generally, *E. coli* counts peaked at the height of summer in July. A positive correlation to the concentration of Total Suspended Solids was observed.

More recently, *Enterococcus spp.* are being used as an indicator of fecal contamination and risk to human health for recreational waters. Studies found that *E. coli* and coliforms did not have a strong relationship to bather illness, and that Enterococcus species provided a much stronger indicator of health risk (GOA 2019). *Enterococcus spp*. analysis is generally coupled with microbial source tracking techniques to identify sources of bacteria that can better aid in the determination of human health risk.

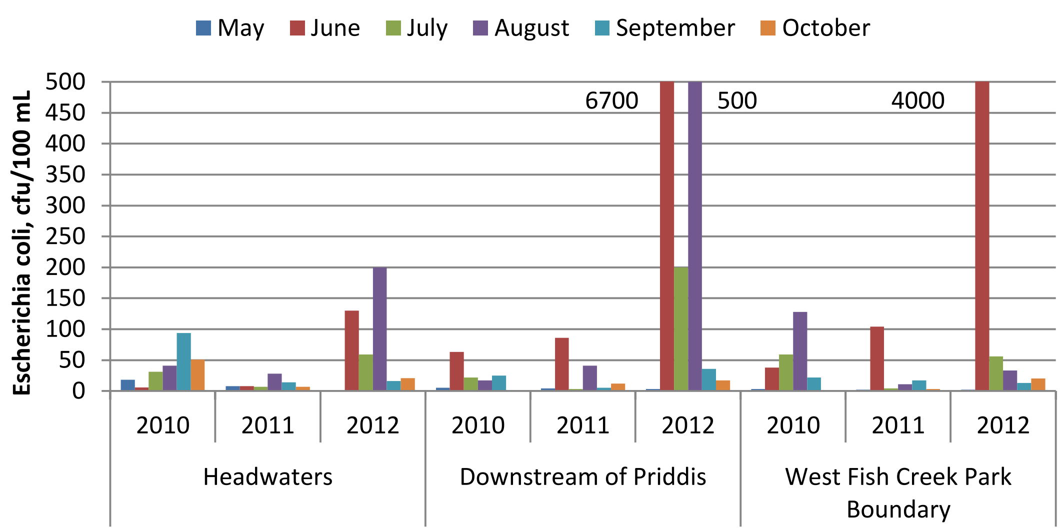


Figure 4.4. *Escherichia coli* counts at upper Fish Creek, 2010-12 (Wisby 2015).

4.2 Groundwater

Groundwater is an important source of domestic water supply (Map 4.1). Maintaining the quality of these supplies is essential. Generally, groundwater quality is influenced by local geology, soil characteristics, and anthropogenic factors (e.g., water withdrawals, contamination).

Comprehensive groundwater quality data is not readily available for the Upper Fish Creek watershed. Some groundwater quality data was obtained from local water co-ops, and a previous groundwater investigation in support of the Priddis subdivision (J.K. Engineering Ltd. 1995).

Rancher's Hill Water Co-op provided results of their monthly groundwater quality testing program for January 2021 (AGAT Laboratories 2021). The results indicate:

- That groundwater in this area tends to be relatively soft; total alkalinity ($CaCO_3$) was 444 mg/L, and bicarbonate was 515 mg/L
- The groundwater was high in dissolved sodium (210 mg/L), which contributes to high electrical conductivity (932 µS/cm) and Total Dissolved Solids (515 mg/L)
- Sulphate and other dissolved ions were generally low, with the exception of dissolved manganese that exceeded the drinking water quality guideline of 0.12 mg/L
- Nitrate-Nitrogen and Nitrite-Nitrogen concentrations were well below the established drinking water guidelines, and were less than the detection limit of the analytical equipment.

In the groundwater investigation of 4 wells near the Priddis subdivision, J.K. Engineering Ltd. (1995) noted total alkalinity (as $CaCO_3$) ranged from 319 to 422 mg/L, dissolved sodium ranged from 107 to 212 mg/L, iron ranged from 0.006 to 0.172 mg/L, and TDS ranged from 374 to 533 mg/L. Sulphates were generally high, ranging from 23 to 51 mg/L. Nitrate+Nitrite-Nitrogen was also high, ranging from <0.05 to 0.18 mg/L. Well depths were 80 to 120 feet deep.

Map 4.1. Water wells in the Upper Fish Creek watershed (Stelfox 2020).

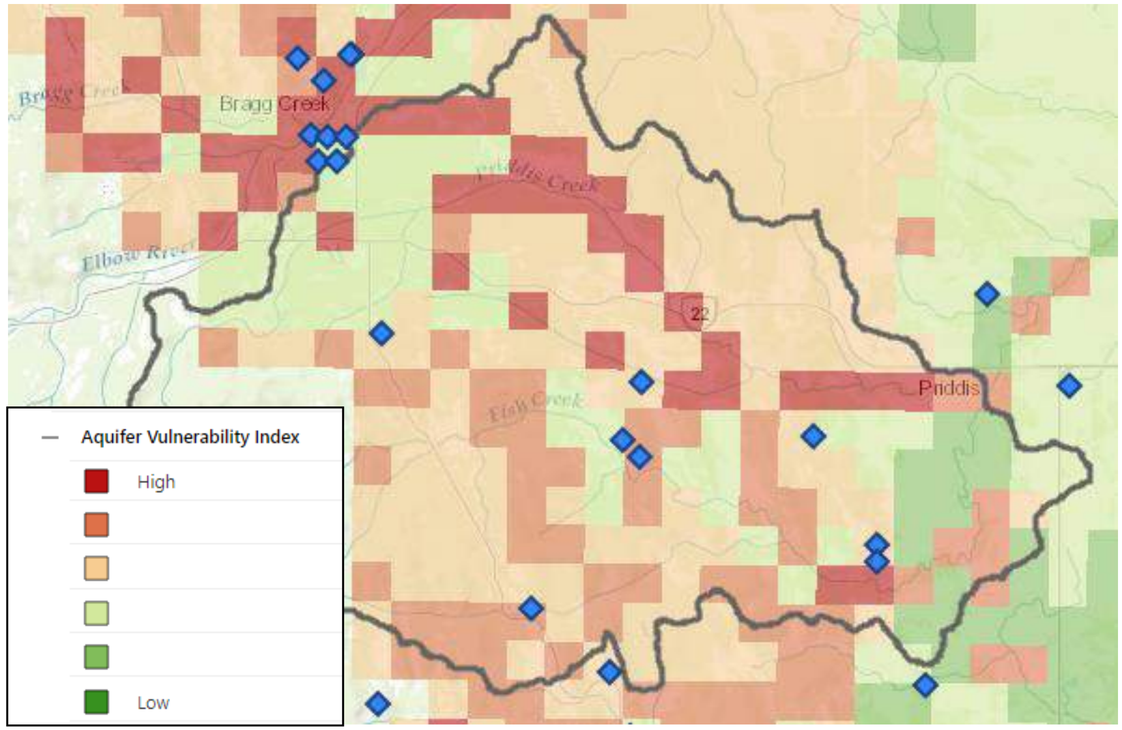
4.2.1 Aquifer Vulnerability

The provincial Aquifer Vulnerability Index (AVI) is a method used to assess the vulnerability of aquifers to surface contaminants in Alberta. This is an important tool when determining appropriate land uses for an area planned for development as it provides a cursory assessment of aquifer vulnerability to potential contamination. The depth to the aquifer and the types of geological materials above them are considered in the assessment (AAF 2016).

For example, aquifers closer to the surface overlain with pervious surface materials are more vulnerable to contaminants, compared to aquifers found deeper and covered with a thick layer of impervious material. The AVI ratings indicate the potential of surficial materials to transmit water with contaminants to the aquifer over a period of time.

Map 4.2 shows the aquifer vulnerability ratings for aquifers in the Upper Fish Creek watershed. There is substantial area in the watershed that is considered highly vulnerable, particularly areas around Priddis Creek (Map 4.2). Note that the Kananaskis Improvement District was not included in the provincial assessment.

Map 4.2. Aquifer vulnerability index for the Upper Fish Creek watershed (AAF 2016). Note that the Kananaskis Improvement District was not included in the provincial assessment. Blue diamonds are known spring locations

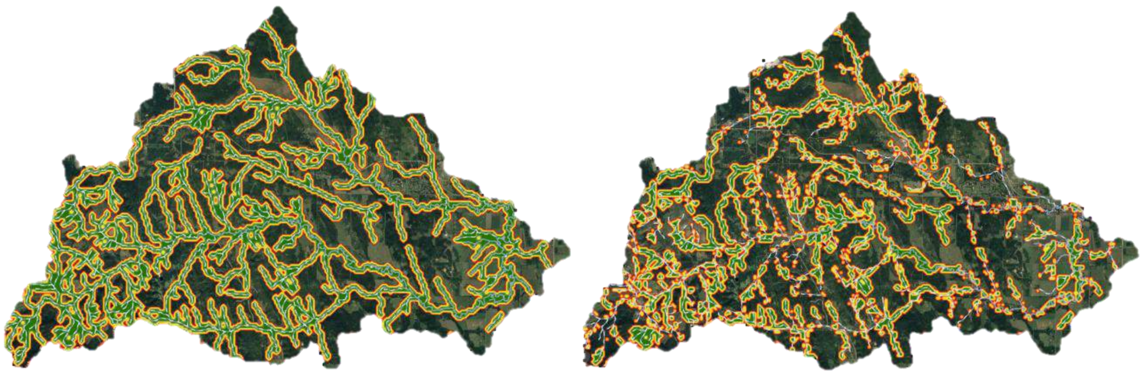


5.0 RIPARIAN AREAS

Riparian lands are important transition areas between water and upland ecosystems. Riparian areas are characterized by soil and vegetation and other biological characteristics that are influenced by the permanent or temporary presence of water. Riparian areas are essential features in watershed that have important functions that include:

- Trapping and storage of sediment
- Building and maintaining streambanks and shorelines
- Storage of water and energy
- Aquifer recharge
- Filtering and buffering water
- Reduction and dissipation of energy
- Maintaining biodiversity

Historically, riparian areas covered about 108 km^2 or 41% of the watershed (Stelfox 2020). After applying land use footprints to riparian areas, it was estimated that about 14.3 km^2 or 13% of riparian area has been impacted. The footprint from all land uses on riparian areas is summarized in Figure 5.1. Forestry had the largest footprint on riparian areas (about 49% of the total footprint), followed by residential development (20%) and agriculture (cropland) (16%).



A. Historic riparian area B. Remaining riparian area

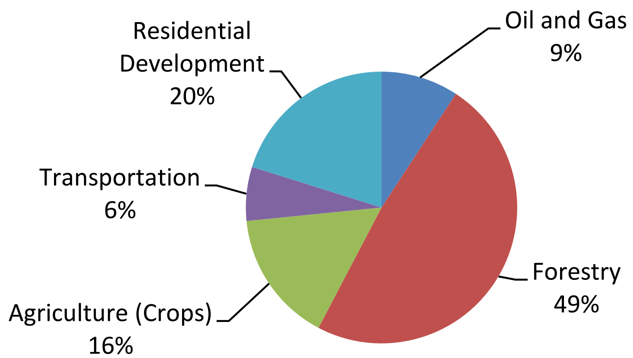


Figure 5.1. Percentage footprint on riparian areas by sector.

5.1 Riparian Health Assessment

Nineteen riparian health inventories have been completed in the Fish Creek watershed upstream from the City of Calgary (Figure 5.2) since 1999 by the Alberta Riparian Habitat Management Society (Cows and Fish). Seven sites were assessed in 1999, two sites in 2015 and four sites in 2016; the remaining six inventories were completed in 2020. In total, 11.5 km of stream corridor and 73.4 ha of riparian habitat was assessed. About half of the riparian inventories were completed along Fish Creek (9 sites), three sites were inventoried on Priddis Creek, and the remaining inventories were completed on unnamed tributaries to Fish Creek (7 sites). No lentic (wetland/lake) riparian health assessments have been completed to date in the watershed.

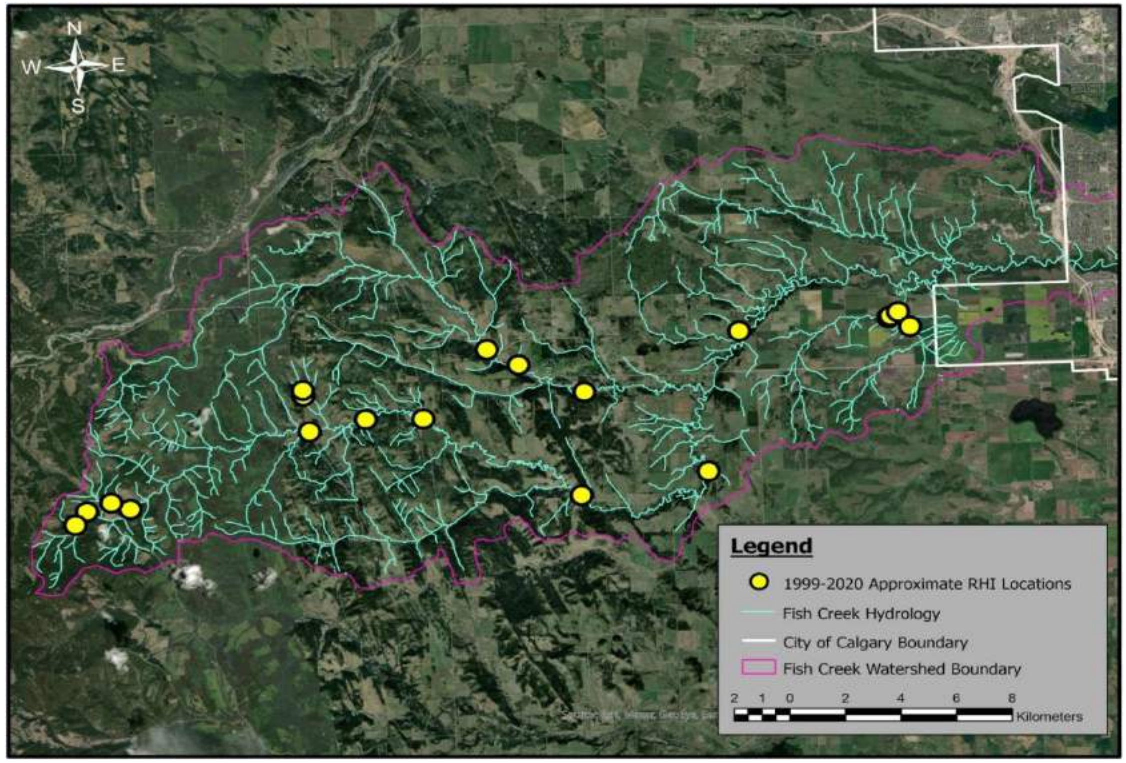


Figure 5.2. Map showing approximate locations of the Riparian Health Inventories , 1999-2020.

5.1.1 Riparian Health Scores

A variety of indicators are measured in the field to determine riparian health, including those presented in Table 5.1. A score is assigned to each indicator during the assessment. Scores less than 60 indicate an *Unhealthy* rating, scores ranging between 60 and 79 indicate *Healthy but with problems*, and scores equal to or greater than 80 indicate a *Healthy* rating. For more information about riparian health inventory methodology refer to https://cowsandfish.org/health-assessment-and-inventory-forms/ .

5.1.2 Riparian Health Results

Riparian health inventories were completed in collaboration with local landowners or municipalities at selected rather than randomized locations. As such, the available dataset combines results from multiple time periods and is not representative of overall watershed conditions. Of the nineteen sites assessed in the Fish Creek watershed upstream of Calgary, 37% rated *Healthy*, 47% rated *Healthy but with Problems*, and 16% rated *Unhealthy* (Figure 5.3). The average riparian health score for all sites was 75 (i.e., Healthy but with Problems).

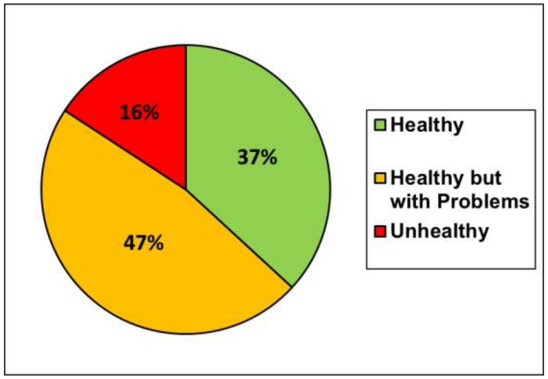


Figure 5.3. Average Riparian Health Score in the watershed (n=19).

This score is higher than the provincial average score of 69 that is based on 2,974 sites, on 822 waterbodies in Alberta (1996-2019 Cows and Fish data).

On average, most of the individual parameters rated above 60 (Table 5.1). The parameters that scored below this threshold (i.e., *Unhealthy*) were associated with invasive weeds (i.e. Noxious / Prohibited Noxious Weeds regulated by the Alberta Weed Control Act), disturbance-caused undesirable plants and browse (from wildlife and/or livestock). Issues related to these parameters are common across the province, especially in areas where there is frequent disturbance or where multiple land-uses overlap.

Table 5.1. Average riparian health scores by parameter for all sites assessed, 1999-2020.

Parameter	Average Score	Health Rating
Vegetative Cover of Floodplain and Streambanks	88	Healthy
Total Canopy Cover of Invasive Plants	39	Unhealthy
Density Distribution of Invasive Plants*	25	Unhealthy
Total Canopy Cover of Disturbance-caused Plants	49	Unhealthy
Preferred Tree/Shrub Establishment and Regeneration	98	Healthy
Utilization of Preferred Woody Plants	44	Unhealthy
Live Woody Vegetation Removal by Humans or Beaver (this parameter was not measured in 1999)	94	Healthy
Standing Decadent and Dead Woody Material	93	Healthy
Streambank Root Mass Protection	84	Healthy
Human-caused Bare Ground	82	Healthy
Streambanks Structurally Altered by Human Activity	82	Healthy
Human Physical Alterations to the Floodplain	72	Healthy but with Problems
Stream Channel Incisement	84	Healthy
Overall Average Score	**75**	**Healthy but with Problems**

Overall, limited conclusions can be drawn from the sparse riparian health data available. To better understand current watershed-scale riparian conditions, a more comprehensive and repeatable GIS-based assessment should be considered. Coupled with ongoing community engagement and ground-based riparian health inventories, the GIS assessment could also be used to highlight riparian restoration opportunities and habitat management or protection priorities for the watershed.

5.2 Wetlands

Wetlands are lentic (non-flowing) riparian areas. Wetlands provide many of the same functions as lotic (flowing) riparian areas, and are important for flood protection, drought mitigation, maintaining water quality and biodiversity. Studies have shown that a variety of seasonal and permanent wetlands are required to maintain appropriate water balance in watersheds (van der Kamp and Hayashi 2009).

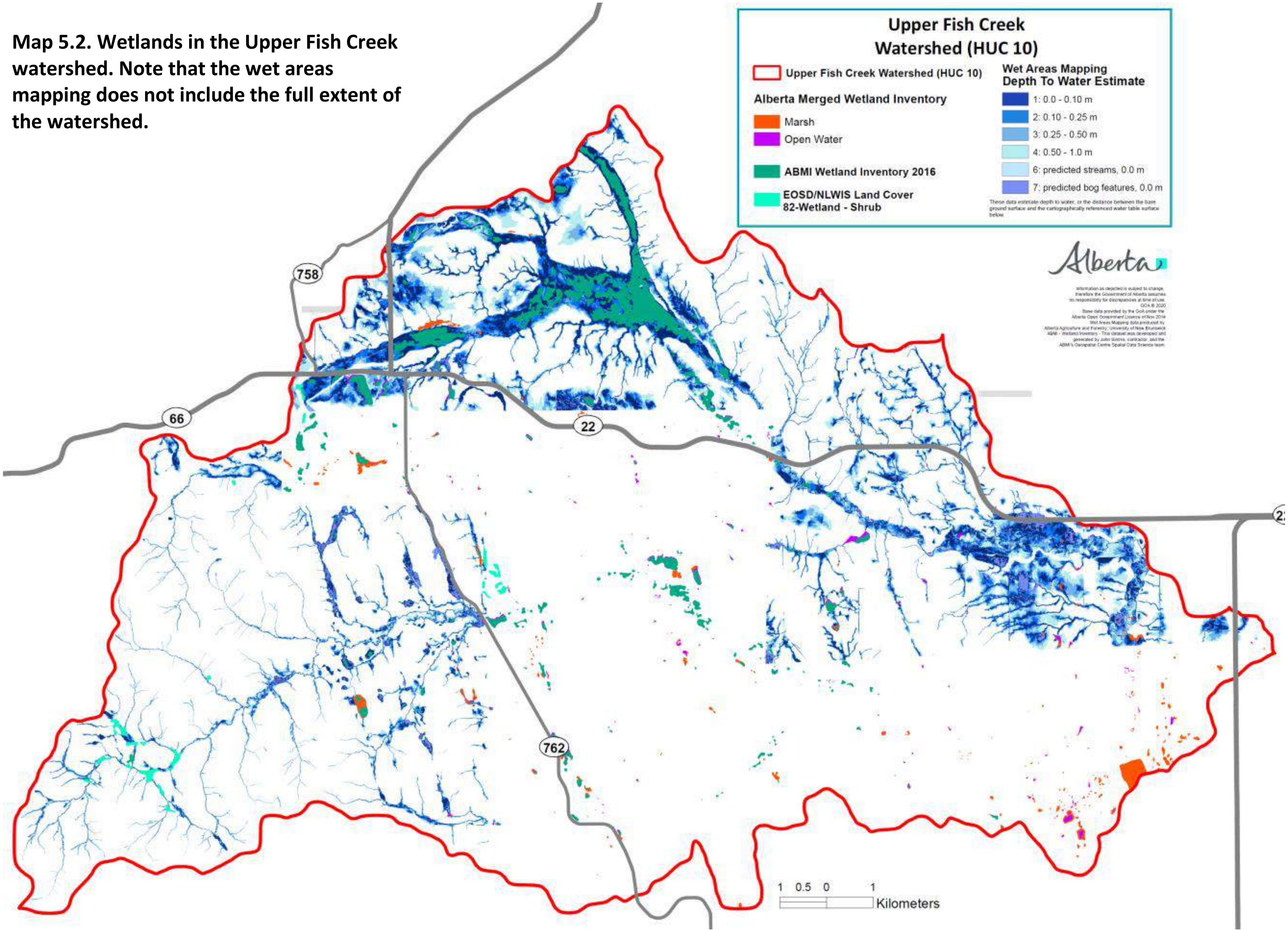
Wetlands are described by the permanency of water that is present throughout the year. The Stewart and Kantrud wetland classification system describes wetlands as permanent, semi-permanent. Wetlands are further classified as marsh, swamp, fen, bog and open water.

Wetlands in the Upper Fish Creek watershed are identified in a few different provincial GIS land cover data sets, however, the areas identified as wetland cover type vary among the data sets (Map 5.1). To best understand the extent of wetlands in the area, several data sets were combined (Map 5.2).

From the combined data sets, wetlands make up approximately 1.35% of the watershed. Wetlands were classified as either marsh or open water (Map 5.2). Some of the largest wetland areas were found on Tsuut'ina First Nation in the northern part of the watershed, and near the Hamlet of Priddis (Map 5.2).

Currently, there are plans to complete a more comprehensive wetland inventory in the Bow River region. This work will benefit the Upper Fish Creek watershed.

Map 5.1. Wetland density in the Upper Fish Creek watershed.



Map 5.2. Wetlands in the Upper Fish Creek watershed. Note that the wet areas mapping does not include the full extent of the watershed.

6.0 Biodiversity

6.1 Fish Community

6.1.1 Fish Creek

Fish sampling occurred in the Fish Creek watershed from 1978 to 2013 resulting in 31 sampling events (Appendix B, Table 1). A total of 12 fish species plus one hybrid species were captured at Fish Creek with a total of 1,776 fish captured (Appendix B, Table 1). Table 1 reveals two distinct fish communities at Fish Creek: 1) A fish community from the Hamlet of Priddis upstream to the Coalmine Road comprised primarily of small- and large-bodied forage fish and 2) an upper reach community comprised primarily of trout from approximately Highway 762 upstream to the headwaters (including the McLean Creek Off-Highway Vehicle PLUZ). Almost no fish sampling has been completed between the Coalmine Road and Highway 762.

Hamlet of Priddis upstream to the Coalmine Road

The fish community from the Hamlet of Priddis upstream to the Coalmine Road has been sampled 14 times from 1986 to 2013. A total of nine fish species and 769 fish were captured and comprised the following: Rainbow Trout (19), Brook Trout (5), White Sucker (75), Longnose Sucker (205), unidentified Sucker Sp. (8), Trout-Perch (70), Longnose Dace (338), Lake Chub (43), Pearl Dace (3) and Fathead Minnow (3) (Figure 6.1).

- The fish community was primarily composed of five species that accounted for 96% of the total fish captured (1986-2013): Longnose Dace, Longnose Sucker, White Sucker, Trout-Perch and Lake Chub. These species would be considered <u>abundant</u> from the Hamlet of Priddis upstream to the Coalmine Road.

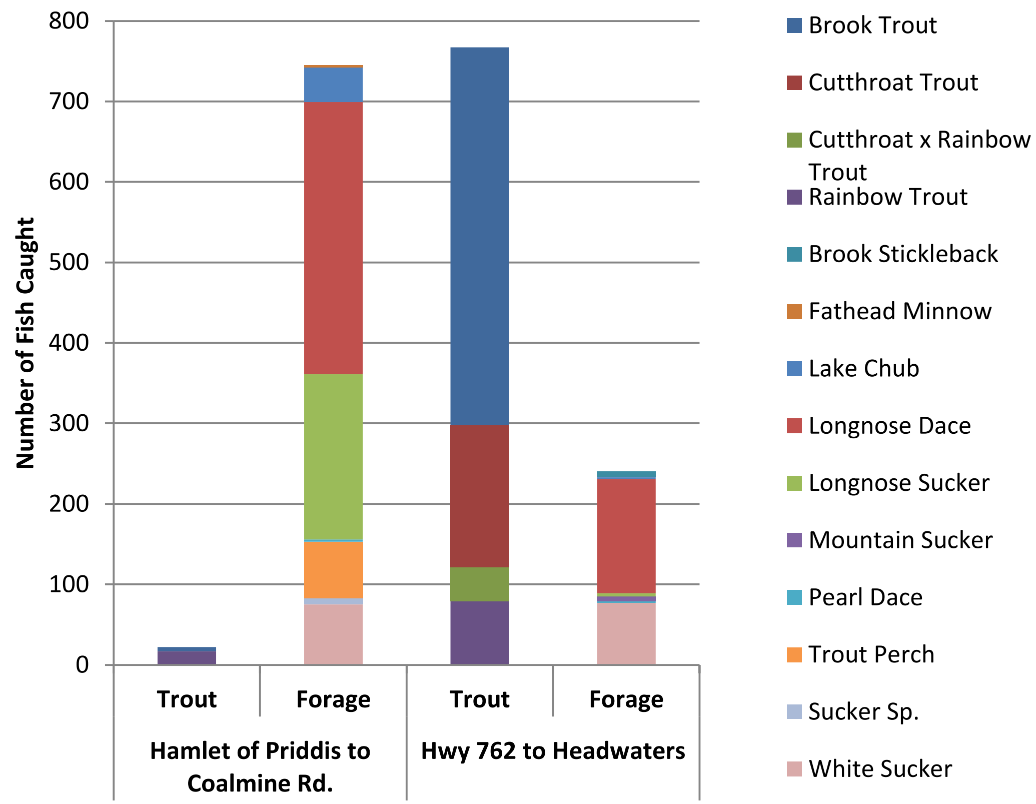


Figure 6.1. Fish community in Fish Creek at two reaches: Hamlet of Priddis to Coalmine Rd. (1986-2013) and Hwy 762 to Headwater (1978-2013).

- Rainbow Trout comprised 2% of the total catch and would be considered common from the Hamlet of Priddis upstream to the Coalmine Road
- Brook Trout, Pearl Dace and Fathead Minnow comprised 2% of the total catch and would be considered uncommon from the Hamlet of Priddis upstream to the Coalmine Road.

By total number of fish captured, the fish community was composed primarily of small- and large-bodied forage fish (97%) and only 3% were trout. Cutthroat Trout, Cutthroat Trout x Rainbow Trout hybrids, Mountain Sucker and Brook Stickleback were not captured from the Hamlet of Priddis upstream to the Coalmine Road.

Hwy 762 to Headwaters of Fish Creek

The fish community at the upper reach of Fish Creek has been sampled 17 times from September 1978 to June 2013. A total of 10 fish species (and one hybrid species) and 1,007 fish were captured and comprised the following: Rainbow Trout (79), Brook Trout (469), Cutthroat Trout (177), Cutthroat Trout x Rainbow Trout hybrid (42), White Sucker (77), Longnose Sucker (4), Mountain Sucker (6), Longnose Dace (142), Lake Chub (2), Pearl Dace (2) and Brook Stickleback (7) (Figure 6.1).

- The fish community at the upper reach was primarily composed of five species which accounted for 94% of the total fish captured (1978-2013): Brook Trout, Cutthroat Trout, Longnose Dace, Rainbow Trout and White Sucker. These species would be considered abundant from Highway 762 upstream to the headwaters.
- Cutthroat Trout x Rainbow Trout hybrids comprised 4% of the total catch in the study area and would have been considered common from Highway 762 upstream to the headwaters. The Cutthroat Trout x Rainbow Trout hybrids (sometimes referred to as 'Cutbows') were only captured in 1978 and 1993 and have not been observed since. Cutthroat Trout x Rainbow Trout hybrids are difficult to identify 'in hand'; therefore, the accuracy of hybrid identification in the 1970s, 1990s and thereafter is unknown.
- Brook Stickleback, Longnose Sucker, Lake Chub and Pearl Dace comprised 2% of the total catch in the study area and would be considered uncommon from Highway 762 upstream to the headwaters.

By total number of fish captured, the fish community at the upper reach of Fish Creek was composed primarily of trout (76%) and small- and large-bodied forage fish (24%). Trout-Perch and Fathead Minnow were not captured from Highway 762 upstream to the headwaters (Figure 6.1).

Shift in Fish Community

A comparison of the percent composition of the trout captures in the upper reach of Fish Creek from three time periods indicates a fish community shift:

- In 1978 the trout community was dominated by Cutthroat Trout (69%) and Rainbow Trout (27%) with low numbers of Brook Trout (4%).
- In 1993 the trout community was dominated by Brook Trout (83%) with lower numbers of Cutthroat Trout (12%) and Rainbow Trout (5%).
- From 2000 to 2013 the trout community was dominated by Brook Trout (65%) with lower numbers of Cutthroat Trout (25%) and Rainbow Trout (10%).

In the 1970s, the upper reach from Highway 762 upstream to the headwaters was dominated by Cutthroat Trout/Rainbow Trout and Brook Trout occurred in low numbers. However by the early 1990s the fish community was dominated by Brook Trout and the trout community continued to be dominated by Brook Trout after 2000.

Spawning

No recent Rainbow Trout spawning surveys have been documented for Fish Creek. Historical Rainbow Trout spawning observations date back to 1972, 1973 and 1983 when no Rainbow Trout redds were observed in an area upstream of Priddis, and upstream of the Priddis Creek mouth. In 1986, three Rainbow Trout redds were observed in an area 1 km upstream and 1 km downstream of Priddis Creek mouth. In 1979, observations of spawning Rainbow Trout were made in an area within 3 km upstream and downstream of Highway 762. Five ripe male Rainbow Trout were also captured immediately upstream of Highway 762 in 1993 (Baayens and Brewin 1999).

No Cutthroat Trout or Brook Trout spawning surveys have been documented for Fish Creek in the FCWA boundary. However, two ripe female and 14 ripe male Cutthroat Trout were captured near McLean Creek Trail in spring 1993 near the headwaters (Baayens and Brewin 1999). Ripe male and female Brook Trout (and spent females) were also captured in an area from Highway 762 upstream to Fish Creek East Trail in fall 1993 (Baayens and Brewin 1999).

While specific areas of Rainbow Trout, Cutthroat Trout and Brook Trout spawning were not identified by Baayens and Brewin (1999) at Fish Creek, the presence of ripe male and female trout (and spent females) in spring and fall 1993 indicates likely spawning areas from approximately Highway 762 upstream to the headwaters in the McLean Creek Off-Highway Vehicle PLUZ.

Fish Habitat

Baayens and Brewin (1999) concluded the upper reaches of Fish Creek in Kananaskis Country had largely intact fish habitat.

Two potentially important fish habitat areas were identified in the upper reach: 1) from Highway 762 upstream for 1 km and 2) from 4.5 km downstream of McLean Creek Road to 1.5 km upstream of the McLean Creek Road.

During November 1993 these two areas were ice-free while the rest of the creek was frozen over. The ice-free areas were attributed to the presence of warmer groundwater inputs. Baayens and Brewin (1999) documented high numbers of sportfish in these two areas including ripe and spent Brook Trout. They concluded these areas may provide critical fall-spawning for Brook Trout and overwintering areas for trout. Brook Trout are known to spawn in areas of groundwater upwellings and trout have been documented to seek out deeper pools with groundwater discharge in winter.

An aerial survey in 1993 indicated that the predominantly private lands adjacent to Fish Creek in the middle reach from Priddis to Highway 762 had a degraded riparian area due to relatively heavy clearing and development (Baayens and Brewin 1999). The authors concluded that Fish Creek from Priddis upstream to Highway 762 was subject to habitat degradation, low flows and excessive beaver damming that had likely caused declines in the population of resident sportfish and Rainbow Trout from the Bow River that previously utilized this reach of Fish Creek for spawning and rearing. A section of ice-free creek from Highway 762 downstream for 3 km was identified as potentially important fall-spawning for Brook Trout and an overwintering area for trout (Baayens and Brewin 1999).

6.1.2 *Priddis Creek*

Fish sampling occurred in the Priddis Creek watershed from 1979 to 2020 during 14 sampling events (Appendix B, Table 2). A total of 11 fish species were captured in Priddis Creek with a total of 831 fish captured. The dominant fish community in the Priddis Creek watershed (based on capture abundance) was composed of three species: White Sucker, Longnose Dace and Lake Chub (Appendix B, Table 2). These three species accounted for 70% of the total fish captured from 1979 to 2020 and would be considered <u>abundant</u> in Priddis Creek.

White Sucker represented 34% of the total catch and was found in both mainstem and tributaries of Priddis Creek. Lake Chub represented 22% of the total catch and was found in both mainstem and tributaries of Priddis Creek. Longnose Dace represented 14% of the total catch and was captured in mainstem Priddis Creek. Longnose Dace have not been captured in tributaries to Priddis Creek.

Rainbow Trout, Fathead Minnow and Brook Stickleback comprised 26% of the total catch in the study area, occurred in moderate numbers and would be considered <u>common</u> in Priddis Creek. Fathead Minnows accounted for 14% of the total catch but almost all of them were captured in a tributary in the upper headwaters of Priddis Creek. Brook Stickleback accounted for 7% of the total catch and was found in both mainstem and tributaries of Priddis Creek. Rainbow Trout accounted for 5% of the total catch and were only captured in the mainstem of Priddis Creek.

The remaining five fish species in Priddis Creek were Brook Trout, Cutthroat Trout (*Oncorhynchus clarki*), Longnose Sucker (*Catostomus catostomus),* Trout-Perch and Pearl Dace (*Semotilus margarita*). These five species represented 4% of the total catch, occurred in low numbers and would be considered <u>uncommon</u> in Priddis Creek.

Something Fishy is Going on Here

I've been observing fish in Fish Creek and Priddis Creek for decades. In the spring, when I can finally get my bikes out (bicycle and motorcycle), one of my favourite things to do is stop on the bridges and look for fish. Some years are better than others. Priddis Creek has way better clarity [than] Fish Creek. In fact they are amazingly different that way. One of the good things about 2020 was it brought awesome conditions for spawning fish. Lots of really big fish, easily in the 20" range. The highlight was watching a couple of spawning rainbows in the shallows and then catching sight of a massive bull trout flash through a deep pool adjacent to the riffle. I heard bull trout will follow the rainbows in the hopes of gorging on eggs.

Fish Creek and Priddis Creek have so much potential to be productive spawning streams. I worry that all the unnamed creeks and springs that feed into Fish Creek and Priddis Creek are being overlooked with respect to protection.

– P. Adams

Based on historical fish sampling prior to 2020, sportfish appeared to be nearly absent from Priddis Creek with only four Rainbow Trout and one Cutthroat Trout captured between 1979 and 2012, and comprising 0.7% of the total catch. The Rainbow Trout were captured in 1979 and 1993 and none were captured in sampling events in 1986, 2001, 2002, 2005, 2007, 2010 or 2012.

However, recent fish sampling in August 2020 indicated that Rainbow Trout were more abundant than previously indicated (Appendix B, Table 2). Brook Trout were also captured in 2020; although, they had not previously been reported in the provincial database.

Spawning

No recent Rainbow Trout spawning surveys have been documented for Priddis Creek. In May 1972, 52 Rainbow Trout were observed digging redds from the mouth to 3.2 km upstream. However, during May 1983, no redds (2 large trout observed) were recorded from the mouth to 3 km upstream. In May 1986, no Rainbow Trout redds (or sportfish) were recorded from the mouth to 1 km upstream (Baayens and Brewin 1999). Spawning Rainbow Trout were observed near the 256 St. W bridge (5.9 km upstream of the mouth) on May 30, 2020 (Peter Adams, watershed resident, pers. obs.). Beaver activity is common on Priddis Creek, and dams at times may limit access to spawning areas.

Fish Habitat

Baayens and Brewin (1999) concluded from an aerial survey that the predominantly private lands adjacent to Priddis Creek had a degraded riparian area due to relatively heavy clearing and development. Baayens and Brewin (1999) also concluded the habitat degradation, low flows and excessive beaver damming of Priddis Creek had likely caused declines in the population of resident sportfish and Rainbow Trout from the Bow River that previously utilized Priddis Creek for spawning and rearing.

6.1.3 Whiskey Creek

Fish sampling (electrofishing and minnow traps) occurred at Whiskey Creek from 1993 to 2012 during 5 sampling events (Appendix B, Table 3). A total of 9 fish species were captured with a total of 311 fish captured. The dominant fish community in Whiskey Creek, based on capture abundance and number of sampling events the species was captured in, was composed of three species: White Sucker, Brook Stickleback and Lake Chub (Appendix B, Table 3). These three species accounted for 84% of the total fish captured from 1993 to 2012 and historically would be considered abundant in Whiskey Creek. White Sucker represented 51% of the total catch and was captured in 5 of 5 sampling events. Brook Stickleback represented 19% of the total catch and was captured in 5 of 5 sampling events at Whiskey Creek. Lake Chub represented 14% of the total catch and was captured in 3 of 5 sampling events. The capture of a 'ripe' male White Sucker and a 'spent' female White Sucker in 1993 suggests spawning by this species occurs in Whiskey Creek.

Longnose Dace and Trout-Perch comprised 11% of the total catch in the study area, occurred in moderate numbers and historically would be considered common in Whiskey Creek. Trout-Perch were only captured during the 1993 sampling event near the confluence with Fish Creek and may have a limited distribution in Whiskey Creek.

The remaining four fish species in Whiskey Creek were Fathead Minnow, Pearl Dace, Longnose Sucker and Rainbow Trout. These four species represented <5% of the total catch, occurred in low numbers and historically would be considered <u>uncommon</u> in Whiskey Creek. Pearl Dace, Longnose Sucker and Rainbow Trout were only captured during the 1993 sampling event near the confluence with Fish Creek and may have a limited distribution in Whiskey Creek.

Based on historical fish sampling, sportfish appear to be absent or nearly so from Whiskey Creek with only one Rainbow Trout captured in 1993. Subsequent sampling after 1993 did not capture any Rainbow Trout suggesting they are absent from Whiskey Creek or occur in very low numbers. Cutthroat Trout were historically reported in Whiskey Creek prior to 1945 (Baayens and Brewin 1999). A total of 2000 Cutthroat Trout were stocked at Whiskey Creek in September 2000 and a further 2000 were stocked in fall 2002 approximately 1.5 km downstream of Highway 762. The stocked Cutthroat Trout were between 50 and 56 mm long (FWMIS online). Subsequent fish sampling in 2004 and 2012 in the area of the Cutthroat Trout stocking location did not capture any Cutthroat Trout suggesting poor survival and recruitment.

6.1.4 Condition Assessment

Fish Creek

- In the 1970s, Fish Creek from Highway 762 upstream to the headwaters was dominated by Cutthroat Trout/Rainbow Trout and Brook Trout occurred in low numbers. However from the 1990s onward the fish community has been dominated by Brook Trout. The upper Fish Creek within Crown land areas probably has the most intact fish habitat at Fish Creek.
- Fish Creek from Priddis upstream to Highway 762 has been subject to habitat degradation, low flows and excessive beaver damming that has likely caused declines in the population of resident sportfish and Rainbow Trout from the Bow River that previously utilized this reach of Fish Creek for spawning and rearing.

Priddis Creek

- Based on historical fish sampling prior to 2020, sportfish appeared to be nearly absent from Priddis Creek with only four Rainbow Trout and one Cutthroat Trout captured between 1979 and 2012. Recent fish sampling in 2020 indicated that Rainbow Trout were more abundant than previously indicated. Brook Trout were also captured in low numbers in 2020 and had not previously been reported in the provincial database.
- The presence of mature Brook Trout captured in 2020 at Priddis Creek indicates adults probably reside in the creek year-round. The low numbers of small Brook Trout captured during 2020 suggests low survival and recruitment of Brook Trout. Overwintering Brook Trout eggs and larval fish may experience high mortality in the substrate from de-watering, freezing or low dissolved oxygen.
- Habitat degradation, a degraded riparian area, low flows and excessive beaver damming probably limits the sportfish population at Priddis Creek.

Whiskey Creek

- Based on historical fish sampling since 1993, sportfish appear to be absent or nearly so from Whiskey Creek with only one Rainbow Trout captured in 1993 at the mouth. Subsequent sampling after 1993 has not captured any sportfish.
- Similar to Fish Creek downstream of Highway 762, it is likely that habitat

degradation, a degraded riparian area, low flows and excessive beaver damming has limited the fish population at Whiskey Creek to non-sportfish such as White Sucker, Brook Stickleback and Lake Chub.

6.2 Plants

Native plant communities are important to the overall health of watersheds, contributing to soil structure and habitat for insects, birds and wildlife. When sites are disturbed, the local plant community may be displaced by new species that are better able to establish on disturbed or poor soils. Early colonizing species often have biological advantages that help them establish, thereby outcompeting local plants. Disturbance-caused species may be native, or they can be introduced. Often disturbance facilitates the colonizing of invasive plants. These plants, if left uncontrolled, can take over sites. They often do not have the same value for biodiversity as the community they displaced.

The upper Fish Creek watershed is rich in plant diversity. Cows and Fish completed detailed plant community inventories at four sites in the upper watershed. They documented 4 tree species and 20 different shrub species, including 11 species of willow. Thirty-one grass and grass-like species were identified along with 68 unique forbs. A complete plant list can be found in Appendix C.

Disturbance-caused grasses observed in the upper watershed were foxtail barley (native) and red fescue (may be native or introduced). Introduced disturbance-caused grasses included Kentucky bluegrass, meadow foxtail, orchard grass, smooth brome, and timothy.

Tall Larkspur

Disturbance-caused native forbs (broad-leafed plants) observed in the upper watershed included field mouse-ear chickweed and wild strawberry. Disturbance-caused introduced forbs included alsike clover, bluebeard, common dandelion, common plantain, green sorrel, hemp-nettle, red clover and white clover.

Not all native plants are desirable. Some species are poisonous and can be deadly to livestock when ingested, while others are highly invasive when left uncontrolled. Tall larkspur and common horsetail are two poisonous plants that were found in the upper Fish Creek watershed. Introduced invasive species identified were Canada thistle and tall buttercup.

Municipalities are responsible for controlling the spread of weeds through the administration of the Alberta Weed Act. Landowners identifying invasive or poisonous plants on their property, must take steps to control their spread.

6.3 Wildlife

The upper Fish Creek watershed provides a variety of habitats for amphibians, mammals and birds. The Alberta Fish and Wildlife Management System lists some species in its database, however, residents and landowners have observed more species than currently listed suggesting that there have been few wildlife surveys completed in the watershed (Table 6.1).

Table 6.1. Some wildlife observed in the Upper Fish Creek watershed. An asterisk* indicates resident/landowner observations.

Group	Species
Amphibians	Northern Leopard Frog
Mammals	Beaver
	Bobcat
	Coyote*
	Cougar
	Grizzly Bear
	Moose*
	Mule Deer*
	Muskrat
	Pine Marten*
	White-tailed Deer*
	Wolf*
Birds	Alder Flycatcher
	Bald Eagle
	Barn Swallow
	Barred Owl
	Common Yellowthroat
	Great Blue Heron
	Great Gray Owl
	Least Flycatcher
	Northern Goshawk
	Northern Pygmy-Owl
	Olive-sided Flycatcher
	Pileated Woodpecker
	Sora
	Western Wood-Pewee

Beavers

Beaver activity in the Upper Fish Creek watershed is extensive. Numerous dams have been observed at Fish and Priddis creeks. Beavers have the ability to transform landscapes by creating dams that store water and alter hydrology of local streams. Beavers alter stream gradients, elevate stream channels, change cross-sectional valley profiles and aid riparian vegetation. They can substantially increase open water area within watersheds, and increased wetted-width of streams. Ponds slow water which can reduce water velocity and streambank erosion, as well as trap and store sediment, thereby improving water quality (Fitch 2016).

While there are many benefits of the presence of beavers in watersheds, they can be a nuisance when desired trees are harvested for dam-building and ponded water upstream of the dam impacts infrastructure. In recent years, effort has increased to identify tools that can be used to mitigate nuisance activity and maintain beaver on the landscape. Tools identified include fencing desired trees, repellents, and water level controls (Fitch 2016).

Pond leveller at Upper Fish Creek

7.0 SUMMARY

Indicators of watershed condition provide evidence of the growing cumulative impacts on watershed resources in the Upper Fish Creek watershed. Despite the limited availability of data for some indicators, noteworthy findings were made:

- Historically, annual streamflows have not met Water Conservation Objectives about 60% of the time at Fish Creek (1912-2008), particularly during winter, late summer and fall
- At Priddis Creek during the open water season (2008-2020), Instream Objectives were not met an average of 15% of the time (range: 0-39%) mainly during summer; In 2018, a particularly dry year, Instream Objectives were not met 56% of the time
- Although water quality data is limited, preliminary data suggests that high summer water temperature is a concern for aquatic life
- A loss of riparian habitat has occurred (about 13% loss)
- A loss of riparian function has occurred; of the 19 sites assessed, only 37% rated *Healthy*
- Species composition at Fish and Priddis creeks has been altered; fish habitat and species composition is considered degraded at Whiskey Creek
- Climate change is predicted to increase stress on watershed resources

A complete summary of watershed condition assessment results are provided in Table 7.1.

Similar to other watersheds in Alberta, there are many factors that contribute to increasing pressure on natural resources, including the cumulative impact of

- Increasing populations placing pressure on limited resources
- Development of roads and other linear disturbances
- Country-residential developments that contribute to urban sprawl
- Industrial activity, including logging, oil and gas, gravel extraction, farming and ranching, and intensive recreational use

Additional monitoring and assessment is needed to prioritize conservation and restoration efforts to areas in the watershed that will receive the greatest benefit. Collaboration among residents, landowners, businesses, First Nations, municipalities and the provincial government is an essential next step to preserve quality of life and prosperity for everyone in the watershed.

The following Section 7.1 describes data gaps that should be addressed by the FCWA and partners to improve understanding of watershed processes and condition, and to manage resources for future generations.

Table 7.1. Summary of the Upper Fish Creek watershed conditions.

Indicators and Measures	Status	Potential Threats	Opportunities
Land Use			
Population (number/density)	Increasing. 2,229 people or 8.5 people/km^2	• Potential changes in land use. • Increased pressure on surface water supply.	• Planning
Land cover (human footprint)	Increasing. Human footprint is estimated to be 29%.	• Fragmentation of the landscape.	• Planning • Stewardship
Agricultural Activity	Unknown.	• Limited data readily available	• Improved rangeland monitoring
Oil and Gas Activity	Footprint is relatively small; activity has decreased.	• Limited data readily available	• Improved monitoring and reporting • Collaborative planning
Forestry	Activity is increasing; Activity is guided by an approved Forest Management Plan	• Limited data readily available • Forest fire and Mountain Pine Beetle infestations • Success rate of reforestation	
Tourism and Recreation	Activity is increasing; a 25% increase in camp registrations was observed from 2012 to 2020	• Limited data readily available	
Road Density	1.3 km/km^2	• Increased road density due to population growth and development	• Planning
Water Quantity			
Surface water supply and demand	Water supply is at risk and demand is increasing as indicated by frequent water shortage advisories. Supply is not currently meeting human and environmental needs, particularly during low flow periods. Historically, Water Conservation Objectives were not met an average of about 60% of the time at Fish Creek (1912-2008). At Priddis Creek (2008-2020), Instream Objectives (IOs) were not met an average of 15% of weeks. In 2018, a particularly dry year, IOs were not met 56% of the time	• Climate change • Increasing water use within existing water licenses • Water license transfers altering designated uses	• Increased monitoring and reporting • Increased awareness • Planning
Groundwater supply and demand	Groundwater supply and use is stable and currently meeting human and environmental needs	• Limited data available. Increased pressure due to restrictions on new surface water licenses and transfers	• Planning

Table 7.1. Summary of the Upper Fish Creek watershed conditions summary continued...

Indicators and Measures	Status	Potential Threats	Opportunities
Water Quality			
Surface Water Quality (e.g., dissolved oxygen, conductivity, nutrients, sediment, bacteria)	Undetermined; Data suggests that dissolved oxygen is meeting the needs of aquatic life, but water temperature may be a concern for sportfish in Fish and Priddis creeks	• Limited comprehensive data available	• Improved monitoring and reporting
Riparian Areas and Wetlands			
Riparian health assessment scores	Limited current data available for the Upper Fish Creek watershed. Although 19 sites have been assessed, only 8 of these are within the Upper Fish Creek watershed and are more recent than 2015. As such limited conclusions are possible on riparian health condition at the watershed scale. Of sites assessed, 37% sites *Healthy*; 47% sites *Healthy but with Problems*; 16% sites *Unhealthy*	• Limited data available • Invasive species encroachment • Increasing intensity of multiple land uses and resulting loss of riparian functions due to soil/hydrology alterations or impacts to riparian vegetation	• Increased riparian health monitoring • GIS-based riparian assessment techniques. • Citizen science monitoring programs • Community engagement
Percent cover of wetland area	1.3%	• Incomplete data available	• Improve wetland inventory; validate
Loss of riparian area	Estimated loss of 13%	• Increased loss of riparian area and/or functions	• Improved riparian management • Improved riparian setback and protection policies. • Education and awareness
Biodiversity			
Fish Species composition	Altered species composition at Fish and Priddis creeks; Degraded condition at Whiskey Creek (e.g., loss of sportfish)	• Climate change • Low streamflow • Increased water temperature • Habitat loss	• Improved water management to meet instream objectives
Fish Population estimates	Undetermined		
Wildlife	Undetermined	• Limited data available	• Increased monitoring and reporting
Invasive, disturbance, rare plants	Present	• Limited data available	• Increased monitoring

7.1 Data Gaps

Numerous data gaps were identified during the development of this State of the Watershed Report. Additional data should be collected to assist with condition assessments at Upper Fish Creek.

Water Quantity

- Continuous streamflow data for Priddis Creek
- Assessment of natural flow at Priddis Creek
- Assessment of timing of withdrawals to support fisheries and water quality at Priddis Creek
- Explore water losses through evapotranspiration of riparian vegetation at all creeks
- Explore opportunities to augment low flow periods with water from existing storage reservoirs
- Understand the volume of water supplied to residents by water truck

Water Quality

- Lack of current and comprehensive water quality data for the upper Fish Creek watershed limits the assessment of conditions at Fish, Priddis and Whiskey creeks.
- Continuous water temperature data to assist in the assessment of fish habitat conditions.
- Additional groundwater quality monitoring to establish baseline conditions.

Riparian Areas and Wetlands

- A comprehensive assessment of riparian health at the watershed-scale would help focus activity for future riparian health inventory in collaboration with landowners.
- Riparian Health Inventories at Whiskey Creek
- A field-validated wetland inventory for the Upper Fish Creek watershed

Biodiversity

- Fish sampling and habitat assessments should be completed at a lower, middle and upper site in Whiskey Creek.

Fisheries at Fish Creek:

- Spawning locations by trout in Fish Creek are unknown. Historical fish sampling from 1993 captured Rainbow Trout, Cutthroat Trout and Brook Trout in spawning condition upstream of Highway 762.
- Almost no fish sampling has been completed from the Coalmine Road upstream to Highway 762.

Fisheries at Priddis Creek

- The distribution of Rainbow Trout and Brook Trout in Priddis Creek is uncertain. Until recent sampling in 2020, sportfish use of Priddis Creek was considered to be very low (Baayens and Brewin 1999).
- Spawning locations by trout in Priddis Creek are unknown and past spawning surveys (1970s to 1980s) are dated. The fish sampling from August 2020 captured smaller Rainbow Trout and Brook Trout which suggests spawning occurs in Priddis Creek.

Fisheries at Whiskey Creek

- Baayens and Brewin (1999) recommended that fisheries and habitat inventories be completed at Whiskey Creek as there is little information on sportfish in this stream. No information on fish habitat was found for Whiskey Creek with the exception of an observation that the riparian area was degraded from an aerial survey conducted on May 19, 1993 (Baayens and Brewin 1999). Only limited fish sampling has occurred in 1993, 2000, 2004 and 2012.

Land Use

Stream Crossings

- It is unknown if stream crossings are a barrier to fish passage at Fish Creek, Priddis Creek or Whiskey Creek.

Forestry

- Understand the effectiveness of forest reclamation practices (road reclamation, reforestation activities).
- Understand how riparian setbacks are being used in the upper watershed
- Understand the impact of forestry activity on local hydrology.

7.2 Recommendations and Next Steps

1. Review data gaps and develop a strategy to address them. Priorities should include
   a. Streamflow data collection at Priddis Creek
   b. Riparian intactness assessment
   c. Comprehensive water quality data collection
   d. Fish sampling

2. Develop an Integrated Watershed Management Plan (Strategic Watershed Plan) in collaboration with watershed stakeholders (e.g., provincial and municipal government, First Nations, industry, landowners and residents) that includes:
   a. Issue statements as identified in the State of the Watershed Report and through further discussion with stakeholders
   b. Management objectives, targets and thresholds
   c. Recommendations to address issues
   d. A strategy to guide implementation

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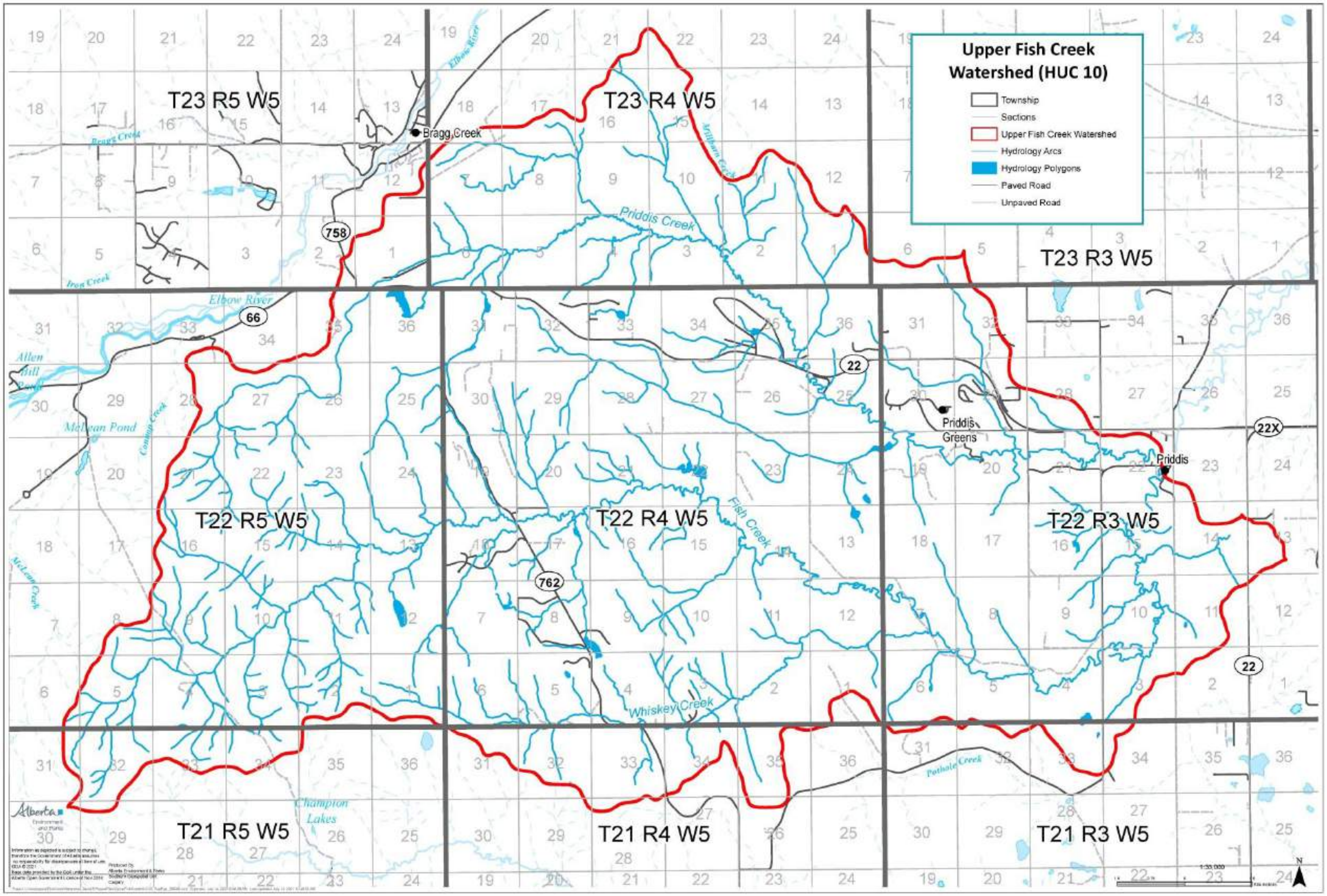
APPENDIX A. REFERENCE MAP SHOWING TOWNSHIP AND RANGE FOR THE UPPER FISH CREEK WATERSHED.



APPENDIX B. FISHERIES DATA

Table 1 - Fish capture and habitat information for Fish Creek, Alberta (Data from Alberta Environment and Parks fisheries database [FWMIS] unless otherwise indicated).

Location	Date	Species (No. Captured)	Method - Fishing Effort	Comments
MAINSTEM FISH CREEK				
-site located in Hamlet of Priddis, 150 m downstream of bridge (186 Avenue W) Lat./Long. 50.88564 -114.327	Sep. 6, 2006	Longnose Sucker (189) Trout-Perch (35)	Electrofishing: 40 m, 2867 seconds	
-site locate 1 km upstream of 186 Avenue W (Priddis) Lat./Long. 50.88107 -114.331	Jun. 18, 2013	Longnose Dace (8)	Electrofishing: 300 m, 1432 seconds	-water depths: 0.1 to 1.28 m -wetted widths: 6.3 to 12.6 m -channel units: 18% pool, 32% riffle, 50% run
-site located 3.9 km downstream of 240 St W. road Lat./Long. 50.85467 -114.330	Jun. 23/24, 2009	White Sucker (14) Trout-Perch (7) Longnose Dace (17) Lake Chub (11)	Minnow Traps Electrofishing: 600 m, 1264 seconds	
-site located 2.3 km downstream of 240 St W. road Lat./Long. 50.84699 -114.333	Aug. 26, 1986	White Sucker (10) Trout-Perch (7) Longnose Dace (28) Lake Chub (12) Sucker species (8)	Electrofishing: 300 m	-water quality: pH 8, conductivity 409 µS/cm, oxygen 7.5 mg/L, water temp. 18.6°C -water depths: 0.07 to 0.20 m -wetted width: 5.4 m -substrate: 9% fines, 58% gravel, 30% cobble, 3% boulder -channel units: 18% pool, 32% riffle, 50% run
-site located 410 m downstream of 240 St W. road Lat./Long. 50.84915 -114.344	Jun. 18, 2013	White Sucker (3) Longnose Dace (28)	Electrofishing: 300 m, 1080 seconds	-water quality: pH 8.76, conductivity 371 µS/cm, oxygen 8.6 mg/L, water temp. 14.3°C -water depths: 0.77 to 1.35 m -wetted width: 7.2 to 11.1 m -channel units: 32% pool, 9% riffle, 59% run
-site located 75 m downstream of 240 St W. road (Site Fs3 - Baayens and Brewin 1999) Lat./Long. 50.848349 -114.346932	May 21, 1993	Brook Trout (1) White Sucker (4) Trout-Perch (5) Longnose Dace (14) Lake Chub (1)	Electrofishing: 230 m, 1862 seconds	-wetted width: 7.78 m -Brook Trout: 234 mm long
-site located 400 m upstream of 240 St W. road Lat./Long. 50.84534 -114.349	Aug. 28, 1986	Rainbow Trout (2) White Sucker (17) Longnose Sucker (2)	Gill net	
-site located 2.2. km downstream of Coalmine Road bridge Lat./Long. 50.84278 -114.370	Jun. 12, 2013	White Sucker (3) Trout-Perch (4) Longnose Dace (24) Lake Chub (7)	Electrofishing: 300 m, 1648 seconds	-water quality: pH 8.61, conductivity 363 µS/cm, oxygen 9.4 mg/L, water temp. 10.5°C -water depths: 0.27 to 0.95 m -wetted width: 7.0 to 9.7 m -channel units: 18% pool, 45% riffle, 37% run

Table 1 - Fish capture and habitat information for Fish Creek, Alberta (Data from Alberta Environment and Parks fisheries database [FWMIS] unless otherwise indicated).

Location	Date	Species (No. Captured)	Method - Fishing Effort	Comments
-site located 50 m downstream of Coalmine Road bridge Lat./Long. 50.84682 -114.393	Sep. 8, 2008	Rainbow Trout (9) White Sucker (5) Longnose Sucker (1) Trout-Perch (4) Longnose Dace (11) Fathead Minnow (1) Pearl Dace (2)	Electrofishing: 200 m, 561 seconds	-water quality: pH 10.1, conductivity 460 µS/cm, water temp. 10.1°C -wetted width: 6.9 to 10.6 m -substrate: 19% fines, 22% gravel, 55% cobble, 4% boulder -channel units: 40% riffle, 60% run
-site located 50 m upstream of Coalmine Road bridge (Site Fs4 - Baayens and Brewin 1999) Lat./Long. 50.848 -114.394	June 10, 1993	Brook Trout (1) White Sucker (4) Longnose Sucker (4) Trout-Perch (3) Longnose Dace (5) Lake Chub (2)	Electrofishing: 285 m, 1422 seconds	-wetted width: 7.05 m -Brook Trout: 212 mm long
-site located 500 m downstream of Whiskey Creek mouth Lat./Long. 50.85006 -114.398	Aug. 27, 1986	Rainbow Trout (3) White Sucker (10) Longnose Sucker (9) Trout-Perch (1) Longnose Dace (37) Lake Chub (2) Pearl Dace (1)	Electrofishing: 300 m	-water quality: pH 7.6, conductivity 377 µS/cm, oxygen 7.4 mg/L, water temp. 12.6°C -water depth: 0.21 -wetted width: 4.74 m -substrate: 9% fines, 21% gravel, 25% cobble, 45% boulder
-630 m upstream of Whiskey Creek mouth -800 m downstream of Coalmine Road Lat./Long. 50.85531 -114.405	Jun. 18, 2013	Rainbow Trout (5) Brook Trout (2) White Sucker (1) Trout-Perch (2) Longnose Dace (110) Lake Chub (7)	Electrofishing: 300 m, 1415 seconds	-water quality: pH 8.58, conductivity 324 µS/cm, oxygen 8.8 mg/L, water temp. 13.1°C -water depth: 0.25 to 0.52 -wetted width: 5.8 to 10.8 m -channel units: 32% riffle, 15% pool, 53% run
-4.3 km upstream of confluence with Whiskey Creek - Coalmine Road located 140 north of site Lat./Long. 50.86178 -114.427	Jun. 11, 2013	Brook Trout (1) White Sucker (4) Trout-Perch (2) Longnose Dace (56) Lake Chub (1) Fathead Minnow (2)	Electrofishing: 300 m, 2014 seconds	-water quality: pH 8.25, conductivity 70 µS/cm, oxygen 10.1 mg/L, water temp. 9.3°C -water depth: 0.57 to 0.94 -wetted width: 7.7 to 21.8 m -water stage: high -channel units: 8% riffle, 28% pool, 64% run
-located 440 m downstream of Highway 762 Lat./Long. 50.87546 -114.529	Jun. 10, 2013	Rainbow Trout (15) Brook Trout (28) Longnose Dace (2)	Electrofishing: 300 m, 1609 seconds	-water quality: pH 8.45, conductivity 236 µS/cm, oxygen 10.1 mg/L, water temp. 7.0°C -water depth: 0.26 to 0.67 -wetted width: 4.45 to 13.8 m -water stage: high

Table 1 - Fish capture and habitat information for Fish Creek, Alberta (Data from Alberta Environment and Parks fisheries database [FWMIS] unless otherwise indicated).

Location	Date	Species (No. Captured)	Method - Fishing Effort	Comments
				-channel units: 46% riffle, 9% pool, 45% run
-located 75 m downstream of Highway 762 Lat./Long. 50.87479 -114.532	Jul. 27, 2000	Rainbow Trout (5) Brook Trout (42)	Electrofishing: 510 m, 400 seconds	
-located 25 m upstream of Highway 762 (Site Ff3 - Baayens and Brewin 1999) Lat./Long. 50.874663 -114.533550	November 12 and 13, 1993	Rainbow Trout (6) Brook Trout (142) Cutthroat ***x*** Rainbow Trout hybrid (5) White Sucker (58) Longnose Sucker (4) Longnose Dace (45) Lake Chub (2)	Electrofishing: 400 m, 3753 seconds (two passes)	-wetted width: 7.6 m -water temp.: 0.5°C -Brook Trout: 1 ripe male, 1 spent female
-located 100 m upstream of Highway 762 (Site Fs5 - Baayens and Brewin 1999) Lat./Long. 50.875 -114.534	May 31, 1993	Rainbow Trout (15) Brook Trout (54) Cutthroat Trout (1) Mountain Sucker (1) Longnose Dace (11) Pearl Dace (2)	Electrofishing: 300 m, 4159 seconds (three passes)	-wetted width: 5.83 m -water temp.: 9°C -Rainbow Trout: 5 ripe males
-located 870 m upstream of Highway 762 Lat./Long. 50.87497 -114.541	Aug. 27, 1986	Rainbow Trout (5) Brook Trout (12) White Sucker (15) Mountain Sucker (5) Longnose Dace (83) Brook Stickleback (7)	Electrofishing: 300 m	-water quality: pH 7.8, conductivity 393 µS/cm, oxygen 6.8 mg/L, water temp. 18.8°C -water depth: 0.09 to 0.20 -wetted width: 3.72 m -substrate: 6% fines, 33% gravel, 43% cobble, 18% boulder
-located 3 km upstream of Highway 762 Lat./Long. 50.87043 -114.564	Sep. 25, 1978	Rainbow Trout (31) Brook Trout (1) Cutthroat ***x*** Rainbow Trout hybrid (1) Longnose Dace (1)	Electrofishing	
-located 5.2 km upstream of Highway 762 Lat./Long. 50.87002 -114.583	Jul. 23, 2007	Brook Trout (22) Cutthroat Trout (3)	Electrofishing: 1156 m, 732 seconds	
-located approximately 3 km downstream of McLean Creek Trail (Site Ff4 - Baayens and Brewin 1999) Lat./Long. 50.859 -114.604	November 12 and 13, 1993	Brook Trout (121) Cutthroat Trout (17) Cutthroat x Rainbow Trout hybrid (35)	Electrofishing: 400 m, 5085 seconds (two passes)	-wetted width: 3.15 m -water temp.: 1°C -Brook Trout: 5 ripe male, 4 spent female, 2 ripe female

Table 1 - Fish capture and habitat information for Fish Creek, Alberta (Data from Alberta Environment and Parks fisheries database [FWMIS] unless otherwise indicated).

Location	Date	Species (No. Captured)	Method - Fishing Effort	Comments
-located at Fish East Trail Lat./Long. 50.85612 -114.608	Sep. 26, 1978	Rainbow Trout (1) Brook Trout (2) Cutthroat Trout (54) Cutthroat **x** Rainbow Trout hybrid (1)	Electrofishing	
- Fish East Trail located 100 m north of site Lat./Long. 50.85099 -114.618	Sep. 25, 1978	Brook Trout (2) Cutthroat Trout (7)	Electrofishing	-site located 100 m downstream of FC9
- Fish East Trail located 100 m north of site Lat./Long. 50.85095 -114.619	May 5, 2006	Brook Trout (22) Cutthroat Trout (32) White Sucker (3)	Electrofishing: 450 m, 1452 seconds	
-site located 165 m downstream of McLean Creek Trail Lat./Long. 50.84494 -114.632	Sep. 25, 1978	Cutthroat Trout (20)	Electrofishing	
-located 50 m downstream of culvert at McLean Creek Trail (Site Fs6 - Baayens and Brewin 1999) Lat./Long. 50.844637 -114.633608	May 27, 1993	Cutthroat Trout (28)	Electrofishing: 400 m, 1206 seconds	Cutthroat Trout: 2 ripe females, 14 ripe males
-located at McLean Creek Trail Lat./Long. 50.84444 -114.634	May 5, 2006	Brook Trout (11) Cutthroat Trout (15) White Sucker (1)	Electrofishing: 380 m, 866 seconds	
-located 200 m upstream of McLean Creek Trail Lat./Long. 50.84454 -114.637	Jun. 18, 2013	Rainbow Trout (1) Brook Trout (8)	Electrofishing: 300 m, 749 seconds	-water quality: pH 8.01, conductivity 242 µS/cm, oxygen 9.0 mg/L, water temp. 7.6^{o}C -water depth: 0.38 to 1.17 -wetted width: 0.8 to 4.9 m -water stage: high -channel units: 50% pool, 50% run
TRIBUTARIES TO FISH CREEK				
-site 1.42 km upstream of confluence with Fish Creek mainstem Lat./Long. 50.862271 -114.471	July 24, 2007	-no fish captured	Electrofishing: 379 m, 589 seconds	-tributary enters mainstem Fish Creek 9.3 km upstream of confluence between Whiskey and Fish creeks
- site 1.3 km upstream of confluence with Fish Creek mainstem Lat./Long. 50.88476 -114.527	Jul. 18, 2007	-no sampling, site was dry	--	-tributary enters mainstem Fish Creek 1260 m downstream of Highway 762 bridge

Table 1 - Fish capture and habitat information for Fish Creek, Alberta (Data from Alberta Environment and Parks fisheries database [FWMIS] unless otherwise indicated).

Location	Date	Species (No. Captured)	Method - Fishing Effort	Comments
-site 1.92 km upstream of confluence with Fish Creek mainstem Lat./Long. 50.86583 -114.547	Jul. 18, 2007	Brook Trout (2)	Electrofishing: 357 m, 523 seconds	-tributary enters mainstem Fish Creek immediately upstream of Highway 762 bridge
-site 590 m upstream of confluence with Fish Creek mainstem Lat./Long. 50.85997 -114.614	July 23, 2007	-no fish captured	Electrofishing: 483 m, 792 seconds	-Fish East Trail located 75 m east of site

Table 2 - Fish capture and habitat information for Priddis Creek, Alberta. (Data from Provincial fisheries database (AEP).

Location	Date(s)	Species (No. Captured)	Method - Fishing Effort	Comments
MAINSTEM PRIDDIS CREEK				
near confluence (mouth) with Fish Creek	Sep. 1, 1979	Rainbow Trout (3) White Sucker (observed) Longnose Dace (observed)	Electrofishing: 300 m Observations	
near confluence mouth with Fish Creek	Aug. 25, 1986	White Sucker (22) Trout-Perch (4) Longnose Dace (2) Lake Chub (5) Brook Stickleback (4)	Electrofishing: 175 m	wetted width: 0.47 m depth: 0.09 to 0.12 m dissolved oxygen: 5.0 mg/L
near confluence (mouth) with Fish Creek (Baayens and Brewin 1999)	May 27, 1993	White Sucker (54) Longnose Sucker (1) Longnose Dace (22) Lake Chub (13)	Electrofishing: 300 m, 2430 s	stream width: 5.83 m
5.5 km upstream of mouth	Aug. 25, 1986	White Sucker (34) Longnose Sucker (1) Longnose Dace (31) Lake Chub (40) Pearl Dace (2) Brook Stickleback (35)	Electrofishing: 300 m	wetted width: 5.5 m depth: 0.16 to 0.18 m dissolved oxygen: 5.8 mg/L
8.5 km upstream of mouth	Aug. 26, 1986	White Sucker (9)	Net: unknown effort	beaver pond area
11 km upstream of confluence with Fish Creek	Aug 26/27, 2020	Rainbow Trout (38) Brook Trout (6) White Sucker (34) Trout-Perch (5) Longnose Dace (23) Lake Chub (11) Fathead Minnow (2) Brook Stickleback (1)	Electrofishing: 425 m, 1886 s 10 Minnow Traps: 18 hours	Rainbow Trout fork length (48 to 190 mm) Brook Trout fork length (75 to 218 mm) dissolved oxygen: 8.61 mg/L water temperature: 14.3°C
14 km upstream of mouth, near Coalmine Road bridge (Baayens and Brewin 1999)	June 4, 1993	Rainbow Trout (1) White Sucker (12) Longnose Dace (1) Lake Chub (2) Pearl Dace (5) Fathead Minnow (2) Brook Stickleback (1)	Electrofishing: 300 m, 1654 s	stream width: 5.85 m

Table 2 - Fish capture and habitat information for Priddis Creek, Alberta. (Data from Provincial fisheries database (AEP).

Location	Date(s)	Species (No. Captured)	Method - Fishing Effort	Comments
14 km upstream of mouth, near Coalmine Road bridge	July 13, 2010	Longnose Dace (40) Lake Chub (21)	Electrofishing: 200 m, 732 s Minnow Traps	
36 km upstream of mouth (headwaters)	July 18, 2007	No fish captured	Electrofishing: 460 m, 611 s	4.7 km southwest of intersection of Highways 22 and 762
TRIBUTARIES TO PRIDDIS CREEK				
700 m upstream of confluence with mainstem (immediately downstream of Priddis Greens Drive)	May 2, 2012	Cutthroat Trout (1) Brook Stickleback (8)	Electrofishing: 300 m, 849 s Minnow Traps	tributary enters mainstem Priddis Creek 6.6 km upstream of mouth
1 km upstream of confluence with mainstem (immediately upstream of Priddis Greens Drive)	June 25, 2002	White Sucker (3)	Electrofishing: 300 m, 1591 s	tributary enters mainstem Priddis Creek 6.6 km upstream of mouth
3 km upstream of confluence with mainstem	May 25, 2001	White Sucker (112) Lake Chub (90) Fathead Minnow (109) Brook Stickleback (5)	Electrofishing: 254 m, 1564 s	tributary enters mainstem Priddis Creek 11 km upstream of mouth
3 km upstream of confluence with mainstem	Oct. 20, 2005	Brook Stickleback (2)	Electrofishing: 1500 m, 1408 s	tributary enters mainstem Priddis Creek 27 km upstream of mouth

Table 3 - Fish capture and habitat information for Whiskey Creek, Alberta. (Data from Provincial fisheries database (AEP).

Location	Date(s)	Species (No. Captured)	Method - Fishing Effort	Comments
WHISKEY CREEK				
-near the confluence with Fish Creek	June 4, 1993	Rainbow Trout (1) White Sucker (21) Longnose Sucker (1) Trout-Perch (16) Longnose Dace (9) Lake Chub (6) Pearl Dace (7) Brook Stickleback (3)	Electrofishing: 130 m, 1505 seconds	Rainbow Trout: 92 mm long White Sucker: 1 ripe male, 1 spent female Stream Width: 1.57 m Water Temp.: 10.5°C
Lat 50.833527 Long -114.488669 676837 E 5634318 N -117 (Zone 11) -approximately 1.5 km downstream of Highway 762	Jul 20, 2000	White Sucker (22) Longnose Dace (11) Lake Chub (23) Fathead Minnow (5) Brook Stickleback (36)	Electrofishing: 250 m, 1211 seconds	-downstream of bridge Sampled by Pisces Environmental Consulting Ltd.
Lat 50.833725 Long-114.521248 674543 N 5634262 E -117 (Zone 11) -approximately 1.2 km upstream of Highway 762	June 30, 2004	White Sucker (4) Brook Stickleback (1)	Electrofishing: 609 seconds	Sampled by Fisheries Management
Lat 50.833740 Long-114.480 677468 N 5634364 E -117 (Zone 11) -approximately 2 km downstream of Highway 762	June 30, 2004	White Sucker (109) Lake Chub (14) Fathead Minnow (2) Brook Stickleback (10)	Electrofishing: 497 seconds	Sampled by Fisheries Management
Lat 50.834889 Long -114.518814 674710 E 5634398 N -117 (Zone 11) -approximately 1 km upstream of Highway 762	Oct 4, 2012	White Sucker (2) Brook Stickleback (8)	Electrofishing: 295 seconds Minnow Traps: 6	Sampled by Amec Foster Wheeler Environment & Infrastructure

Notes:

1) An aerial survey on May 19, 1993 indicated that the riparian area was degraded (Baayens and Brewin 1999).
2) Arthur Ball reported capturing Cutthroat Trout in Whiskey Creek as a child, prior to 1945 (Baayens and Brewin 1999).
3) Baayens and Brewin (1999) recommended that "Fisheries and habitat inventories should be conducted on Whiskey Creek since there is little information on sportfish in this stream and Cutthroat Trout historically utilized this stream in some capacity."
4) 2000 Cutthroat Trout were stocked at Whiskey Creek in September 2000 and 2000 were stocked in September 2002 approximately 1.5 km downstream of Highway 762. Cutthroat Trout were between 50 and 56 mm long (FWMIS)

APPENDIX C. PLANT LIST FROM FOUR SITES LOCATED IN THE UPPER FISH CREEK HEADWATERS (COWS AND FISH 2020).

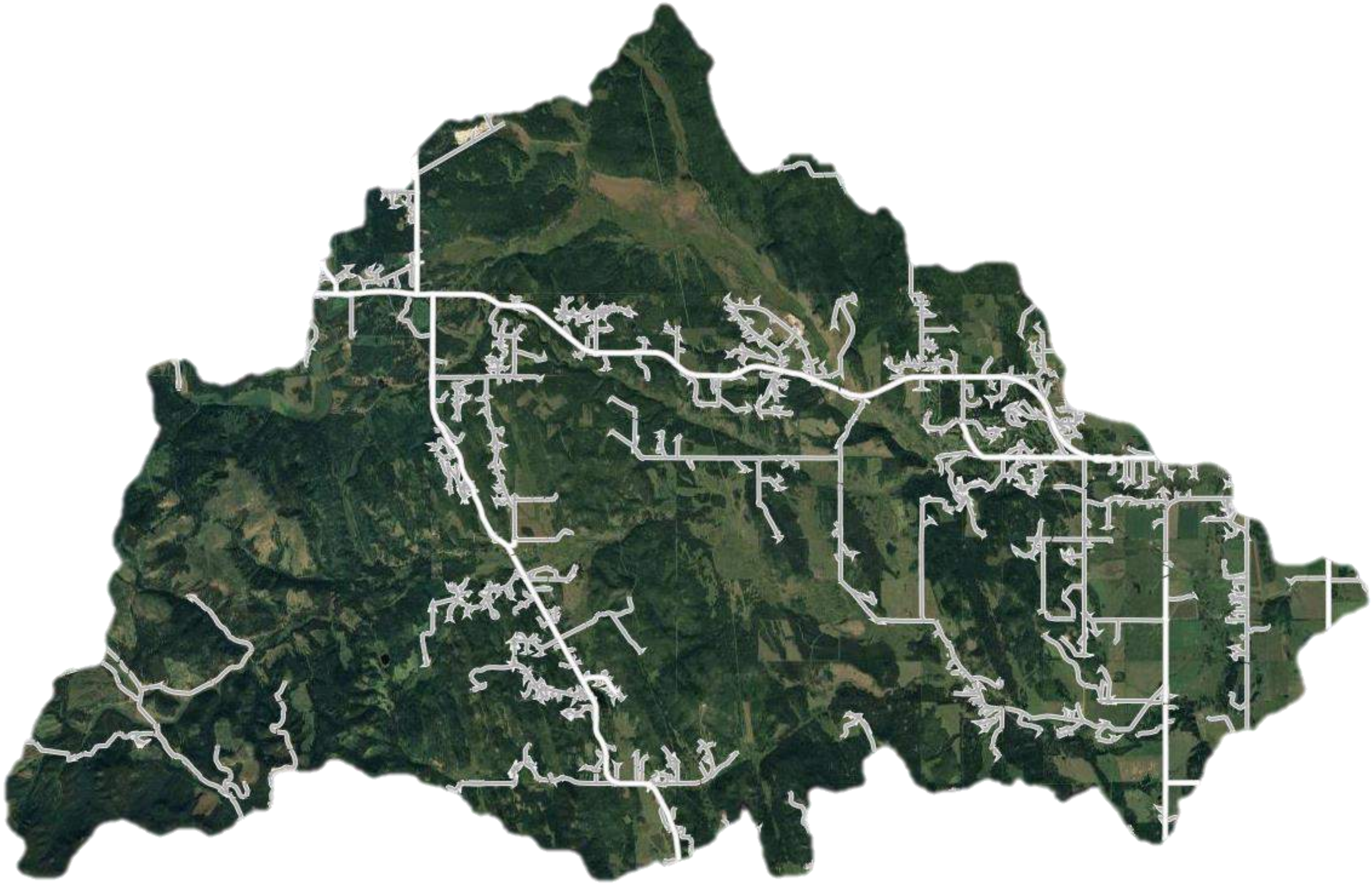
Plant Type	Category
Trees	
aspen *(Populus tremuloides)*	native
balsam poplar *(Populus balsamifera)*	native
lodgepole pine *(Pinus contorta)*	native
white spruce *(Picea glauca)*	native
Shrubs	
basket willow *(Salix petiolaris)*	native
beaked willow *(Salix bebbiana)*	native
bog birch *(Betula glandulosa)*	native
bog cranberry *(Vaccinium vitis-idaea)*	native
bog willow *(Salix pedicellaris)*	native
bracted honeysuckle *(Lonicera involucrata)*	native
common bearberry *(Arctostaphylos uva-ursi)*	native
Drummond's willow *(Salix drummondiana)*	native
dwarf raspberry *(Rubus arcticus)*	native
false mountain willow *(Salix pseudomonticola)*	native
Farr's willow *(Salix farriae)*	native
flat-leaved willow *(Salix planifolia)*	native
myrtle-leaved willow *(Salix myrtillifolia)*	native
northern gooseberry *(Ribes oxyacanthoides)*	native
prickly rose *(Rosa acicularis)*	native
short-capsuled willow *(Salix brachycarpa)*	native
shrubby cinquefoil *(Potentilla fruticosa)*	native
smooth willow *(Salix glauca)*	native
velvet-fruited willow *(Salix maccalliana)*	native
wild red raspberry *(Rubus idaeus)*	native

Plant Type	Category
Grasses (and grass-like species)	
alpine foxtail *(Alopecurus occidentalis)*	native
awned sedge *(Carex atherodes)*	native
beaked sedge *(Carex utriculata)*	native
closedhead sedge *(Carex media)*	native
few-flowered spike-rush *(Eleocharis quinqueflora)*	native
foothills rough fescue *(Festuca campestris)*	native
fowl bluegrass *(Poa palustris)*	native
fowl manna grass *(Glyceria striata)*	native
foxtail barley *(Hordeum jubatum)*	*disturbance,* native
hairy wild rye *(Elymus innovatus)*	native
hay sedge *(Carex siccata)*	native
Kentucky bluegrass *(Poa pratensis)*	*disturbance, introduced*
marsh reed grass *(Calamagrostis canadensis)*	native
meadow foxtail *(Alopecurus pratensis)*	*introduced*
northern awnless brome *(Bromus inermis ssp pumpellianus)*	native
northern wheat grass *(Agropyron dasystachyum)*	native
orchard grass *(Dactylis glomerata)*	*introduced*
purple oat grass *(Schizachne purpurascens)*	native
red fescue *(Festuca rubra)*	native or *introduced*
rush *(Juncus spp.)*	unknown, not unique
sheathed sedge *(Carex vaginata)*	native
slender wheat grass x hairy wild rye hybrid	native

Plant Type	Category
(Agroelymus hirtiflorus)	
small-flowered wood-rush *(Luzula parviflora)*	native
smooth brome *(Bromus inermis)*	*disturbance, introduced*
sweet grass *(Hierochloe odorata)*	native
timothy *(Phleum pratense)*	*disturbance, introduced*
tufted hair grass *(Deschampsia cespitosa)*	native
two-stamened sedge *(Carex diandra)*	native
water sedge *(Carex aquatilis)*	native
wild rye *(Elymus spp.)*	unknown, not unique
wire rush *(Juncus balticus)*	native
Forbs (broad-leaf plants)	
alsike clover *(Trifolium hybridum)*	*disturbance, introduced*
American milk vetch *(Astragalus americanus)*	native
arrow-leaved coltsfoot *(Petasites sagittatus)*	native
aster *(Aster spp.)*	unknown, not unique
beardtongue *(Penstemon spp.)*	unknown, not unique
bishop's-cap *(Mitella nuda)*	native
bitter cress *(Cardamine pensylvanica)*	native
bluebur *(Lappula squarrosa)*	*disturbance, introduced*
blunt-leaved sandwort *(Moehringia lateriflora)*	native
bog violet *(Viola nephrophylla)*	native
Canada anemone *(Anemone canadensis)*	native
Canada thistle *(Cirsium arvense)*	***invasive,*** *introduced*
common dandelion *(Taraxacum officinale)*	*disturbance, introduced*

Plant Type	Category
common fireweed *(Epilobium angustifolium)*	native
common horsetail *(Equisetum arvense)*	native, ***poisonous***
common pink wintergreen *(Pyrola asarifolia)*	native
common plantain *(Plantago major)*	*disturbance, introduced*
common red paintbrush *(Castilleja miniata)*	native
common yarrow *(Achillea millefolium)*	native
cow parsnip *(Heracleum lanatum)*	native
cream-colored vetchling *(Lathyrus ochroleucus)*	native
cushion milk vetch *(Astragalus gilviflorus)*	native
Drummond's rock cress *(Arabis drummondii)*	native
early blue violet *(Viola adunca)*	native
elephant's-head *(Pedicularis groenlandica)*	native
entire-leaved groundsel *(Senecio integerrimus)*	native
field mouse-ear chickweed *(Cerastium arvense)*	*disturbance,* native
graceful cinquefoil *(Potentilla gracilis)*	native
green saxifrage *(Chrysosplenium tetrandrum)*	native
green sorrel *(Rumex acetosa)*	*introduced*
hairy rock cress *(Arabis hirsuta)*	native
heart-leaved Alexanders *(Zizia aptera)*	native
hemp-nettle *(Galeopsis tetrahit)*	*disturbance, introduced*
large-leaved yellow avens *(Geum macrophyllum)*	native
lilac-flowered beardtongue *(Penstemon gracilis)*	native
marsh horsetail *(Equisetum palustre)*	native
mountain cinquefoil *(Potentilla diversifolia)*	native
mountain shooting star *(Dodecatheon conjugens)*	native
narrow-leaved dock *(Rumex triangulivalvis)*	native
northern bedstraw *(Galium boreale)*	native
northern hedysarum *(Hedysarum boreale)*	native

Plant Type	Category
northern twayblade *(Listera borealis)*	native
northern valerian *(Valeriana dioica)*	native
northern willowherb *(Epilobium ciliatum)*	native
palmate-leaved coltsfoot *(Petasites palmatus)*	native
prairie gentian *(Gentiana affinis)*	native
purple avens *(Geum rivale)*	native
red clover *(Trifolium pratense)*	*disturbance, introduced*
saline shooting star *(Dodecatheon pulchellum)*	native
showy Jacob's-ladder *(Polemonium pulcherrimum)*	native
slender blue beardtongue *(Penstemon procerus)*	native
smooth aster *(Aster laevis)*	native
snakeroot *(Sanicula marilandica)*	native
star-flowered Solomon's-seal *(Smilacina stellata)*	native
swamp horsetail *(Equisetum fluviatile)*	native
tall buttercup *(Ranunculus acris)*	***invasive,*** *introduced*
tall larkspur *(Delphinium glaucum)*	native, ***poisonous***
tall lungwort *(Mertensia paniculata)*	native
veiny meadow rue *(Thalictrum venulosum)*	native
vine-leaved coltsfoot *(Petasites vitifolius)*	native
western dock *(Rumex occidentalis)*	native
western lousewort *(Pedicularis bracteosa)*	native
white clover *(Trifolium repens)*	*disturbance, introduced*
wild bergamot *(Monarda fistulosa)*	native
wild strawberry *(Fragaria virginiana)*	*disturbance,* native
wild vetch *(Vicia americana)*	native
woodland horsetail *(Equisetum sylvaticum)*	native
yellow avens *(Geum aleppicum)*	native



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