Fish Creek Water Quality Analysis Project

Prepared for the Friends of Fish Creek Provincial Park Society

Prepared by Jeffrey Wisby

April, 2015

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Acknowledgements

The Fish Creek Water Quality Monitoring Project was made possible by the diverse, generous and meaningful contributions of many individuals and organizations. ALS Environmental provided laboratory analysis as in-kind support, while the Bow River Basin Council, the Alberta Conservation Association and the Land Stewardship Centre of Canada provided annual financial support for the project. Access to the creek at the Priddis/Tsuu T'ina sampling site was provided by Trakehner Glen. Thank you also to Alberta Parks for supporting this project in a number of indispensable ways. A heartfelt thank you to all involved, including the following volunteers:

Sarah Dixon	Caitlin Gifford	Naomi Parker
Addison Dragland	Elizabeth Hoyeck	Jenn Sutey

The author wishes to thank the various funders and landowners for their ongoing support, as well as the volunteers and staff of the Friends of Fish Creek Provincial Park Society for their dedicated efforts to contribute to this project.

Introduction

Overview

Between 2007 and 2013, The Friends of Fish Creek Provincial Park Society (the Friends) conducted a volunteer-driven water quality sampling program in Fish Creek. This effort consisted of gathering water samples on a monthly basis, from May through to October, at five consistent locations within park boundaries. In order to gain insight into background water quality, and potential stressors upstream of Fish Creek Provincial Park, water samples were also collected from the Fish Creek headwaters located in the extreme west end of the creek, as well as the Priddis -Tsuu T'ina First Nation boundary.

The objective of this sampling program was originally to collect baseline data on surface water quality parameters for Fish Creek. The program has evolved into a longitudinal study intended to capture data prior to and following mitigating measures such as storm water retrofit ponds (also known as engineered wetlands)[1].

The objective of this report is to communicate results of the water quality investigation for use in public education and engagement, park management and future planning.

Methodology

Water quality data in raw laboratory analytical reports as well as several excel spreadsheets were provided with the intent of consolidating this information into a single record. The water quality parameters reviewed in this report include *E.coli*, Nitrate, Total Phosphorus, Total Suspended Solids and Chloride ions for the 2009 through 2013 sampling period[2]. A full data set including routine potable water quality parameters, two metals in water, and miscellaneous parameters are available in excel format and are located with the Friends. Data was compared against relevant water quality criteria, and reviewed for trends or anomalies.

Based on the data review, potential opportunities for improvement were identified.

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1 There are several engineered wetlands and ponds situated throughout Fish Creek Provincial Park. These locations are intended to act as a natural treatment for urban runoff and storm water discharge. Due to the infrequency of samples collected from these locations and the unknown specific sampling points, the data set for engineered wetlands was not reviewed as part of this report.

2 This report covers a span of five years' worth of sampling data (from 2009 through to 2012). For information on analytical results from the 2007 and 2008 sampling programs, please reference the Cindy Leung Report (Leung, 2009) which provides detailed analysis on the sampling data from this period.

Description of sample locations

Headwaters

The headwaters of Fish Creek are located in the McLean Creek Provincial Recreation Area. This area is designated as foothills parkland which is composed of a series of rolling hills dominated by boreal forest habitat. Primary land uses involve commercial logging, and backcountry recreation involving off-highway-vehicle (OHV) trails and backcountry camping (Figure 1).

This area was selected to be included into the sampling program in 2010, and sampled until 2012. The area is representative of the headwaters of the Fish Creek and the potential stressors the area may have, and was therefore included in the sampling program.

Figure 1: Aerial photograph of the Headwaters Sample Site. The red dot represents the approximate location of the sample site.

Figure 2 Photo of headwaters Sample Site. (All photos of sampling locations are courtesy of the Friends of Fish Creek Provincial Park Society).

Priddis – Tsuu T'ina First Nation boundary

Following the headwaters region, Fish Creek flows approximately 30km through an expanse characterized by cattle ranchland, agricultural cropland and scattered rural acreages.

The Priddis-Tsuu T'ina sample site is located on the southern boundary of the Tsuu T'ina First Nation, just north of the Hwy 22 – Hwy 22X interchange (Figure 3). This sample location is important as it serves as a background control for water entering the Tsuu T'ina region of the creek, and is critical in identifying potential stressors representative of the rural agricultural-ranchlands located upstream.

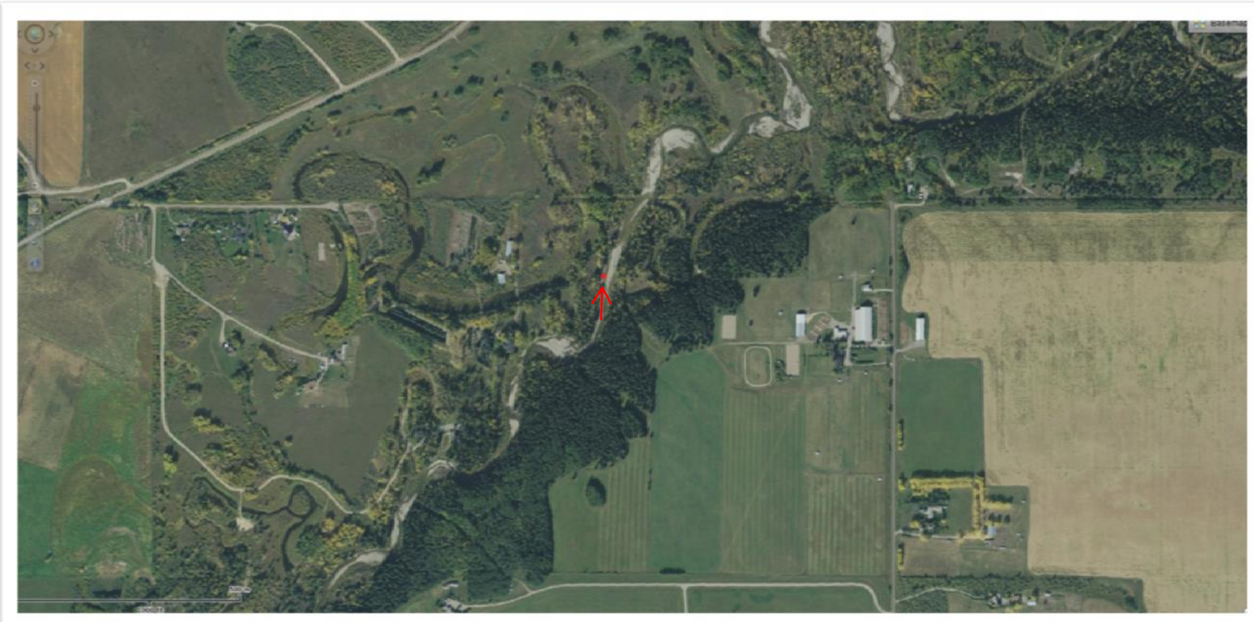

Figure 3: Aerial photograph of Priddis Sample Site.

Figure 4 Photo of the Priddis Sample Site.

Site 1

Following the Priddis landscape, Fish creek flows through the lands of the Tsuu T'ina First Nation. In this sparsely developed region, the creek flows through natural lands of mixed parkland and fescue grassland with the occasional dwelling or agricultural operation.

Sample Site 1 is located just downstream of the Tsuu T'ina First Nation boundary, at the extreme west end of Fish Creek Provincial Park. The sample location is on a small point bar near the Shannon Terrace Bridge. This location is critical as it represents background conditions of Fish Creek prior to its entry into the park.

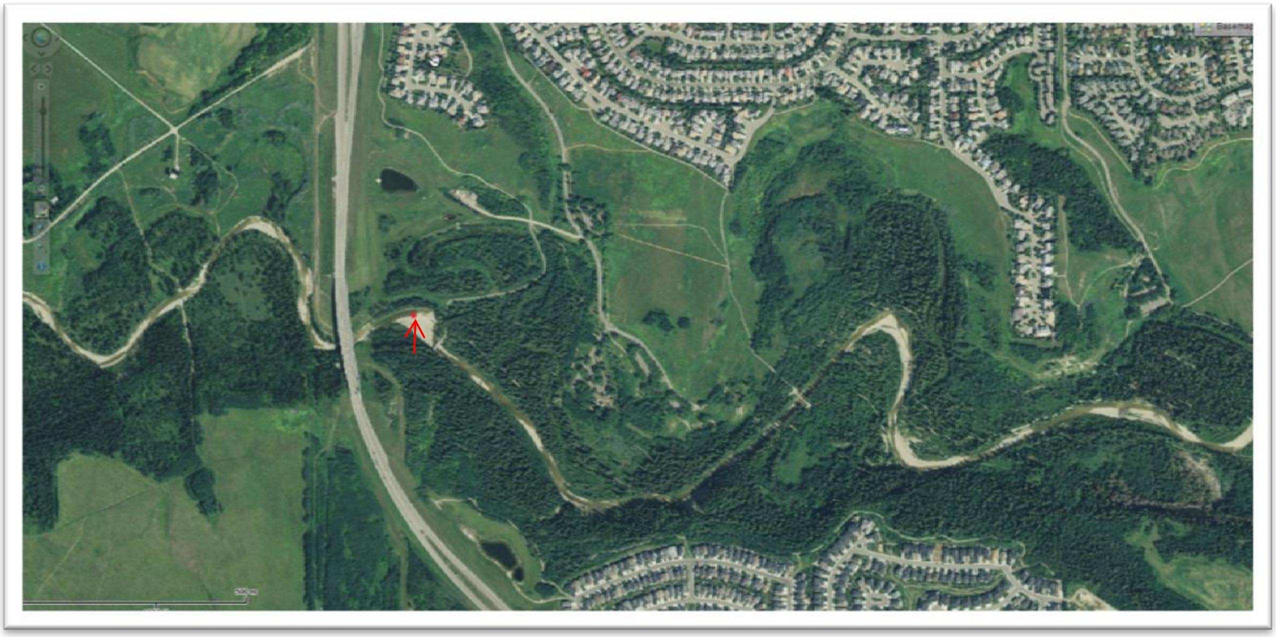

Figure 5: Aerial photograph of Sample Site 1.

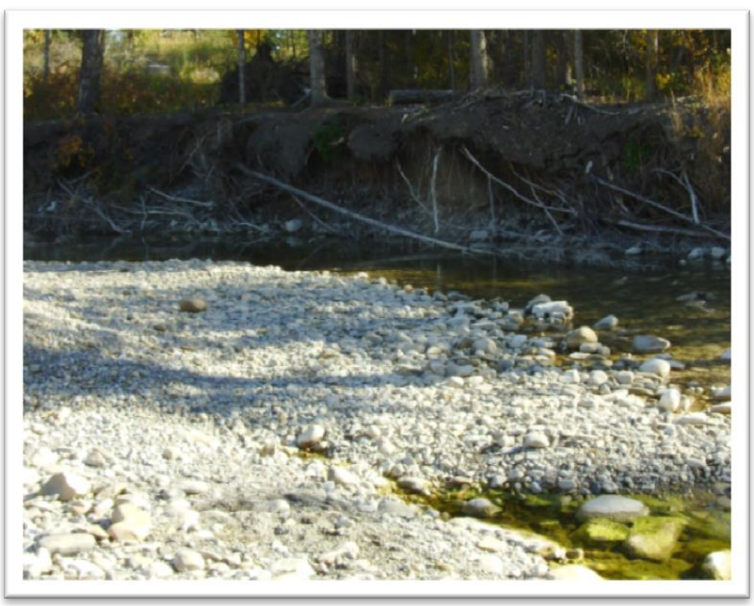

Figure 6: Photo of Sample Site 1.

Site 2

Sample Site 2 is located within Fish Creek Provincial Park, upstream of the Votier's Flats day use area. The sample location is located near the Evergreen street storm water outfall (F-7), near the community of Evergreen (Figure 7).

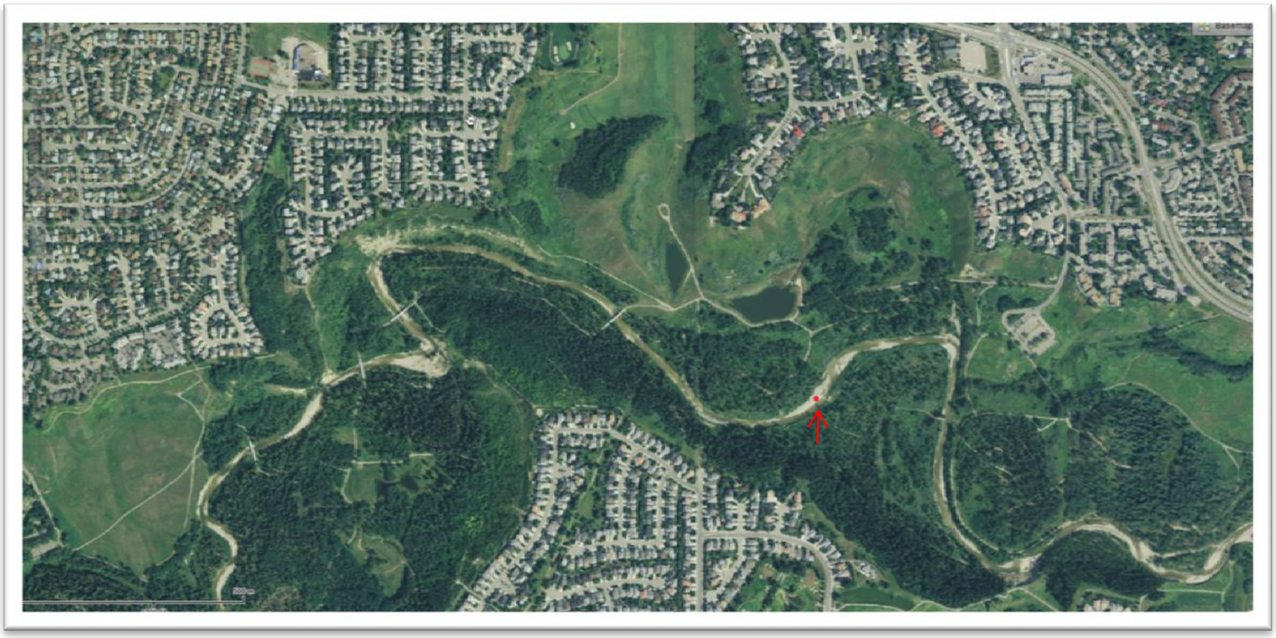

Figure 7: Aerial photograph of Sample Site 2.

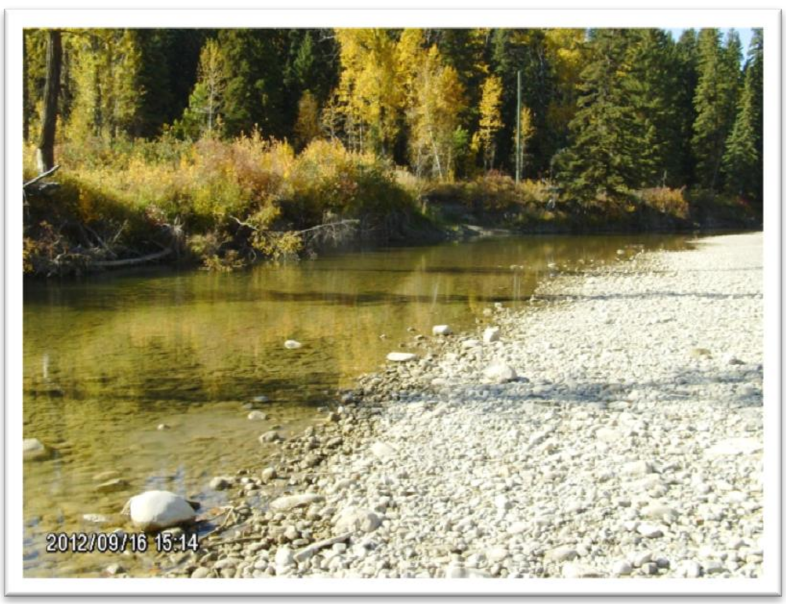

Figure 8: Photo of Sample Site 2.

Site 3

Sample Site 3 is located within Fish Creek Provincial Park on the east side of McLeod Trail at the base of a storm water outfall (F-2). This site is within close proximity to approximately three storm water outfalls and is directly downstream of two train bridges and the McLeod Trail Bridge (Figure 9).

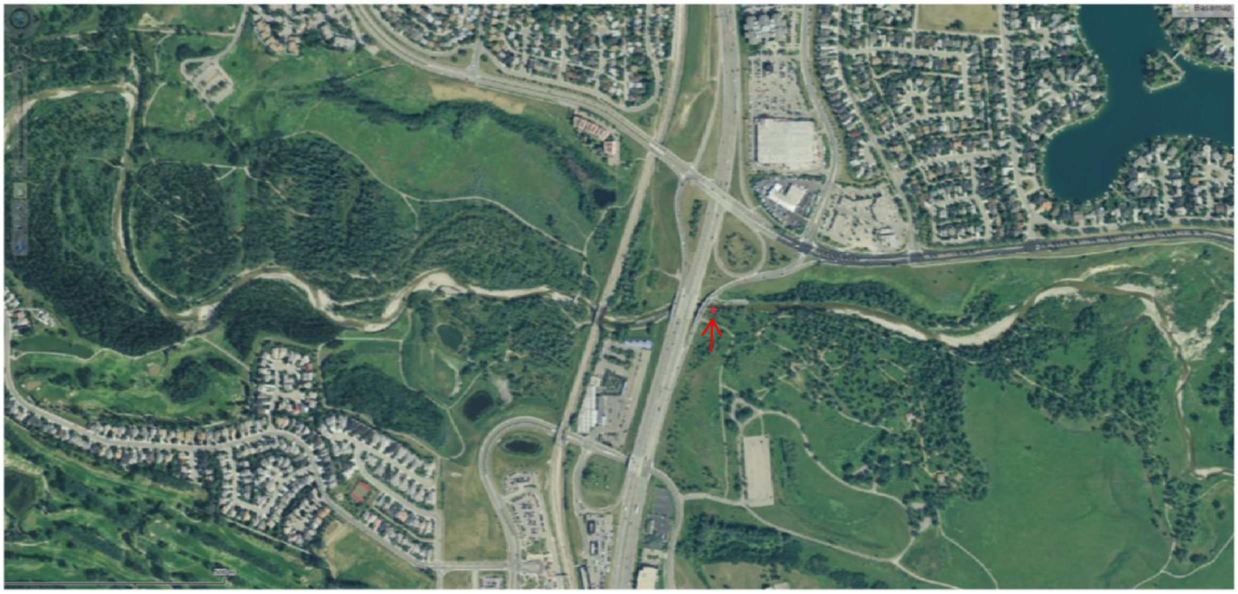

Figure 9: Aerial photograph of Sample Site 3.

Figure 10: Photo of Sample Site 3.

Site 4

Sample Site 4 is located at the base of the Acadia Drive Outfall. As of 2014, this section of the stream was cut off from the primary channel of Fish Creek due to the formation of an oxbow lake in 2012. This portion of Fish Creek has also had sustained beaver activity (ponds, dams, etc.) since at least 2012.

Figure 11: Aerial photograph of Sample Site 4.

Figure 12: Photo of Sample Site 4.

Site 5

Sample Site 5 is located at the mouth of Fish Creek at the confluence with the Bow River. This sample location is important as it serves as a record as to the quality of water entering the Bow River. During periods of high flow within the Bow River, it can be expected that some mixing of water occurs at this location.

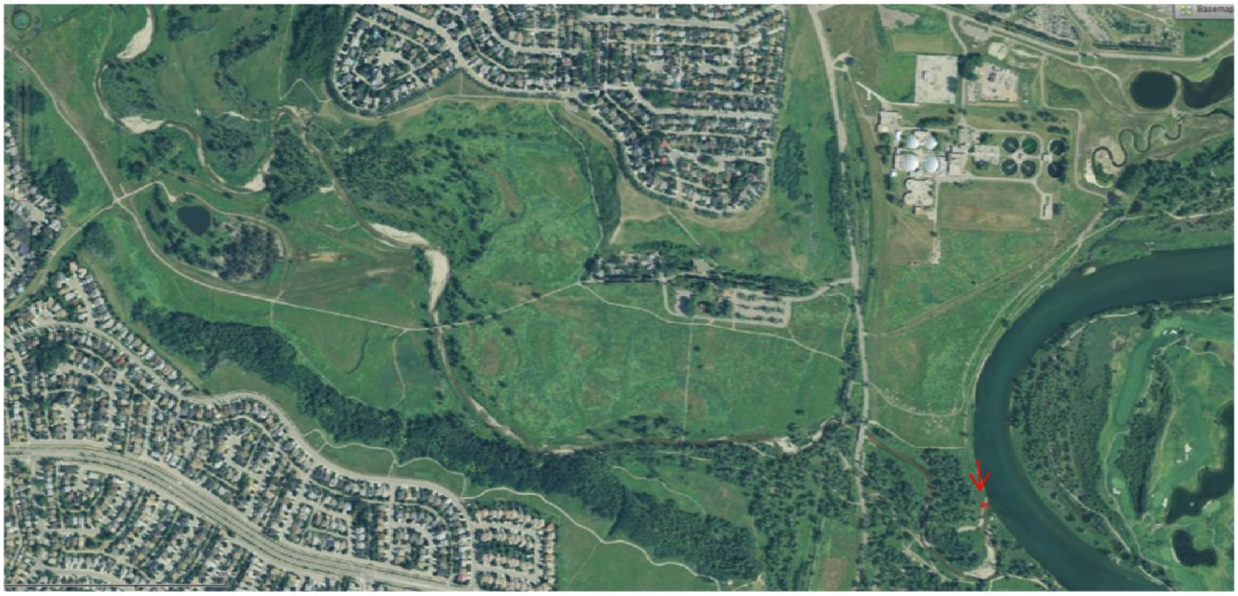

Figure 13: Aerial photograph of Sample Site 5.

Figure 14: Photo of Sample Site 5.

Summary of Results

E.coli

Water samples were submitted for microbial analysis to evaluate the presence of *E. coli*. *E.coli* is a critical parameter in evaluating water quality as it is indicative of fecal contamination as well as the possible presence of other disease-causing pathogens, such as bacteria, viruses, and parasites. *E.coli* bacteria originate in the intestines of all mammals and are frequently associated with runoff from manure laden cropland, leaky septic fields and sewage lines, and urban runoff (Center for Disease Control and Prevention , 2014). Although most strains of *E.coli* bacteria are harmless, certain strains may cause illness in humans (Center for Disease Control and Prevention , 2014).

Analytical Summary

The results of the *E. coli* analysis was compared to the Environmental Quality Guidelines for Alberta Surface Waters (EQGASW), as well as the Guidelines for Canadian Recreational Water Quality (CGRWQ), which are established to monitor recreational water quality, including indicators of fecal contamination (Alberta Environment and Sustainable Resource Development (ESRD), 2014).

The Alberta surface water quality guidelines will be used to evaluate the annual geometric mean concentration of *E.coli*. This guideline has a set threshold for annual concentrations of bacteria.

- The EQGASW for *E. coli* are *126 E.coli* /100 mL (Geometric mean concentration - minimum 5 samples).

The Guidelines for Canadian Recreational Water Quality will be used to evaluate *E. coli* concentrations from specific samples.

- The CGRWQ single sample maximum concentration of ≤ 400 *E. coli* / 100 mL will also be referenced (Health Canada, 2012).

Both guidelines are determined based on the consideration of the human health risks associated with recreational activities in rivers and lakes such as swimming, canoeing, and rafting (Alberta Environment and Sustainable Resources Development (ESRD), 2014).

The majority of samples collected since 2009 indicated annual geometric mean concentrations of *E. coli* bacteria below the criteria of 126 / 100ml. The guideline was, however, exceeded at one occurrence. In 2013, geometric mean concentrations at Site 4 slightly exceeded the guideline (Table 1).

Single sample concentrations of *E. coli* are presented in Table 2. As seen in Table 2, the maximum single sample concentration criteria of 400 *E. coli* / 100ml was exceeded in 20 samples. The majority of these exceedances occurred during the months of May, June, and July when numerous samples exceeded guidelines by several orders of magnitude. In July 2009, *E. coli* was detected at concentrations slightly above the guidelines at all locations sampled (Sites 1-5). Similarly, in June of 2012, high concentrations of *E. coli* were detected at all locations excluding the headwaters. Data also indicates that the concentrations of *E.coli* generally peak at the height of summer in July and have a positive correlation to the concentration of Total Suspended Solids.

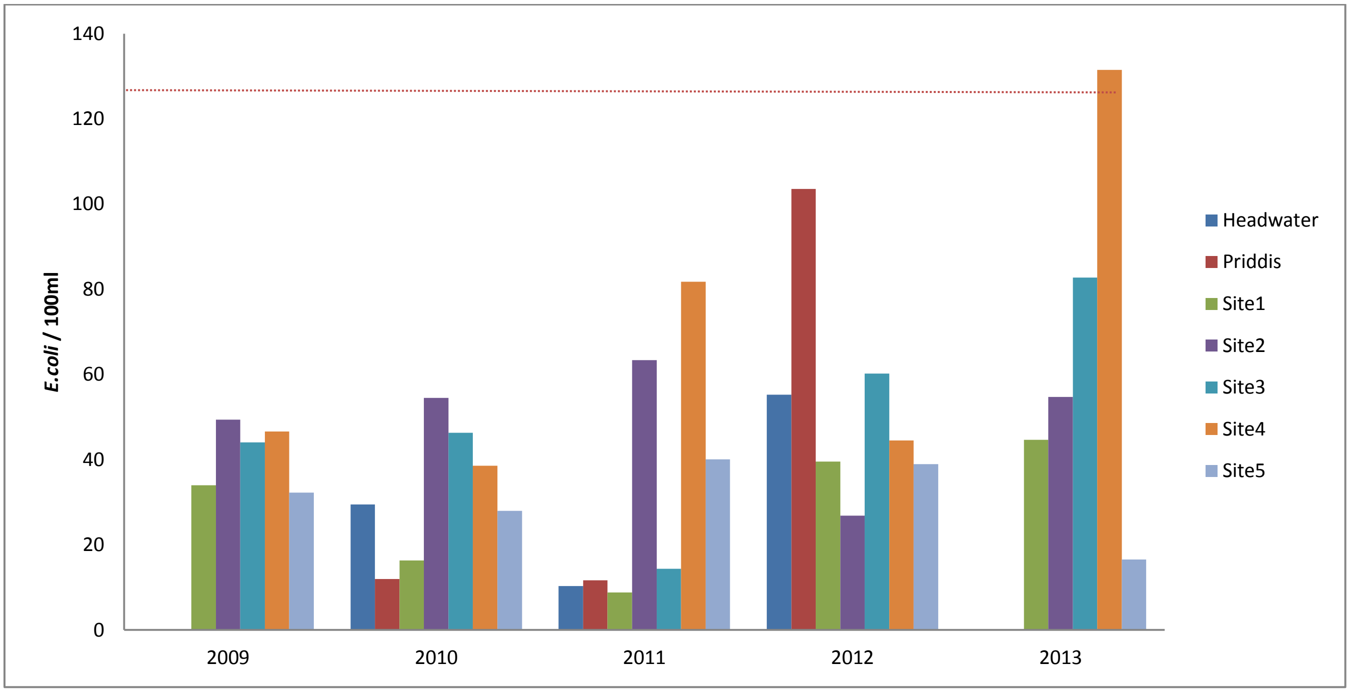

Table 1: Annual geometric mean concentration of *E. coli*

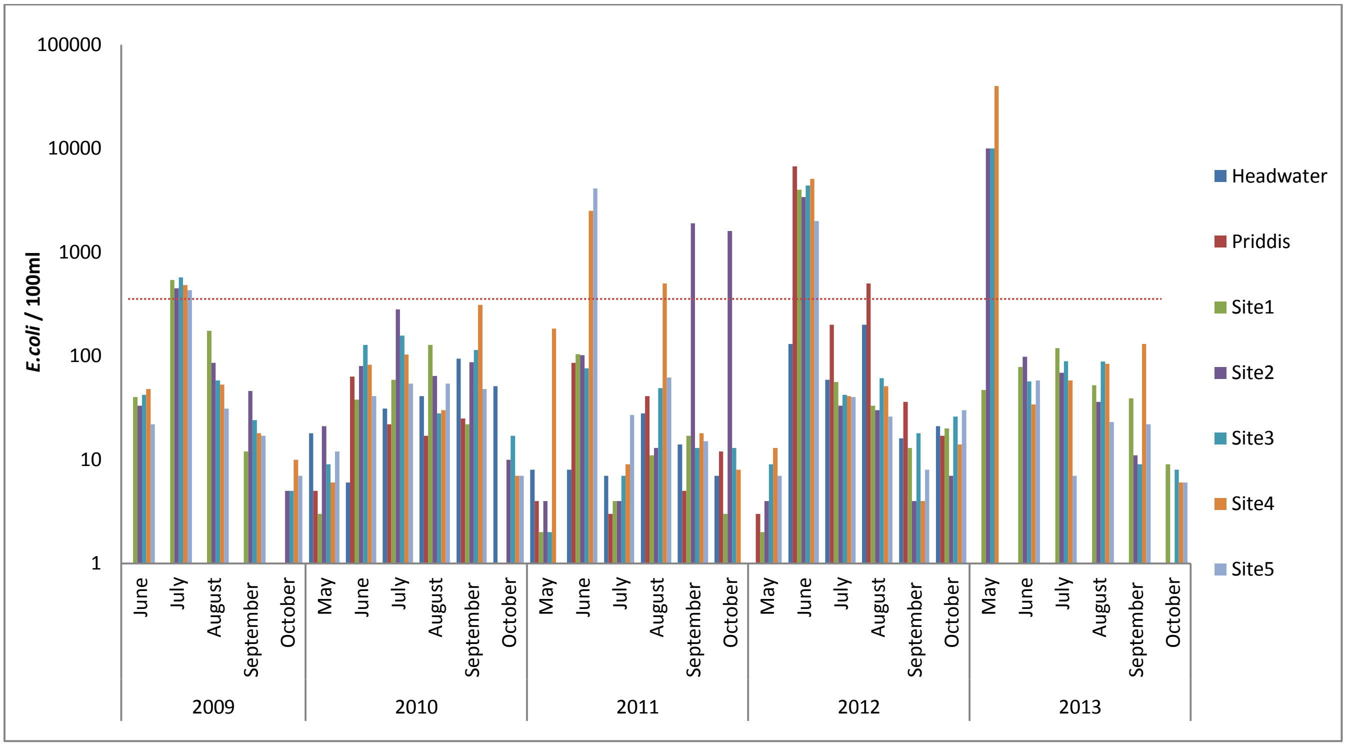

Table 2: Single sample concentrations of *E.coli*.

Discussion

Aerial Photographs indicate that several non-point sources of *E. coli* are present throughout both the upper and lower reaches of Fish Creek. As a result, *E. coli* is expected to leach into Fish Creek during the spring and early summer months of the year. Due to urban and rural runoff, high concentrations of *E. coli* may also be expected during periods of increased precipitation or stormflow events.

E. coli was detected in essentially all water samples, indicating the presence of fecal contamination in Fish Creek during the sampling program. The fact that the geometric mean concentrations are below guidelines in all but one occurrence may suggest that the overall annual concentrations for *E. coli* in Fish Creek are not at chronic levels, and that the 2012 exceedance at Site 4 was an isolated event as a result of stream flow disruptions at that location (the formation of an oxbow lake). The relative spikes of single sample concentrations, however, are above the relative criteria and are most likely attributed to high precipitation (stormflow) or runoff events typical in early summer (such as was seen in the spring of 2009, 2012, and 2013).

The results do not specify an obvious single point source; therefore the high concentrations of *E. coli* may be attributed to non-point sources such as runoff from agricultural fields, urban storm water runoff or possibly sewage from groundwater seepage (septic fields, outhouses, etc.). The elevated concentrations within the Headwater/Priddis region in 2012 are most likely attributed to runoff from manure fertilized fields, while the exceedances at sample site 2 and 4 may be attributed to non-point sources within the drainage system.

Nutrients (Nitrate & Phosphorus)

Nitrogen and phosphorus are two of the most important nutrients within the ecosystem (Baird, 2003). All living things require ample supplies of both for survival. However, an excess of these nutrients within rivers and lakes can not only cause significant environmental damage, but can also be a threat to human health (Baird, 2003). Excessive nutrient concentrations in water can promote unsightly blooms of algae and aquatic plants, which will eventually die, decompose and deplete the waterway of dissolved oxygen - an essential element for aquatic life (Baird, 2003). Ultimately, nutrient contamination results from such sources as agricultural runoff (manure and fertilizers), extensive cultivation of lands, sewage, and urban runoff (USGS, 1996); therefore monitoring Fish Creek for nutrients will assist in the identification of potential point-sources of contamination and/or areas at risk of anthropogenic eutrophication.

Analytical Summary

To determine nutrient levels in streams, concentrations of Nitrate Ion (NO_3) and Total Phosphorus (TP) are typically monitored (Canadian Council of Ministers of the Environment, 2012).

Nitrate Ion (NO_3)

The Environmental Quality Guidelines for Alberta Surface Waters do not have criteria for Nitrate (Alberta Environment and Sustainable Resource Development (ESRD), 2014). The results of the Nitrate analysis were therefore compared to the Canadian Water Quality Guidelines for the Protection of Aquatic Life (CWGPAL), which is used to measure the quality of aquatic and terrestrial ecosystems in response to Nitrate concentrations (Canadian Council of Ministers of the Environment, 2012).

- The *CWGPAL* Long term and short term exposure limits are 13 mg/L and 550 mg/L respectively (Canadian Council of Ministers of the Environment, 2012)

The concentrations of Nitrate included in the sampling program were reported at concentrations below both the long term and short term exposure limit. However, concentrations at Site 4 were reported above 8mg/L at six independent sampling events which may indicate the possibility that the criteria are frequently exceeded at this location.

Nitrate concentrations remain relatively stable throughout the sampling program with the exception of Site 4. The concentrations of Nitrate at Site 4 were seen to increase in concentration beginning in the summer of 2012. Since then, the concentrations observed at Site 4 have been noticeably higher than the concentrations at other sampling locations (Table 3).

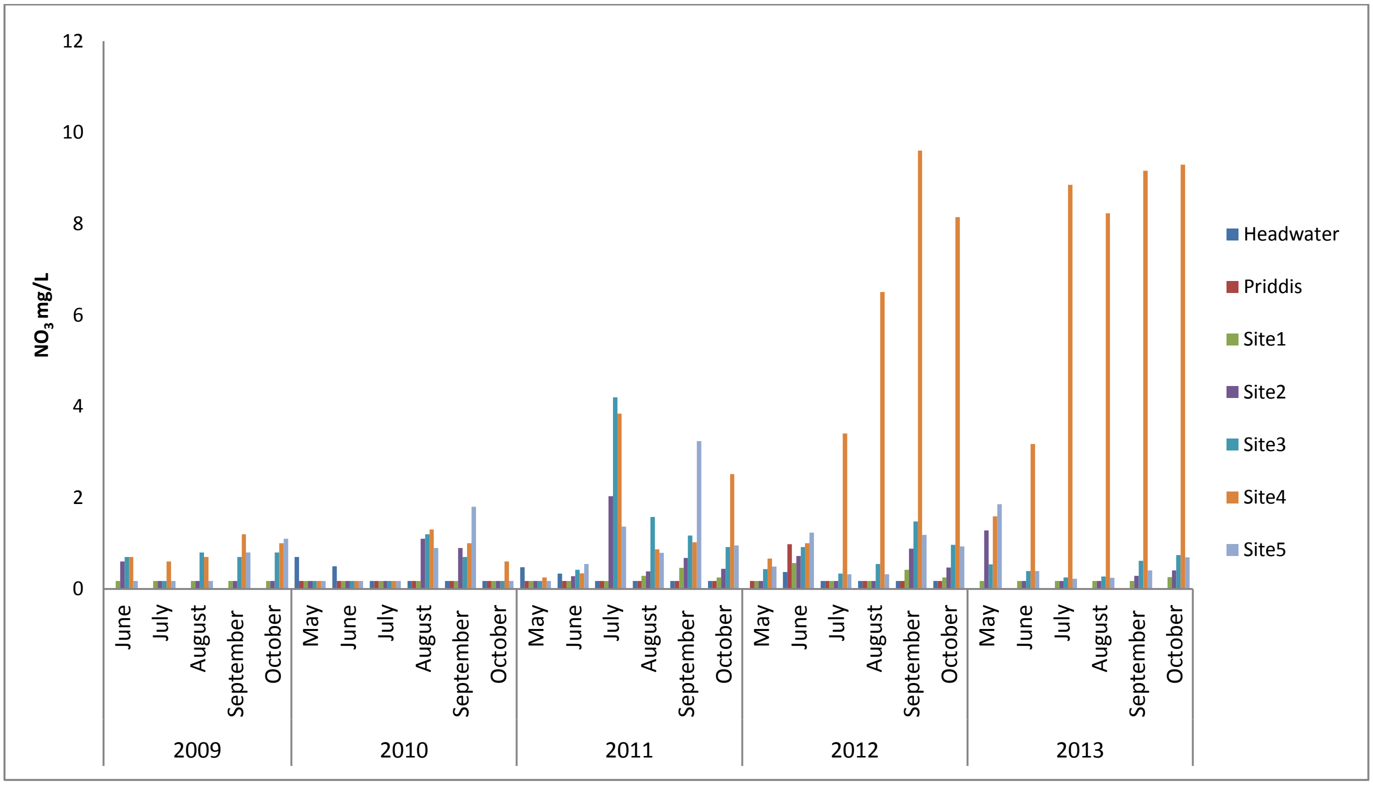

Table 3: Nitrate (NO_3) concentrations in Fish Creek.

Total Phosphorus

Numeric guidelines for Total Phosphorus (TP) were withdrawn from the EQGASW framework in 2014 (Alberta Environment and Sustainable Resource Development (ESRD), 2014). New guidance suggests that with the absence of science-based numeric guidelines for TP, concentrations should be maintained at levels to prevent the excessive growth of algal and aquatic plants, which may contribute to eutrophic conditions (Alberta Environment and Sustainable Resource Development (ESRD), 2014).

TP concentrations appear to remain relatively consistent with a noticeable spike in the late spring - early summer months of the sampling program (Table 4). Concentrations of TP were at a peak in all sampling locations in June of 2012 and May of 2013. Site 5 experienced several spikes in concentration while Site 4 maintained a slightly higher overall average concentration when compared to other sample locations with the park. The concentrations of TP upstream of Site 2 were regularly lower than concentrations downstream within the park.

The laboratory detection limit for Total Phosphorus (TP) changed in 2011 to allow for the increased ability to detect TP at lower concentrations. All but one sample between 2009 and 2010 was reported below the detection limit (BDL) (which is displayed graphically at a numerical value of 50% BDL).

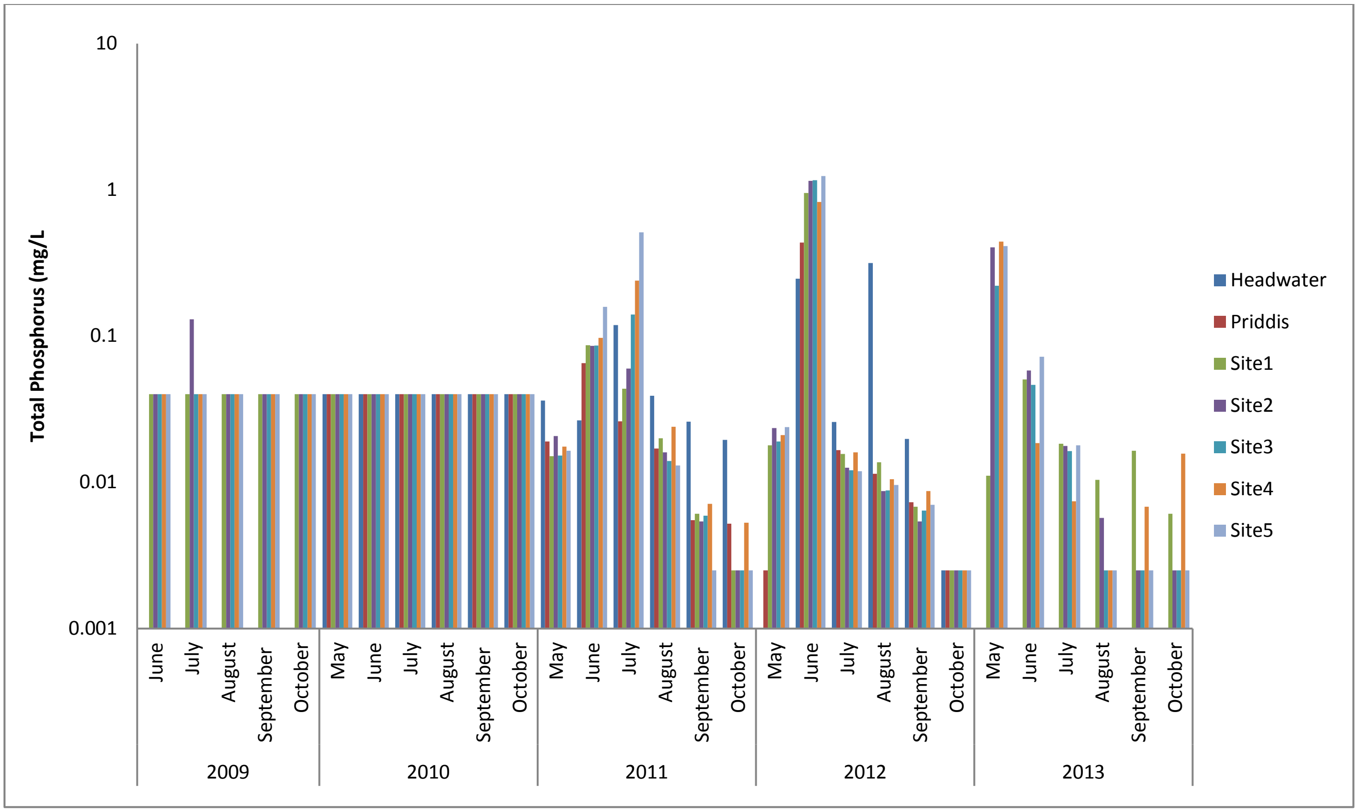

Table 4: Total Phosphorus concentrations in Fish Creek between 2009 and 2013. Note a change in laboratory detection limits in 2011 resulted in the improved detectability of TP at lower concentrations.

Discussion

Due to natural nitrogen and phosphate cycles, it is expected that both Nitrate and TP will be found within Fish Creek. However, most surface waters have less than 0.3 mg/L of nitrate (Baird, 2003) and natural background TP concentrations vary from less than 0.006 mg/L in mountainous/low productivity regions, to more than 0.08 mg/L in agricultural regions (Smith, Alexander, & Schwarz, 2003). Nitrate and TP are also heavily associated with urbanization (Smith, Alexander, & Schwarz, 2003). Anthropogenic discharges of Nitrates and TP include point sources such as municipal and industrial wastewaters, septic tanks, and non-point sources such as agricultural runoff, feedlot discharges, urban runoff, lawn fertilizers, landfill leachate, and storm sewer overflow (Canadian Council of Ministers of the Environment, 2012). Considering that Fish Creek flows through regions of agriculture as well as a major urban center, it can be expected to find elevated concentrations of both Nitrate and TP in the waters of Fish Creek, especially during and after high runoff/storm flow events.

The results of the sampling program for Nitrate and TP support these expectations. The concentration of Nitrate in the headwaters and the Priddis/Tsuu T'ina and Site 1 sampling locations were consistently below 0.3 mg/L, while the concentrations of Nitrate increase as the creek flows through the remainder of Fish Creek Provincial Park. However, the sharp and sustained rise in Nitrate concentrations at Site 4, noticed initially in July 2012, is most likely attributed to the high stream flow noticed in late spring/early summer 2012 and the streamflow changes at the sampling point as a result of oxbow lake formation and the presence of sustained beaver activity.

The seasonal increase in TP concentrations is most likely attributed to annual runoff and stormflow. Since phosphorus is generally the most limiting nutrient, its input to fresh water systems can cause extreme proliferations of algal growths, and is therefore considered the prime contributing factor to anthropogenic eutrophication in fresh water systems (Smith, Alexander, & Schwarz, 2003).

Salts (Chloride Ion)

Chloride (Cl^-) is considered an indicator of salts within the water system as it appears in the highest concentrations in natural fresh water systems of all other halides (salts) (Canadian Council of Ministers of the Environment, 2011). Although chloride is used as an important indicator of increased urbanization in watersheds, the chloride ion is in fact naturally occurring, and therefore detection of increased levels of chloride in surface waters does not necessarily imply an anthropogenic source (Canadian Council of Ministers of the Environment, 2011). This is especially evident in Alberta which has many natural salt deposits (BRBC, Fish Creek - Risks and Pressures, 2010).

Analytical Summary

Environmental Quality Guidelines for Alberta Surface Waters has a long term (chronic) exposure concentration at 120 mg/L, and a short term (acute) exposure limit of 640 mg/L for the chloride ion (ESRD, 2012). The concentrations of chloride were reported below these criteria for all but one sample. The concentration of chloride in July, 2013, at Site 4 was 123 mg/L which is slightly above the chronic exposure limit for the protection of freshwater aquatic life (Table 5).

Chloride concentrations remain moderately constant at low concentrations at sampling sites in the upper reaches of Fish Creek, and tend to seasonally fluctuate and increase as the sample locations move from the headwaters to Site 5 (Table 5). Concentrations appear to decrease in the spring months and increase as the sampling season progresses to September and October. Concentrations of chloride at Site 4 spike in July through October in both 2012 and 2013.

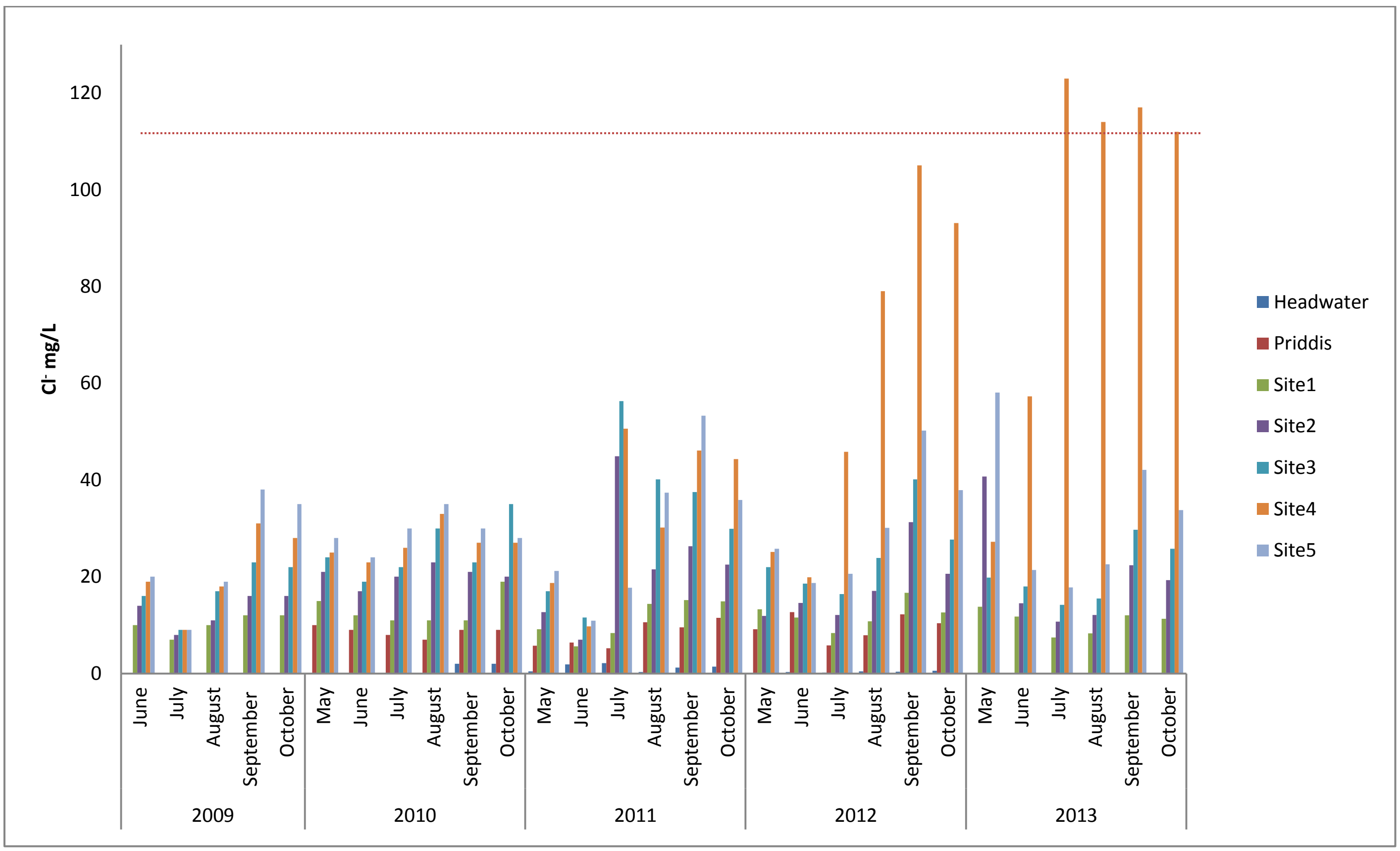

Table 5: Chloride concentrations in Fish Creek between 2009 and 2013.

Discussion

The average chloride concentration in natural fresh waters is approximately 8.3 mg/L (Canadian Council of Ministers of the Environment, 2011). Without any large point sources along the length of Fish Creek, it can be expected that concentrations of chloride will remain relatively consistent with comparative seasonal fluctuation, throughout the length of the creek.

Concentrations of chloride did remain relatively stable both temporally and spatially, at concentrations less than 15 mg/L at, and upstream of, Site 1. However, concentrations do increase as the creek flows through the Fish Creek Provincial Park, especially as the summer season progresses and water volumes decrease. The increased concentrations of chloride may be may related to non-point source urban runoff, but are most likely attributed to natural salt deposits along the creek system.

Chloride concentrations at Site 4 were frequently higher than concentrations found at other sample locations. This sustained increase in chloride since 2012, is most likely due to the stagnant streamflow conditions already described at this location. The presence of an oxbow lake and beaver pond at Site 4 would expedite evaporation thus increasing the salt concentration, especially if increased salt was within the storm water discharge. The EQGASW chronic exposure limit for the protection of freshwater aquatic life was slightly exceeded in June 2012. Considering the relatively high concentrations in this area since 2012, it can be assumed that the concentrations at Site 4 periodically exceed the guideline. If so, long term negative impacts may result, especially to benthic invertebrates and possibly amphibians at this location (Canadian Council of Ministers of the Environment, 2011).

With the exception of Site 4, the overall chloride concentrations appear to be relatively stable within Fish Creek, with a slight increase as the river flows through Fish Creek Provincial Park.

Solids (Total Suspended Solids)

Total suspended solids (TSS) are measured to determine the concentrations of organic and inorganic solid materials that are suspended within the waterway. Suspended solids can have an adverse effect on the aquatic ecosystem by damaging fish habitat and aquatic vegetation, and may also serve as a conduit for bacteria, nutrients and pesticides.

Analytical Summary

The Environmental Quality Guidelines for Alberta Surface Waters for the protection of freshwater aquatic life have several guidelines in place for TSS based on the relative background conditions. The guidelines state:

- During clear flow periods a maximum increase of 25 mg/L from background concentrations for any short-term (24hr period). A maximum average increase of 5mg/L from background levels for longer term exposures.
- During high flow or turbid waters a maximum increase of 25 mg/L from background levels at any time when background levels are between 25 and 250 mg/L. For periods when background concentrations are above 250 mg/L, the concentration must not increase by more than 10%.

Considering that monthly samples were taken for this program, and that exposure periods are unavailable, the more conservative, long term exposure guideline will be used for reference.

The concentrations of TSS remained relatively consistent throughout the sampling program (Tables 6 and 7). Out of 180 samples analyzed for TSS, 12 were found to be in concentrations above the guideline relative to background conditions. The exceedances were found in all downstream sample sites between May and July. Tables 6 and 7 compare sample locations within Fish Creek Provincial Park to background conditions (Headwater, Priddis, and Site 1).

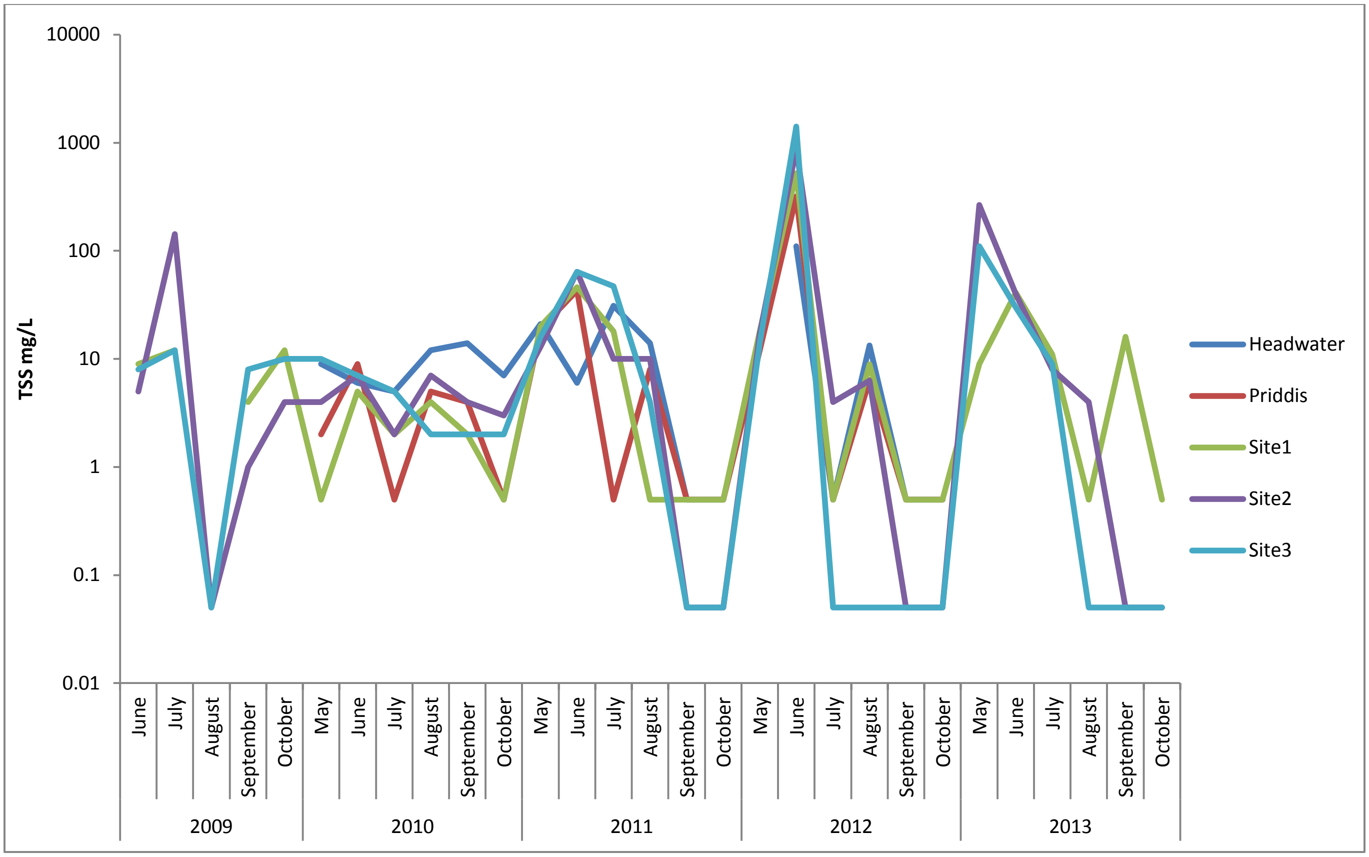

Table 6: TSS concentrations at background locations and sample Sites 1-3.

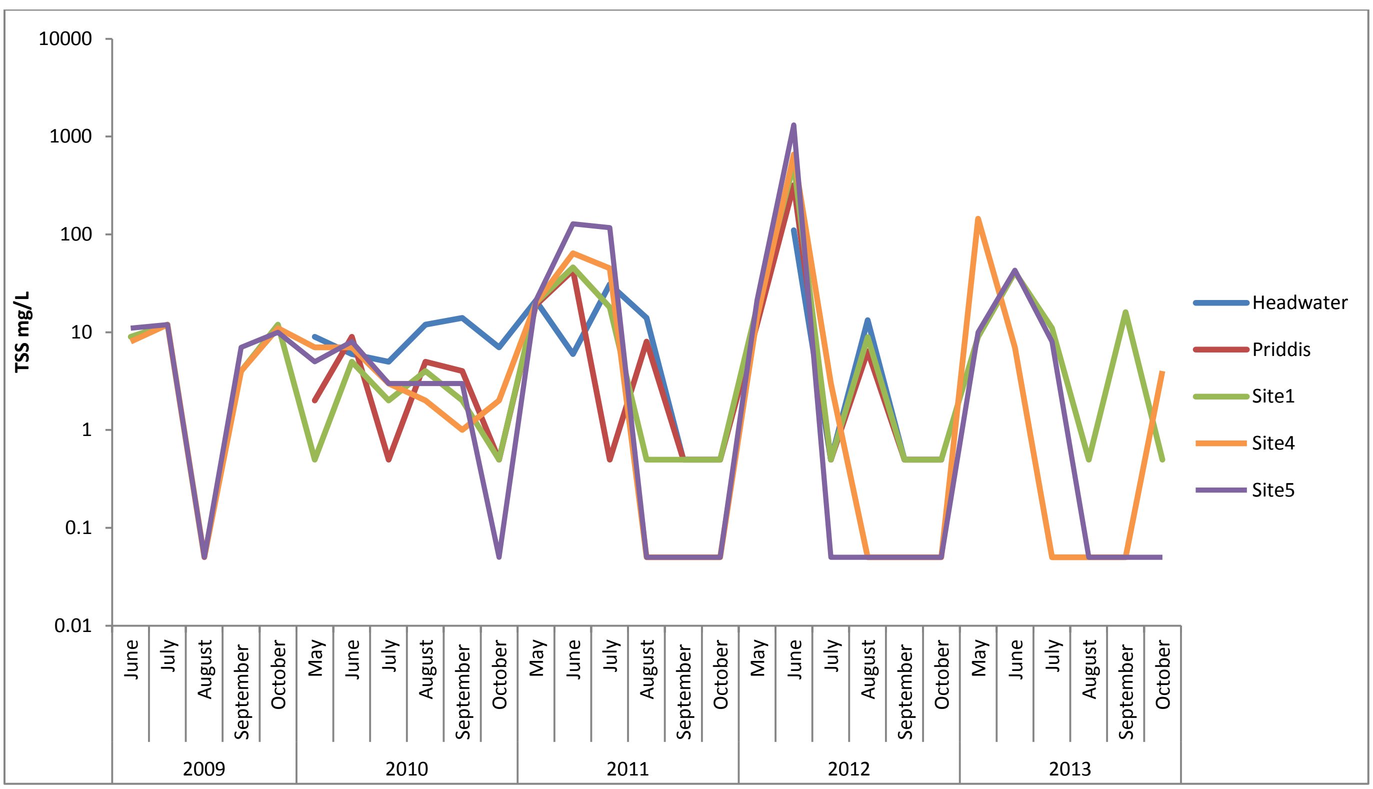

Table 7: TSS concentrations at background locations and Sample Sites 4-5.

Discussion

Anthropogenic factors contribute to increase in TSS, especially relative to background conditions (Canadian Council of Ministers of the Environment, 2002). The removal of natural vegetation and riparian ecosystems through land disturbance near the creek shore, caused by off-highway-vehicle use, agriculture, commercial forestry, construction and urbanization, can all result in an increased erosion of sediments - especially during stormflow and seasonal runoff events. Due to the high concentration of suspended sediments in storm water, it can be expected that levels of suspended solids will increase in surface waters that receive storm water discharge.

The data indicated very little variation between background concentrations of TSS and samples collected through the lower reaches of Fish Creek. However, 12 samples exceeded the guideline for the protection of freshwater aquatic life. These incidents were most likely due to urban/rural runoff during storm events, erosion during spring melt and possible disturbances in the headwater region of Fish Creek.

Conclusions

The results of the sampling program indicate that the water quality of Fish Creek is subject to change between the seasons – particularly during the spring and early summer months when stormflow conditions are common. Stormflow conditions result in an increase in both surface runoff and storm water both of which may contain impurities from the surrounding landscape.

E. coli concentrations in Fish Creek were frequently above the Guidelines for Canadian Recreational Water Quality throughout the sampling program. Elevated concentrations of *E. coli* were seen at the Priddis-Tsuu T'ina sample site in 2012, which is most likely a result of high stream flow and agricultural runoff from fields fertilized with raw manure upstream of this location. Elevated concentrations of *E. coli* at Site 2 between 2009 and 2011 are most likely attributed to the storm water outfall located below the community of Evergreen, yet the cause of the decrease in 2012 and 2013 is uncertain. The predictability of high concentrations of *E. coli* during times of increased discharge (May – July) and during stormflow events, represent an opportunity to educate park visitors to the presence of elevated concentrations of bacteria during such events and the potential for an increased risk of infection – especially in regions of the park where contact with the water occurs.

Nutrient concentrations within Fish Creek are below the appropriate guidelines and appear to be within expectations of a creek which passes through an agricultural and urban region. Since 2012, the streamflow issues at Site 4, specifically, have resulted in elevated concentrations of both nitrate and phosphorus at this location. Algae growth was visible in the September 2012 sampling photo (Figure 12), and is most likely attributed to the high concentrations of Nitrate and/or phosphorus reported for that period. The section of the creek where Site 4 is located may continue to accumulate nutrients to the point where algal blooms persist and intensify, eventually depleting the concentration of dissolved oxygen within the water. The outcome of these conditions will impact aquatic life and be unsightly to park visitors. Furthermore, this region may also become a point source of nutrients which may leach into the primary channel of the Fish Creek, which may lead to an increase in nutrient concentrations along the stream. It is recommended to discuss the conditions at Site 4 with appropriate members of Alberta Parks to determine a best management strategy for the area. This may include a storm water retention pond and/or management of beaver population to address the decreasing water quality at this location.

Salt concentrations within Fish Creek remain fairly consistent upstream of the Provincial Park boundaries but begin to increase within boundaries. The increase, which is still below long term exposure levels, appears to be a result of storm water/urban runoff or is quite possibly a result of natural salt formations located within the park. The data suggest that Site 2 is where the concentrations begin to increase, which is then sustained throughout the remainder of the streamflow towards to Bow River. The sharp increase in salt concentrations at Site 4 since 2012 is most likely due to the issue explained above regarding connectivity to the primary channel and decreasing water levels. Further investigation into the conditions of the storm water management system near Site 2 may be conducted to determine potential non-point sources of salts, and potential mitigations.

Total Suspended Solids remain relatively consistent to background conditions throughout the sampling program. Suspended solids are high in late spring/early summer and low in late summer/ early autumn. Any deviation from background conditions will be attributed to suspended solids in the storm water network or erosion along the banks of the Creek. Although suspended solids are naturally associated with high stream flows, ongoing attention to riparian management throughout the length of the Creek and the storm water distribution system within Fish Creek Provincial Park will help manage human caused contributions to the suspended sediment concentration.

Opportunities to Improve the Water Quality of Fish Creek within Fish Creek Provincial Park

Aside from potential upstream sources of pollutants, there are many non-point sources of impurities that may find their way into Fish Creek as the waters flow through Fish Creek Provincial Park. Fish Creek Provincial Park is surrounded by suburban communities, busy roadways and has approximately 3 million visitors per year. Bacteria, pathogens, nutrients, suspended solids, salts, heavy metals, and other contaminants may enter the stream through community runoff and the activities of park visitors. It is therefore important for both members of the surrounding communities as well as park visitors to understand the various activities they may do individually to contribute to a healthy and sustainable Fish Creek. Educational outreach makes up a critical component of an overall management approach to maintain or enhancing the water quality of Fish Creek. It is therefore recommended that a public awareness campaign include the following approaches and key messages for maintaining a healthy Fish Creek and urban parkland.

Activity	Water Quality Parameter Addressed
Promptly clean up pet waste during walks, off-leash parks visits and at home in the yard.	*E.coli*
Use sustainable landscape construction techniques (such as rain gardens) to reduce household runoff containing manure-based fertilizer, lawn fertilizers, herbicides, pesticides and sediments.	*E.coli*, Nutrients, Suspended Solids,
Incorporate drought resistant landscaping (xeriscaping techniques) to reduce overwatering and associated runoff.	*E.coli*, Nutrients, Suspended Solids, Salts
Use commercial carwashes and avoid cleaning vehicles equipment at home.	Suspended Solids, Salts, Metals
Use sand and gravel opposed to salt based deicers and promptly sweep up sediments in the spring for reuse.	Salts, Suspended Solids
Avoid over fertilizing lawns and green spaces.	Nutrients
Stay on pathways within Fish Creek Park and avoid riding bicycles through the Creek	Suspended Sediments
Educate park visitors on the impacts excessive beaver activity has on the ecosystem of the park particularly when beaver dams are constructed downstream of storm water outfalls.	*E.coli,* Nutrients, Salts

Along with public outreach, there are several management opportunities that may be employed to maintain and enhance the water quality of Fish Creek on a go forward basis.

1. Identify erosion trouble spots within the park and implement measures to limit disturbance from park visitors.
2. Identify and monitor areas with excessive algae and aquatic vegetation as these areas may be polluted by nutrients and at risk of eutrophication. A starting point would be to monitor and observe the visual signs of impact near Site 4, which has frequently higher concentrations of salts, nutrients and *E. coli*.

3. Discuss the water quality situation at Site 4 with Alberta Parks and/or officials and investigate potential mitigations at this location within the park.
4. Educate visitors on the historic state of water quality, especially relating to high concentrations of impurities, especially *E. coli*, seen during periods of increased runoff (May through July).
5. If water sampling is to be continued,
    - Expand the sampling program to include analysis for Total Cadmium, Copper and Nickel to track metals in a more comprehensive manner.
    - Install automatic flow meters to help monitor hydraulic discharge (streamflow).
    - Sample engineered wetlands or ponds within the Park. Ideally, the sampling program would sample the direct (input) discharge into the wetlands, and the water at the discharge (output) point to Fish Creek.
    - Evaluate the need for site-specific surface water quality guidelines for Fish Creek.

Closing

Fish Creek is a major tributary of the Bow River, originating in the parkland foothills of western Alberta. Along with Whiskey and Priddis creek, Fish Creek makes up the Fish Creek Sub Basin (BRBC, 2010). The Fish Creek Sub Basin provides essential habitat for a variety of plant and animal life as well as providing people with many ecosystem services essential to not only the recreation and culture of those who use it, but also the economics of the region.

The growth of Calgary has left Fish Creek Provincial Park bordered on all sides by urbanization. No less than eleven storm water outfalls drain into Fish Creek within this region from surrounding communities. Prior to 2007, storm water was largely untreated; however, the City of Calgary has since retrofitted many of the storm water outfalls located within the region with storm water retrofit ponds (BRBC, Fish Creek - Risks and Pressures, 2010). Regardless of engineered treatment, local residents can do more to reduce the volume of water leaving their residence by the incorporation of smart landscaping approaches such as the City of Calgary’s Yardsmart program. Where landscaping is not an option, residents may directly assist in reducing the contaminant load of urban runoff by: promptly removing animal waste from their yards and parkways; reducing the amount of fertilizer used on yards; utilizing salt-free alternatives for de-icing of driveways and walkways; and, preventing gravel, sand, and other sediments from being washed away by snowmelt or rainfall events.

A sustainable Fish Creek is one that meets the needs of both human and wildlife, inside and outside the park, without jeopardizing future generations from meeting their needs. Therefore, sustainability within Fish Creek is all about looking after the future state of the river system, and all those who depend on it for life, recreation and income. To do so means that we must all do what we can to identify the primary risks to this system and adopt opportunities for continued improvement.

The Fish Creek Water Quality Analysis Project was valuable program that provided a lasting record to the state of water quality during the sampling program. The project itself will provide a lasting record to the current state of water quality within the Fish Creek sub basin, as well as provide insight into the success of future improvements. With the increasing population in Calgary and the surrounding regions, the potential for cumulative impacts to affect the water quality of Fish Creek are also increasing. Ongoing programs for environmental stewardship are essential for the biodiversity and ecosystems services the Fish Creek Sub Basin provides.

I’d like to extend my deepest thanks to the Friends of Fish Creek Provincial Park Society for conducting this research.

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Limitations and use of this report

This report was prepared for the exclusive use of the Friends of Fish Creek Provincial Park Society. Permission must be requested from Friends of Fish Creek for any use by third parties. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of the third parties.

The report is based on data and information collected during a volunteer driven sampling program by parties other than the author of this report. It is based solely on the conditions of the various sites encountered at the time of the sampling program and the training and technique of those gathering the data. The author has assumed that the information provided is factual and accurate. The author accepts no responsibility for any deficiency, misstatement or inaccuracy contained in this report as a result of errors, omissions or misinterpretations. With respect to regulatory compliance issues, regulatory statutes are subject to interpretation. These interpretations may change over time.

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Appendix A

Opportunities to Improve the Water Quality of Fish Creek Upstream of Fish Creek Provincial Park

This Appendix may be used for reference to potential opportunities for improvement to the headwater regions and upper reaches of Fish Creek.

Headwaters

The headwaters of Fish Creek originate in the Mclean Creek Provincial Recreation Area. Although only three years' worth of data was collected from these sites during the Fish Creek Water Quality Analysis Program, it can be assumed that the primary opportunities for improvement relate to turbidity and contamination by fecal coliforms, both of which are quite easily controlled by a healthy riparian zone which acts as a natural buffer against impurities.

Ongoing efforts should be directed towards enhancing riparian zones by the following opportunities:

1. Work with the relevant organizations to educate recreational (OHV) users to the damage caused by make-shift stream crossings, and to possibly install bridges or natural barricades at areas troubled by erosion.
2. Collaborate with grazing organizations and private ranches to promote reclamation of riparian zones and opportunities to recycle manure in areas used for free range cattle grazing.

Priddis region

Following the headwater region, Fish Creek flows through the rural setting of Priddis. This region is characterized by cattle grazing ranchlands, croplands, scattered acreages and residential developments. The primary concerns to water quality in this region would be associated with agricultural runoff containing nutrients and bacteria, especially during high stream flow events. Although a single point source was unidentified during the Fish Creek Water Quality Analysis Project, the data indicates that the high peaks of *E. coli* seen throughout the 2012 sampling season originate in the Priddis region. The following opportunities may be explored to reduce the risk of *E. coli* originating from the Priddis region of Fish Creek:

1. Work with cropland owners to employ methods to reduce *E. coli* in livestock manures prior to application to cropland. Simple methods such as periodic turning of manure to ensure rapid composting are effective approaches (Berry , Millner, Wells , & Kalchayanand).
2. Collaborate with industry within the area to ensure proper erosion controls are in place at worksites.

Tsuu T'ina First Nation

Fish Creek passes through the Tsuu T'ina First Nation. There appears to be very little development within close proximity to the watercourse that could negatively impact water quality. There is an opportunity to engage with the Tsuu T'ina First Nation to gain further insight into the various land uses and water uses of the creek and to identify any shared concerns regarding water quality. It would be useful to share data and upstream concerns in order to identify synergies and opportunities for ongoing collaboration and partnership.

E.coli (# E.coli/100ml)	2009					2010						2011						2012						2013					
	June	July	August	September	October	May	June	July	August	September	October	May	June	July	August	September	October	May	June	July	August	September	October	May	June	July	August	September	October
Headwater						18	6	31	41	94	51	8	8	7	28	14	7		130	59	200	16	21						
Priddis						5	63	22	17	25	1	4	86	3	41	5	12	3	6700	200	500	36	17						
Site1	40	540	175	12	1	3	38	59	128	22	1	2	104	4	11	17	3	2	4000	56	33	13	20	47	78	119	52	39	9
Site2	33	450	86	46	5	21	80	280	64	87	10	4	102	4	13	1900	1600	4	3400	33	30	4	7	10000	98	69	36	11	1
Site3	42	570	58	24	5	9	128	157	28	114	17	2	76	7	49	13	13	9	4400	42	61	18	26	10000	57	89	88	9	8
Site4	48	480	53	18	10	6	82	103	30	310	7	184	2500	9	500	18	8	13	5100	41	51	4	14	40000	34	58	84	130	6
Site5	22	430	31	17	7	12	41	54	54	48	7		4100	27	62	15	1	7	2000	40	26	8	30		58	7	23	22	6

Chloride (mg/L)	2009					2010						2011						2012						2013					
	June	July	August	September	October	May	June	July	August	September	October	May	June	July	August	September	October	May	June	July	August	September	October	May	June	July	August	September	October
Headwater						0.015	0.015	0.015	0.015	2	2	0.47	1.89	2.16	0.32	1.22	1.45		0.3	0.18	0.42	0.38	0.57						
Priddis						10	9	8	7	9	9	5.75	6.37	5.2	10.6	9.57	11.5	9.17	12.7	5.82	7.91	12.2	10.4						
Site1	10	7	10	12	12	15	12	11	11	11	19	9.14	5.62	8.35	14.4	15.2	14.9	13.3	11.6	8.37	10.8	16.7	12.6	13.8	11.8	7.48	8.31	12	11.3
Site2	14	8	11	16	16	21	17	20	23	21	20	12.7	7.02	44.9	21.5	26.3	22.5	11.9	14.6	12.1	17.1	31.3	20.6	40.7	14.5	10.7	12.1	22.4	19.3
Site3	16	9	17	23	22	24	19	22	30	23	35	17	11.6	56.3	40.1	37.5	29.9	22	18.6	16.4	23.9	40.1	27.7	19.8	18	14.2	15.5	29.7	25.8
Site4	19	9	18	31	28	25	23	26	33	27	27	18.7	9.71	50.6	30.2	46.1	44.3	25.1	19.9	45.8	79	105	93.1	27.2	57.3	123	114	117	112
Site5	20	9	19	38	35	28	24	30	35	30	28	21.2	10.9	17.7	37.4	53.3	35.9	25.8	18.7	20.6	30.1	50.2	37.9	58.1	21.4	17.8	22.6	42.1	33.8

Nitrate (mg/L)	2009					2010						2011						2012						2013					
	June	July	August	September	October	May	June	July	August	September	October	May	June	July	August	September	October	May	June	July	August	September	October	May	June	July	August	September	October
Headwater						0.6994	0.5002	0.1771	0.1771	0.1771	0.1771	0.4781	0.3320	0.1771	0.1771	0.1771	0.1771		0.3719	0.1771	0.1771	0.1771	0.1771						
Priddis						0.1771	0.1771	0.1771	0.1771	0.1771	0.1771	0.1771	0.1771	0.1771	0.1771	0.1771	0.1771	0.1771	0.9783	0.1771	0.1771	0.1771	0.1771						
Site1	0.1771	0.1771	0.1771	0.1771	0.1771	0.1771	0.1771	0.1771	0.1771	0.1771	0.1771	0.1771	0.1771	0.1771	0.2833	0.4648	0.2523	0.1771	0.5666	0.1771	0.1771	0.4161	0.2479	0.1771	0.1771	0.1771	0.1771	0.1771	0.2568
Site2	0.6020	0.1771	0.1771	0.1771	0.1771	0.1771	0.1771	0.1771	1.0978	0.8986	0.1771	0.1771	0.2789	2.0319	0.3851	0.6773	0.4427	0.1771	0.7216	0.1771	0.1771	0.8809	0.4692	1.2838	0.1771	0.1771	0.1771	0.2877	0.4073
Site3	0.6994	0.1771	0.8013	0.6994	0.8013	0.1771	0.1771	0.1771	1.1997	0.6994	0.1771	0.1771	0.4161	4.2010	1.5759	1.1687	0.9163	0.4338	0.9163	0.3320	0.5445	1.4786	0.9695	0.5401	0.3940	0.2479	0.2745	0.6153	0.7437
Site4	0.6994	0.6020	0.6994	1.1997	1.0005	0.1771	0.1771	0.1771	1.3015	1.0005	0.6020	0.2523	0.3409	3.8425	0.8677	1.0226	2.5144	0.6684	1.0005	3.4042	6.5074	9.6062	8.1453	1.5892	3.1740	8.8536	8.2338	9.1635	9.2963
Site5	0.1771	0.1771	0.1771	0.8013	1.0978	0.1771	0.1771	0.1771	0.8986	1.8017	0.1771	0.1771	0.5489	1.3635	0.7924	3.2404	0.9518	0.4869	1.2351	0.3187	0.3232	1.1820	0.9341	1.8548	0.3896	0.2258	0.2435	0.4073	0.6906

Total Phosphours (mg/L	2009					2010						2011						2012						2013					
	June	July	August	September	October	May	June	July	August	September	October	May	June	July	August	September	October	May	June	July	August	September	October	May	June	July	August	September	October
Headwater						0.04	0.04	0.04	0.04	0.04	0.04	0.0362	0.0265	0.119	0.039	0.0259	0.0195		0.246	0.0258	0.315	0.0198	0.0025						
Priddis						0.04	0.04	0.04	0.04	0.04	0.04	0.019	0.0652	0.0261	0.017	0.0055	0.0052	0.0025	0.436	0.0166	0.0114	0.0073	0.0025						
Site1	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.0151	0.0866	0.0436	0.02	0.0061	0.0025	0.0179	0.951	0.0156	0.0137	0.0068	0.0025	0.0111	0.0505	0.0183	0.0104	0.0164	0.0061
Site2	0.04	0.13	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.0207	0.0858	0.06	0.016	0.0054	0.0025	0.0235	1.15	0.0126	0.0087	0.0054	0.0025	0.404	0.0581	0.0177	0.0057	0.0025	0.0025
Site3	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.0152	0.0861	0.14	0.014	0.0059	0.0025	0.019	1.16	0.0121	0.0088	0.0064	0.0025	0.221	0.0463	0.0163	0.0025	0.0025	0.0025
Site4	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.0175	0.0971	0.239	0.024	0.0071	0.0053	0.021	0.826	0.016	0.0105	0.0087	0.0025	0.442	0.0185	0.0074	0.0025	0.0068	0.0157
Site5	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.0164	0.158	0.512	0.013	0.0025	0.0025	0.0238	1.24	0.0119	0.0096	0.007	0.0025	0.412	0.0721	0.0179	0.0025	0.0025	0.0025

TSS (mg/L)	2009					2010						2011						2012						2013					
	June	July	August	September	October	May	June	July	August	September	October	May	June	July	August	September	October	May	June	July	August	September	October	May	June	July	August	September	October
Headwater						9	6	5	12	14	7	21	6	31	14	0.5	0.5		110	0.5	13.3	0.5	0.5						
Priddis						2	9	0.5	5	4	0.5	19	43	0.5	8	0.5	0.5	12	320	0.5	6.4	0.5	0.5						
Site1	9	12	0	4	12	0.5	5	2	4	2	0.5	20	46	18	0.5	0.5	0.5	18	523	0.5	8.9	0.5	0.5	9	41	11	0.5	16	0.5
Site2	5	143	0.05	1	4	4	7	2	7	4	3	13	64	10	10	0.05	0.05	17	887	4	6.3	0.05	0.05	265	40	8	4	0.05	0.05
Site3	8	12	0.05	8	10	10	7	5	2	2	2	16	64	47	4	0.05	0.05	14	1410	0.05	0.05	0.05	0.05	110	30	9	0.05	0.05	0.05
Site4	8	12	0.05	4	11	7	7	3	2	1	2	20	64	45	0.05	0.05	0.05	14	660	3	0.05	0.05	0.05	145	7	0.05	0.05	0.05	4
Site5	11	12	0.05	7	10	5	8	3	3	3	0.05	21	128	117	0.05	0.05	0.05	21	1320	0.05	0.05	0.05	0.05	10	43	8	0.05	0.05	0.05