Swift Current Creek Watershed Stewards Monitoring Project 2013

A Comparative Biomonitoring Assessment on the Macroinvertebrate Communities and Populations in Relation to the Operation of the Swift Current Waste Water Treatment Plant

Prepared for: The Swift Current Creek Watershed Stewards

Prepared by: Dallas E. Peters, B.Sc Environmental Biology; Integrated Resource Management

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Executive Summary

The Swift Current Creek Watershed Stewards (SCCWS) undertook a monitoring project from 2004 -2007 to study the health of the Swift Current Creek (SCC). Data collected consisted of water quality, riparian health, fish populations and communities, and macroinvertebrate diversity. Results of that project showed there were areas that had problems; but in subsequent years some of those issues were addressed through beneficial management practices (BMP) being implemented with various stakeholders. One of those BMP's was the construction of the Swift Current Waste Water Treatment Plant (WWTP) in 2006. In the year following the completion of the WWTP collected data indicated an improvement in water quality data as well as an improvement in fish data for both population and community. There was, however, no improvement in the macroinvertebrate data. The 2013 study was launched as a result of the question; "Has the operation of the WWTP helped to improve diversity and ecosystem health downstream of its influence?" New protocols were adopted in macroinvertebrate sampling on advice from Water Security Agency (WSA) to better link the data to the provincial State of the Watershed report. These new protocols did not change the overall outcome of the data.

We compared results at two sampling sites: one downstream (D-70) and one immediately upstream of the WWTP (H-60). Both sites had been used in the previous study, but at H-60 only water quality data had been collected. The full dataset collected at H-60 in this project was valuable new data. Riparian health assessments ranked each site as "healthy but with problems" with little change from the previous assessments.

Water quality was compared from the previous project to this one. We found that some of the parameters had no improvement and in some cases the water quality worsened. Arsenic levels increased at both sites and exceeded acceptable levels. When the sediment was disturbed at H-60 there was a foul odour and oil slicks that were apparent on the surface of the water.

Data from H-60 indicated an overall poor ecosystem upstream, and this may be valuable for further study and consideration of improvement measures. Site D-70 did show improvement in macroinvertebrate diversity since the 2007 report. H-60 was borderline stressed in

macroinvertebrate community and showed results that will serve as a benchmark to monitor in the future. Results indicated that the WWTP was steadily helping to improve macroinvertebrate and fish community structure downstream of where effluent was previously released into the Swift Current Creek.

Improvement from the WWTP can be inferred from the sheer numbers of fish population species caught as well as the diversity index. Past projects also had good numbers but in 2013 a shift in structure was observed, with new species appearing in the mix. Upstream results, however, were not as promising with far fewer numbers and species caught.

As a result of the data collected there is inherent value in doing more sampling at both sites, especially given the unacceptable arsenic levels. The foul odour and oil slick at H-60 may lead to an opportunity to implement urban BMP’s.

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Fishermen volunteers (left to right) Will Chalk, Ken Broccolo, Bernie Chabot, and Steve Auger

Cover photos: Karlah Rudolph and Dallas Peters; Craig Steinley, Bernie Chabot, Ken Broccolo, and Will Chalk

Coenagrionidae larvae and dragonfly photos courtesy of: Dallas Peters

Abstract-During the first week of September 2013 the Swift Current Creek Watershed Stewards launched a biomonitoring project pertaining to the Swift Current Creek (SCC). Questions arose resulting from a three-year monitoring project that was completed in 2007, in regards to the health of the macroinvertebrate communities downstream of effluent discharges. Upstream and downstream sites were chosen to compare significant differences. In 2006 the Swift Current Wastewater Treatment Plant (WWTP) was brought into operation and species diversity and ecosystem health was left to recover for six years until monitoring began in 2013. Prior to 2006, the city of Swift Current periodically released raw effluent into the SCC. Assessments of riparian areas rated 63% and 65% of upstream and downstream sites respectively in health with water quality lacking significant improvement. Fish assessments were conducted for the first time upstream of the plant, creating a benchmark of diversity for subsequent sampling. Populations were assessed using body condition (length vs. weight), length frequency distributions, and a 1-way ANOVA on sentential species of white sucker and fathead minnow. Downstream individuals showed healthy young of the year dominated populations and more species diversity. Diversity using the Simpson's Index had D=1.054 for upstream and D=0.3821 downstream; indicating ecosystem shifts of diversity. Macroinvertebrates showed a healthy rating downstream with a total species abundance value of D=2.5 within biological confidence interval grouping and upstream is border line stressed with D=2.7 and not within biological confidence grouping. Overall, downstream results showed some improvement in health despite poor upstream health.

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1.0 Introduction

The complexity of a stream ecosystem encompasses both terrestrial and aquatic elements to sustain its health and well-being. The Swift Current Creek is an example of such an ecosystem and is the artery of the Swift Current Creek Watershed located in the semi-arid region of Southwest Saskatchewan. Diversity and ecosystem health has been in question by the Swift Current Creek Watershed Stewards (SCCWS) and a three year project was launched to monitor the entirety of the watershed.

The Swift Current Creek Watershed Stewards Inc. is a non-profit organization primarily created by local stakeholders of the Swift Current Creek Watershed. The SCCWS seek to provide users of the Swift Current Creek with awareness, education, monitoring, and developing an attitude of individual responsibility and stewardship. Water quality and stream health are also promoted and ongoing issues are presented in an array of educational programs to help the users of the valuable resource they have. The Swift Current Creek Watershed is vital to many different users and monitoring sites are chosen as to obtain the best results in helping to understand and maintain the watershed.

Monitoring projects were implemented from 2004 – 2007 with a purpose to evaluate the health of the watershed, explore gaps in data collection, and to address increasing concerns from the public and stakeholders. In 2013 the Stewards conducted a new project with the purpose to determine if the operation of the Swift Current Wastewater Treatment Plant (WWTP) has had a positive effect on the water quality downstream and potentially the diversity of aquatic macroinvertebrates. SCCWS would like to answer the question, “Has diversity and ecosystem health improved since the inception of the WWTP?”

In the 2007 report, it was stated that species diversity was poor. The WWTP was not constructed and in operation until 2006; therefore any change in water quality as a result of the plant was not documented due to little recovery time. Time was a factor as the downstream environment needed an adequate amount to recover from the preceding effluent releases. As in the previous monitoring project, macroinvertebrate biomonitoring, fish populations and communities as well as water quality were also a part of the 2013 study. The purpose stated has its origins in the results from 2007 and interest to answer if the WWTP is fulfilling or exceeding its purposes of improving water quality; thus the health and safety of human consumers and the organisms that inhabit the Swift Current Creek.

Water Quality is one measure of ecosystem health and can be apparent of change within a short time. However sediments trap and hold pollutants and other parameters that cause negative effects on aquatic organisms. Macroinvertebrates are aquatic insects, insect larvae, and crustaceans that live in the bottom portion of a stream or within the sediments (Spellman 2009). Spellman (2009) states macroinvertebrates have been proven to be excellent ecosystem health indicators as they are ubiquitous, relatively sedentary, and long lived. This allows for observances of changes if the stream health has improved, decreased in health, or stayed relatively unchanged. To answer the question at hand, two sites were chosen to monitor; one upstream and one downstream of the treatment plant.

1.1 Site Description

Sites chosen for the project were based on answering the question previously stated in regards to water quality and macroinvertebrate communities. To accomplish this, a control site was chosen immediately upstream of the WWTP to compare to the downstream site. They have been given codes H-60 and D-70 for upstream and downstream respectively. Both sites are a part of the Swift Current Creek Watershed and are located directly on the Swift Current Creek, not a tributary. The watershed lies in the southwest corner of Saskatchewan with the headwaters in Cypress Hills and the mouth emptying into the South Saskatchewan River.

Communities such as Rush Lake, Herbert, and Swift Current all acquire drinking and/or irrigation water from this system. Irrigation canals branching out of the Swift Current Creek Watershed feed into a sub-basin which is directly affected by the creek's flows. Ultimately, some of the water in this basin drains into Reed Lake located by Morse, SK. The Swift Current Creek is fed by three smaller tributary creeks; Rock, Jones, and Bone. Major points (barriers) include Duncairn Dam and Swift Current Weir, as indicated on the following map in Figure 1.

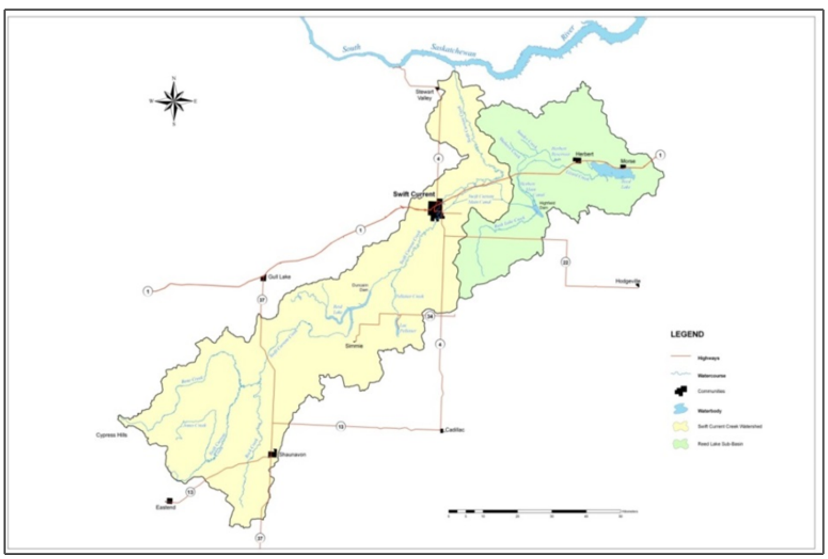

Figure 1- Map of Swift Current Creek Watershed (PFRA 2009)

Site H-60 is located within the city limits of Swift Current. A GPS location was taken at UTM N 50°18.209 and W 107°46.423. The dominant land uses bordering the creek site are golf course greens on the south side and businesses which include car dealerships on the northwest side. An empty field separates roadways directly north and northeast, with a cemetery and cultivated fields to the east across a traffic bridge and Highway #4. Table 1 summarizing the main features of the site is shown below.

Table 1- Site characteristics of H-60

H-60 Site Description	
Mean water velocity (m/s)	0.073
Discharge (m^3/s)	0.445
Elevation (ft.)	2430
Mean depth (m)	0.6
Wetted width of banks (m)	18.3
Mean size of bed particles	silt/clay (less than 0.062 mm)
Dominant riparian vegetation	Common Reed Grass (*Phramites communis)* Smooth Brome (*Bromus inerms)*

Travelling downstream to site D-70 there are changes in land use as it is outside the main core of the city. Location on GPS is UTM N 50°19.513 and W 107°44.640. Land use at this site consists of pastureland for horses, single family living on the south side, corrals, and a ford water crossing located upstream across the creek by gravel road. A summary of the site description can be seen in Table 2.

Table 2- Site characteristics of D-70

D-70 Site Description	
Mean water velocity (m/s)	0.298
Discharge (m^3/s)	0.642
Elevation (ft.)	2412
Mean depth (m)	0.51
Wetted width of banks (m)	13.7
Mean size of bed particles	silt/clay (less than 0.062 mm)
Dominant riparian vegetation	Reed canary grass (*Phalaris arundincacea),* Sedges *(Carex sp),* Western snowberry *(Symphoricarpos occidentalis.)*

2.0 Methods and Materials

2.1 Site Assessments- Riparian Assessment

The riparian assessments were done by the same outside contractor as was used in the previous monitoring project using the *Riparian Health Assessment –Streams and Small Rivers protocols* (Saskatchewan PCAP Greencover Committee 2008). Predetermined sites were assigned and assessed using a scoring system to determine riparian health and ability to serve its function. Several questions were considered for vegetation and soil and hydrology (Hansen 2013). For more information on riparian methodology and assessments please refer to Appendix 3.

2.2 Water Quality Assessment

a.) Water Samples

Water samples were taken at both sites and sent to Saskatchewan Research Council (SRC) in Saskatoon, SK for analysis. SRC was contacted weeks prior to the determined sample collection date in order to obtain the appropriate bottles, preservatives, field blanks, distilled water, contract information, and cooler for shipping. Samples consisted of standard grab samples and field blanks.

Standard samples were collected facing upstream in the center of the creek at the site hub (in this case the hubs were predetermined by the previous monitoring project and were estimated if markings had gone missing). The collector did not touch the inside of the bottle or the inside of the lid to further avoid contamination. Facing upstream, avoiding debris entering the sample bottle, the bottle was placed approximately 20 cm below the water surface, filled, capped and shook, then poured out behind the collector (downstream) in order to rinse the bottle before obtaining a sample. This rinsing method was done three times. The sample was capped underwater and the necessary preservatives were added in the field according to the directions on the labelled bottles. In the case of bacterial testing the sealed, sterilized bottle was not rinsed prior to obtaining a sample. All samples were labelled with site, type of sample, and time of day and kept in a cooler with ice packs until shipped.

Field blanks were made using the same types of sample bottles and filled with distilled water. Necessary preservatives were to be added to the appropriately labelled bottles but were later added at SRC due to missing amounts in the shipment. These blanks were sent to SRC with the grab samples in the same manner to compare results in the event a preservative affected the sample.

Shipment of the samples was done immediately the same day due to time critical testing. Preserved sample bottles were wrapped in newspaper, placed in a cooler with sufficient fresh ice packs, and packed with an analytical letter to SRC and a chain of custody form (also provided) in a plastic ZipLock® bag. The cooler was labelled appropriately with "time critical" and "keep cool" stickers, taped securely shut, and sent by courier to ensure quick delivery.

b.) Water Parameters

Standard parameters such as dissolved oxygen [D.O in (mg/L)], conductivity (μS/cm), and pH were taken at each site during collection of water samples, fish, and macroinvertebrate assessments. Note the pH was taken in lab at SRC due to the in-field Canlab® meter not being reliable. In addition to these, salinity and water temperature (°C) were also taken. To determine D.O and water temperature a Hach Senslon 5 DO meter was used and to determine conductivity and salinity a Hach Senslon 5 Cond meter was used. Both meters were on loan from Water Security Agency (WSA) in Swift Current, SK.

To take an accurate reading using the Hach Senslon 5 D.O meter the unit was turned on and set to measure D.O in either per cent or mg/L. The storage unit was removed and the probe was submerged into the water. The “read” labelled button was pushed and the probe was placed at least 10 cm below the surface and was kept moving in the water as it can give a false reading if it becomes stagnant. The reading was taken when the meter locked onto a value indicated by a beep and lock symbol on the screen. Temperature was automatically taken and displayed on screen.

The conductivity meter was turned on and the probe submerged to a depth of at least 10 cm. To determine conductivity the “Cond” labelled button was pushed and the value read was stabilized. To measure salinity the “salinity” labelled button was pushed and a reading taken. Both meters were used to measure parameters at the right bank, center, and left bank facing upstream. Values were averaged for fish and macroinvertebrate collection data.

2.3 Hydrometrics

Hydrometrics were performed by WSA using standard measuring protocol. The location at each of the monitoring sites chosen to perform readings were based on width of stream, depth, and flow, and a FlowTracker P1549 meter was used for all measurements. A tag line was stretched across the channel for distance measurements in cross section, and velocity was taken at 60 per cent of the total depth on a Sontek wading rod. This was used to determine average velocity. At least 20 points were measured at predetermined marks on the tag line, with no more than 25 points in total. All data was saved onto a computer which the meter recorded and data was sent to SCCWS along with field sheets (E-mail from MacDonald 2013).

2.4 Bioassessments

2.4 a.) Fish Survey

i. Seine Collection Method

Capture of fish was done by blocking off a reach of 100 m upstream and 100 m downstream of the site hub. All lengths from the hub were pre-staked days before or measured out during seine sweeps on shore using a Westward® 100 m/330 ft. measuring tape. Wooden stakes tied with surveyors tape were placed at appropriate locations in a visible area and labelled according to the length onshore. Barrier nets were 8 m seine nets installed using rebar stakes pounded into the sediment ensuring the net was sitting on the creek bottom, the top was not underwater, and the width reached both banks. In the event the net could not reach both banks it was placed in the nearest appropriate location. Seine sweeps were done using an 8 m bag seine pulled upstream at 20 m or 40 m into the current.

Seining required 5-6 people; two pulled the net hooking a loop onto their foot to ensure the net stayed as close to the bottom as possible. One person followed behind the net watching for snags or to untangle the net if needed from rocks or debris. Two "splashers" went slightly ahead along the banks and splashed water towards the center of the creek to scare fish into the net's path.

At the end of the pull a person was waiting with a tub of water to collect the fish. The net would be pulled in together by the people walking towards each other and bringing the net together to avoid escapees. The net's bag was then emptied into the tub sorting out any debris and unwanted catch such as crayfish *(Austropotamobius pallipes).* Crayfish must be removed quickly to avoid fish damage and death. Remaining crayfish were picked out of the net and returned to the creek.

Fish were then sorted into appropriately labelled 5-Gallon pails with water for population sampling or community sampling. Methods described here are shown in Figures 2 and 3.

Figure 2- Seine sampling

Figure 3- Emptying and sorting catch from seine sweep

ii. Fish Population Sampling

Population sampling was composed of two target sentinel species; white sucker *(Catostomus commersonii)* and fathead minnow *(Pimephales promelas).* Selection of these species was based on historical data of healthy populations, ease of capture and identification, non-migratory or sport, and not commercially fished (Tait 2008). In order to produce comparable data a count of 100 individuals each was needed at both sample sites. In the event over 100 fish were caught each individual was still processed from that seine sweep. If both species were at or over the 100 count then no more seines were done (Tait 2008).

Each species was processed following a live release method according to the Environmental Effects Monitoring (EEM) protocol for non-lethal sampling (Gray et al. 2002 as cited by Tait 2008). Only in the event of an abnormality that individual would be kept in a glass vial and preserved with 10% formalin. Fish were sorted according to sentinel species and community species into labelled 5-Gallon pails with creek water. For example pails labelled “WHSC” had all white suckers sorted from the catch, and “WHSC COMPLETE” was the pail designated for fish that had been processed. The same was done for fathead minnow (FTMN) and community. Community fish were sorted into one pail and then further identified. Once processed, all fish were released outside of the barrier net. This eliminated the risk of false population numbers and catching the same individuals repeatedly.

Processing and recording data of the white sucker and fathead minnow included three measurements: fork length (mm), total length (mm), and weight (g). Lengths were taken by placing the fish with its head at the base of the measuring apparatus, which consisted of a clear plastic ruler affixed to three plastic sides to contain the fish, with its snout touching the end.

Measuring fork length is the "fork" base of the tail, and total length which is squeezing the ends of the tail together and taking the measurement at the tip. These measurements were to the nearest millimetre. Proper measuring technique is illustrated in Figure 4.

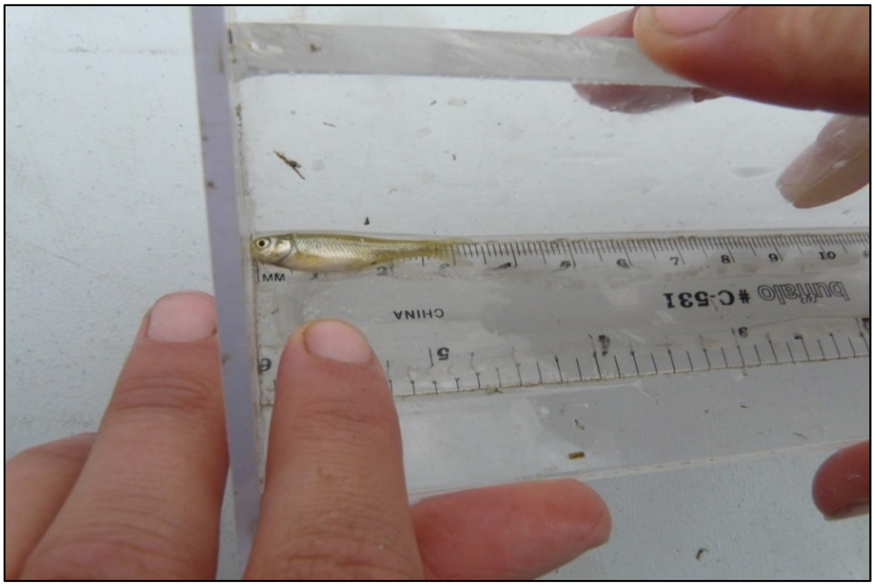

Figure 4- Measurements taken on fathead minnow

Weight was determined by using an OHAUS Scout® Pro Balance scale that was calibrated prior to processing. The scale was affected by wind and had to be placed on a sheltered level surface in order to obtain accurate readings. Weights were read by placing the fish onto the scale and taking a reading when the numbers settled to the nearest 0.01 g. Fish were then placed in "COMPLETE" pails and released in the method previously described. Weighing of fish can be seen in Figure 5.

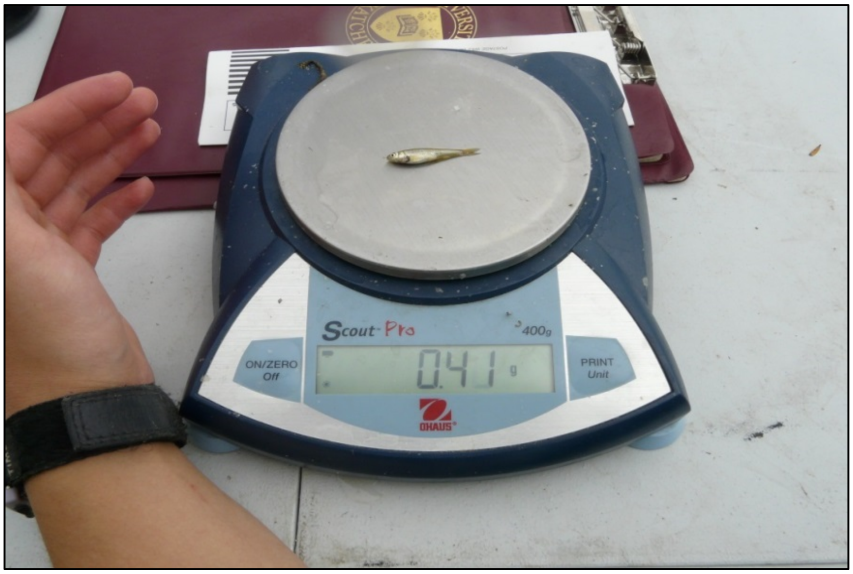

Figure 5-Weight taken on fathead minnow

iii. Community Sampling

Community species were identified to the genus species level and counted before being released. A data sheet containing a list of all species was used to tally the numbers by a recorder. If new or rarely occurring species were found they were added to the list and photographs were taken for records. Community sampling can be seen in Figure 6 and white suckers ready for processing is shown in Figure 7.

Figure 6- Sorting community species

Figure 7- White suckers sorted into 5-Gallon pails ready for observation and processing

iv. Statistics for Population and Community

All population survey and community data were sent to WSA for statistical analysis. Raw data for both population and community were analyzed for the best statistical measures to be conducted. Analysis for population included body condition (length vs. weight), length frequency distributions, and a 1-way ANOVA to compare the two sites. Community analysis included Simpson's Index and species richness to determine the site diversity. The following website was used to calculate certain analyses: <http://www.alyoung.com/labs/biodiversity_calculator.html>. The Simpson's index (D) (2013 E-mail communication from J Sereda) measures diversity which also takes into account both species richness and an evenness of abundance among the species present. In essence it measures the probability that two individuals randomly selected from an area will belong to the same species. The formula for calculating D is presented as:

$$D = \frac{\sum n_i(n_i - 1)}{N(N - 1)}$$

where n_i = the total number of organisms of each individual species

N = the total number of organisms of all species

The value of D ranges from 0 to 1; 0 represents infinite diversity and 1 with no diversity. The bigger the value, the lower the diversity. Previous data descriptors were made using EEM endpoints for non-lethal sampling which included total length, body mass, and body condition. Percent of young of year (YOY) were also determined to serve as an index of reproduction (Tait 2008).

2.4 b.) Macroinvertebrate Survey

i. Habitat Assessment and Site Data Collection

According to Hoemsen (2012) for the Saskatchewan Ministry of Environment (MOE) and Saskatchewan Watershed Authority (SWA), the assessments of site and habitat during macroinvertebrate collection prove to be helpful in determining what type of community may be present. Riparian assessments, as previously stated, were completed by an outside contractor.

The following is a list of all other assessments done at both sites and were all scored based on a provided table describing each category:

- Location by GPS
- Water chemistry- D.O (mg/L), conductivity (µS/cm), temperature (°C), salinity, and pH.
- Flow types- Categorized into runs, riffles, and pools. They represent the flow, depth, and substrate types to create natural habitats in streams (MOE and SWA 2012).
- Habitat types- stream bottom substrates categorized by size: clay (hard-packed), silt (<0.6 mm), sand (0.6-2 mm), gravel (2-65 mm), cobble (65-350 mm), boulders (>350 mm), and bedrock (solid bottom).
- Physical characteristics-velocity (measured by hydrometric instrumentation).
- Stream characterization and condition assessment- embeddedness, channel flow status, sediment deposition, bank stability, in-stream canopy cover, riparian vegetation, aquatic vegetation characterization, abundance of woody debris, detritus, macrophytes, and algae.
- River characterization

ii. Sample Collection in Wadeable Streams

Collection methodology for macroinvertebrates was taken from the *Saskatchewan Northern Great Plains Ecosystem Health Assessment Manual 2012: Version 1.0* prepared by Hoemsen (2012) obtained from MOE and WSA. Macroinvertebrates were collected within the same week and processed in the same manner. Transects started and ended at least 100 m away from any road crossing or bridge and were marked out four times, each 100 m apart from one another, totalling four transects or 400 m of sampling area. At each transect five subsamples were taken moving across the creek channel perpendicular to the imaginary transect at right bank (1/5), right center (2/5), center (3/5), left center (4/5), and left bank. Samples were taken facing upstream and transect order was done beginning from downstream and working upstream.

Figure 8- Integrating samples

All five subsamples were integrated into one sample per transect totaling four at each site, shown in Figure 8 above. The travelling kick and sweep method was used in conjunction with a conventional 30 cm base, 500 µm mesh D-frame net to collect macroinvertebrates. This was done by a collector wading to the first point and setting the flat edge of the net on the creek bottom with the opening facing upstream. A timer would record for 10 seconds and the collector would shuffle and kick the sediment immediately in front of the net, overturning rocks and stirring up the bottom. Once 10 seconds were up the collector swept the net upwards into the current to prevent any escapees and empties into a 4-L plastic pail with lid and labelled with the transect number. Water splashed down the sides of the net helped rinse any attached organisms and thorough inspections were done after each sweep. The travelling kick and sweep method is shown in the following Figure 9.

Figure 9- Travelling kick and sweep method

iii. Preparing Samples for Laboratory Processing

Macroinvertebrates were transferred to the Agriculture and Agri-Food Canada (AAFC) warehouse to be sorted and processed for shipping. Each transect pail was poured over a series of four 20''x20'' layered mesh sorting screens with the bottom being plywood. Screens varied from fine to coarse with sizes of 224, 272, and 625 squares per inch. A water hose was used to rinse the screens and deposit organisms and sediments according to size on the screens. Once sorted, each screen was thoroughly inspected and all organisms were picked with forceps and placed in a labelled 1-L mason jar half full with 95% ethanol (ETOH) (Figures 10 and 11).

Figure 10- Sorting macroinvertebrates on screens

Labelling included Avery® mailing label stickers on the lid and front of jar. Ideally water-proof paper labels should also be placed inside the jars containing all information. All writing was done with a permanent, water-resistant Sharpie® fine tip marker. Labels included date, sample code (SCCWS_2013), site, water body, and transect number. It was ensured to use safety glasses, gloves, and a funnel when working with ethanol for safety and ease of distribution into jars.

Figure 11- Crayfish sorted from sample in 95% ETOH

When each transect pail was completed in this manner the jars were further sorted to remove any remaining sediments or large debris. This was done using a white 34x23.5x5.5 cm plastic tray filled with the sample and ethanol. Sediments were sorted through and any organisms would float slightly for easy visibility. The sample jar was filled with fresh ethanol and all organisms were placed back into the jar, relabelled, and packed for shipping.

Samples were sent to a contracted pre-sorter in Saskatoon before being identified. Once there, the samples were rinsed gently with flowing water through a 500 µm sieve. Rinsed samples were then placed under a microscope to thoroughly inspect for invertebrates. All invertebrates were removed and placed in labelled vials containing 80% ethanol. Vials were then placed in labelled ZipLock® bags and sent to the WSA office for final analysis. A contracted taxonomist further sorted and identified all the organisms for statistical analysis. Statistics were conducted following WSA protocol which was a variation from the previous monitoring project in 2007and included species richness, Simpson's Index as Lambda′, total counts in samples, Marjalef Index, Shannon-Weiner Index, and comparison of Shannon-Weiner Index.

3.0 Results and Discussion

3.1 a.) Site Assessment-Riparian Health at D-70

According to Hansen (2013) ratings for downstream of the wastewater treatment plant averaged healthy but many vegetative species are invasive. With the use of the *Riparian Health Assessment –Streams and Small Rivers protocols* (Saskatchewan PCAP Greencover Committee 2008) the vegetation rating for site D-70 was 70 per cent. There was a general trend of good cover and ideal riparian species found such as Cattail *(Typha latifolia),* Sedge *(Carex spp.),* Reed Canary Grass *(Phalaris arundinacea)* and Manna Grass *(Glyceria stiata).* These species occurred immediately at the stream banks and provide excellent stability with root binding systems (Hansen 2013). The major undesirable invasive species found that provide little to no stream bank stability were Bluegrass *(Poa spp)* and Stinkweed *(Thalpsi arvense).* Woody species were also observed however many were non-preferred (Hansen 2013).

Soil and Hydrology ratings totalled 60 per cent. Horses use trails and low level crossings in the creek and there was extensive pugging and hummocking in these areas (Figures 12 and 13).

Figure 12- Low level crossing frequent by horses (Hansen 2013)

Figure 13- Horse activity at D-70

Extreme lateral cutting was colossally apparent at one end of the reach and appears to be worsening with no vegetation and steep banks (Hansen 2013). Stream incisement classifies as a Stage 2 meaning there is slight incisement along the creek. The overall rating for D-70 is 65 per cent; healthy with problems (Hansen 2013).

b.) Site Assessment-Riparian Health at H-60

Site use varied greatly between sites D-70 and H-60. The primary bordering land use at H-60 is the Elmwood Golf course on the south side and mowed field on the north side. Vegetation rating totalled 73 per cent with good native species similar to D-70 (Hansen 2013). Figure 14 shows Site H-60.

Figure 14- Site H-60 showing vegetative cover and land uses on both banks (Hansen 2013)

Many invasive species were found and indicate a degrading ecosystem according to Hansen (2013). Some included Bindweed *(Convulvulus sepium)*, Indian Hemp *(Apocynum cannabium),* Sow Thistle *(Sonchus arvensis),* and Stinkweed *(Thalpsi arvense).* Woody species were also found here but again most were non-preferred.

The rating for soils and hydrology totalled 53 per cent. There was minimal bare ground and lots of vegetative cover (Hansen 2013). One area showed steep banks with no vegetation and extreme lateral cutting. The majority of the stream banks have been altered for urban development and storm drain discharges. Stream incisement received a score of 3, which is moderately incised (Hansen 2013). Overall this site scored a 63 per cent; healthy with problems (Hansen 2013).

3.2 Water Quality

Assessment of water quality focuses on specific biological, physical, and chemical trends which, on their own, do not fully answer if water quality is acceptable (Tait 2008). In accordance to this the Canadian Council of Ministers of the Environment (CCME) created the Water Quality Index (WQI) to interpret results easily and effectively in an array of areas, with each province attaining their own set of standards (Tait 2008). Saskatchewan protocols for water quality include irrigation, livestock watering, recreation, and protection of aquatic life standards (Tait 2008). To comply with the study in question the Saskatchewan Surface Water Quality Objectives (SWQI) focusing on protection of aquatic life and wildlife were used to analyze water results. This specific objective determines a reasonable degree of protection of fish and other aquatic inhabitants, including plants, in all stages during lifecycles (Saskatchewan Environment 2006 as cited by Tait 2008). A table summarizing the SWQI ratings can be found in Appendix 3.

The water data that was collected from 2005 to 2007 was used as a comparison to interpret the effects of the City of Swift Current's pre-waste water treatment plant (WWTP) and post WWTP operation. In the event of an abnormal or peak occurrence data was further analyzed from 2005-2006.

a.) Comparison of 2007 Deviating Data to 2013 Data

Site H-60 according to Tait (2008) began a downhill plunge in water quality from 2006. The deviating factors contributing to this were arsenic, pH, and ammonia (NH_3) as nitrogen (N). Site D-70 also had these same deviations minus ammonia as nitrogen and the addition of sodium. In 2007 only pH improved but the value for arsenic remained high.

i. Arsenic

Arsenic levels in the Swift Current Creek continued this increasing trend through to 2013. In comparison to September of 2007 arsenic levels at H-60 were at 4.9 ug/L. That value increased to 5.5 ug/L in 2013. Site D-70 levels rose from 4.5 ug/L to 6.2 ug/L. Arsenic lowered travelling downstream from H-60 to D-70 in 2007 but increased in 2013. According to the SWQI for protection of aquatic life and wildlife the arsenic standard is 5ug/L which has been exceeded (Water Security Agency 2006). Such an increase in arsenic levels may be attributed to the charging of groundwater springs which are a natural source of Arsenic (Legualt as cited by Tait 2008). Figure 15 shows Arsenic levels taken in 2007 and 2013.

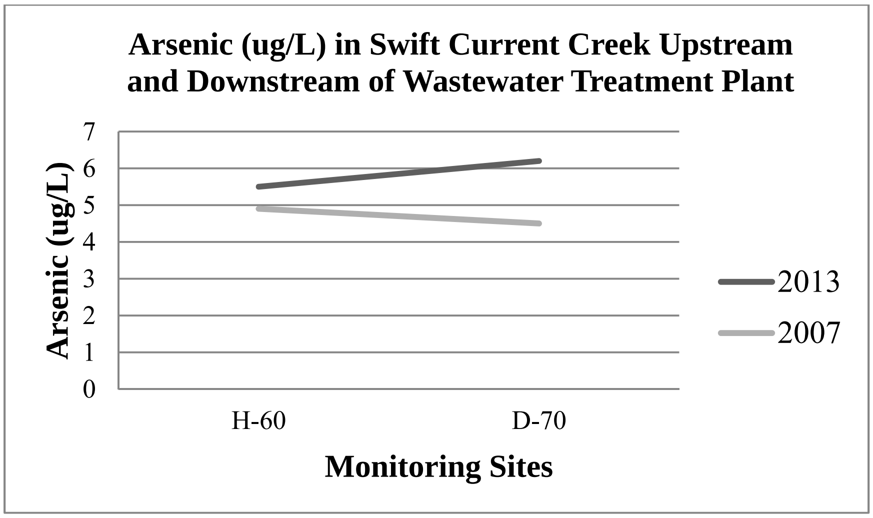

Figure 15- Arsenic (ug/L) in Swift Current Creek upstream and downstream of wastewater plant

ii. pH

pH affects aquatic organisms in that it is needed for the basic regulatory processes used to sustain life (Robertson-Bryan Inc. 2004). It is important in the primary respiration exchange of gasses and salts from aquatic inhabitants with the water surrounding them; with diversity in species also giving a wide range of tolerable pH values (Robertson-Bryan Inc. 2004). The range of tolerable pH values in freshwater can cover 6-9 pH units. According to Robertson-Bryan Inc. (2004) trends in pH can either be sub-lethal (stunted growth) to lethal. An aquatic organisms' ability to use pH also depends on other parameters such as dissolved oxygen and temperature which were also measured in field (McKee and Wolf 1963 as cited by Robertson-Bryan Inc. 2004). Non-lethal levels range from 5-9 with the satisfactory values sitting from 6.5 to 9, and the best values sitting at 6.5 to 8.5 for optimal diversity (Alabaster and Lloyd 1980; Ellis 1937; McKee and Wolf 1963; NTAC 1968; NAS 1972 as cited by Robertson-Bryan Inc. 2004).

Values in pH showed improvement in 2007 from the 3-year monitoring project. This trend continued into 2013 with decreased alkaline values. Based on Robertson-Bryan Inc. (2004) the pH values in 2013 at both sites were at an optimal level for species diversity. Values from 2007 also show optimal ranges from H-60 at 8.48 pH units and D-70 at 8.56 units. pH in 2013 had lowered to 8.35 at H-60 and 8.32 pH units at D-70. Interestingly the trend in pH increased downstream in 2007 and the 2013 data showed a decreased value downstream. Both data sets appear to be in a non-lethal range for both fish and other aquatic inhabitants. Comparison of pH can be seen in the following Figure 16.

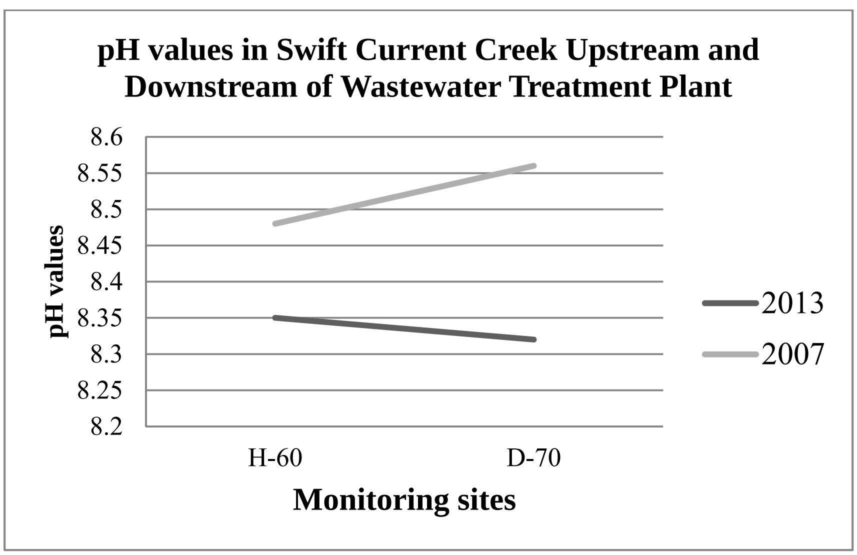

Figure 16- pH comparison from 2007 to 2013 upstream and downstream of wastewater plant

iii. Ammonia as Nitrogen

The final deviation for H-60 was ammonia as nitrogen. Ammonia, though it can be problematic in excessive quantities, is an essential part of the nitrogen cycle and crucial for aquatic life as it is an important source of available nitrogen. It is highly soluble and easily affected by water parameters such as temperature and pH (CCME 2010). The decreasing trend may therefore have a relationship with the decreasing trend of pH as previously described. Ammonia can enter the creek in natural and human-influenced means. Non-point sources of ammonia include agricultural, residential, municipal, and atmospheric releases. The Swift Current Creek's journey flows through areas that include all of these sources, and major agricultural sources which include ammonia-rich fertilizer and decomposition of livestock wastes (Environment Canada 1992; WHO 1986 as cited by CCME 2010). Residential and municipal sources include the use and disposal of cleansing agents and improper disposal, as well as urban runoff (Environment Canada 1997; WHO 1986 as cited by CCME 2010).

It was apparent that both sites were affected as ammonia was elevated downstream at D-70. Data taken in 2007 shows H-60 at 0.06 mg/L and this rose to 0.09 mg/L at D-70. Both of these values are above the standard according to CCME guidelines at 0.019 mg/L. Compared to 2013 results (Figure 17) ammonia has decreased at both sites with the same elevating trend as 2007; where H-60 tested at 0.03 mg/L and D-70 at 0.04 mg/L.

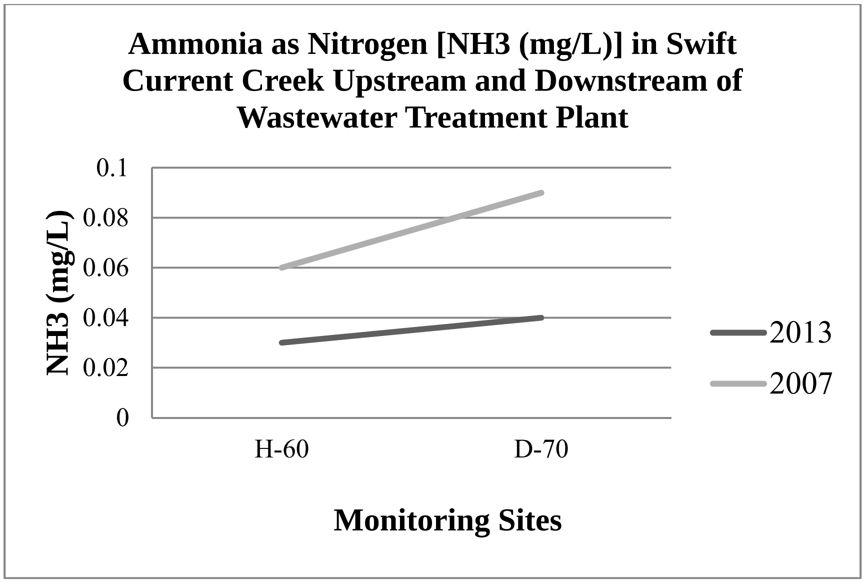

Figure 17- NH3 in Swift Current Creek upstream and downstream of wastewater plant

iv. Sodium

Lastly Site D-70 had a deviation in sodium levels. Sodium was also discussed in previous 2007 data as an important watershed health indicator being in excess of the guideline of 120 mg/L on multiple occurrences. Clearly the elevating trend is apparent and appeared to not have improved over the six years from 2007. Similar to ammonia, sodium is essential in an ecosystem (The British Columbia Groundwater Association 2007 as cited by Tait 2008). Trends show elevation in levels from upstream to downstream (Figure 19) and according to Tait (2008) high levels of sodium in various areas of the watershed could be due to the leaching of the Bearpaw Shale bedrock formations. Comparison of 2007 and 2013 levels can be seen in the following Figures 18 and 19.

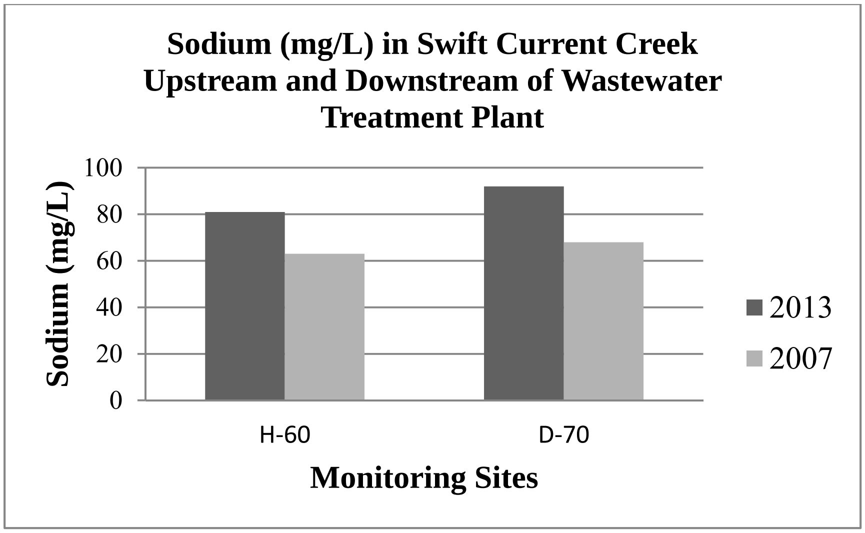

Figure 18- Comparison of elevated levels of sodium upstream and downstream wastewater plant

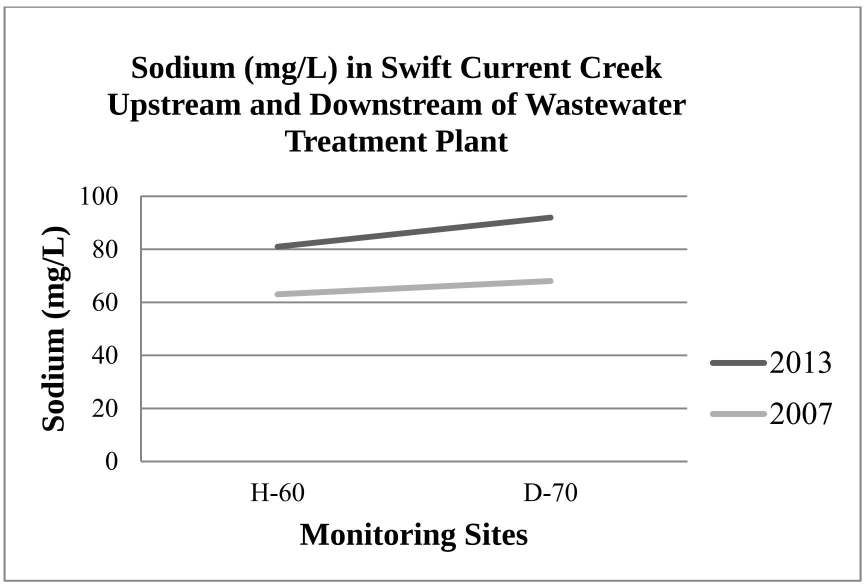

Figure 19- Sodium levels in Swift Current Creek upstream and downstream wastewater plant

b.) Watershed Health Indicators

Briefly discussed with sodium, other watershed health indicators are present and were reviewed with the 2013 data. These included the following:

i. Chloride

Chloride occurs naturally as a salt from chlorine gas and metals. It can occur in various other ways such as road salt, inorganic fertilizer, effluent wastewater, and landfill leach run-offs (KDW 2007 as cited by Tait 2008; Tait 2008). Sources of these are all present along the Swift Current Creek.

ii. Sulfate

Sulfate is present in various mineral salts and also has several sources of contamination: soil leaching, decaying organic matter, water treatment with alum, and fertilizers (U.S Environmental Protection Agency 2006 as cited by Tait 2008). Patterns of sulfate were similar to those of sodium. Trends elevated downstream of the wastewater treatment plant.

iii. Nitrogen

Nitrogen occurs naturally and exists in the environment in many forms, one of which reviewed was nitrate. It is crucial for all living organisms to exist but can also cause overgrowth and lethal outcomes (Kentucky Division of Water 2008 as cited by Tait 2008). Nitrates are present in fertilizers, sewage, and livestock facilities can emit massive amounts (Tait 2008). Worthy of note in this study, is that excessive rainfall can cause elevated run-off and therefore deposit large amounts of nitrates. These, in turn, promote extensive algae growth which dies off and therefore oxygen is consumed at a high rate by decomposition. Subsequently taxa richness can decrease due to lack of available oxygen (Tait 2008).

iv. Total Dissolved Solids

Total Dissolved Solids (TDS) are inorganic substances such as minerals and salts and can occur from natural mineral springs and salt deposits (WHO 1996 as cited by Tait 2008). Human influenced sources include wastewater, urban run-off, and road salts. Trends of TDS increased from upstream to downstream.

v. Dissolved Phosphorus

Dissolved Phosphorus is normally found in freshwater as phosphates and is required by all organisms as a nutrient (Murphy 2007 as cited by Tait 2008). Levels were found to be higher in the 2013 data. Tait (2008) states that an inorganic form of phosphates is orthophosphate which is used by plants and can occur naturally as well as human influenced, mainly in sewage. This can create large amounts of algae and produce a similar result to that of excess nitrogen. Algae blooms are both toxic and deplete oxygen from the water which can deplete diversity in species of aquatic and/or terrestrial organisms (Tait 2008).

vi. Aluminum

Found in nature only in the form of compounds and not an element, Aluminum can be present in effluents and wash water from wastewater treatment plants (KDW 2007 as cited by Tait 2008). This is used in the form of Alum to remove microorganisms which can alter pH (Tait 2008). D-70 exhibited peaks in Aluminum from 2005 to 2007 as it is immediately downstream of the wastewater treatment plant. In 2013 the levels decreased and were considerably lower than 2007 levels. A short summary on all water chemistry parameters is found in Table 3. Figure 20 illustrates the changes in levels of each watershed health indicator.

Table 3- Watershed health indicator water chemistry levels

Site	Parameter (mg/L)	2007	2013
H-60	Chloride	7	9
D-70	Chloride	9	21
H-60	Sulfate	210	300
D-70	Sulfate	230	330
H-60	Nitrate	0.02	<0.04
D-70	Nitrate	0.02	0.75
H-60	Total Dissolved Solids	548	662
D-70	Total Dissolved Solids	0.07	740
H-60	Inorganic Phosphorus	0.06	0.09
D-70	Inorganic Phosphorus	0.05	0.12
H-60	Aluminum	0.69	0.36
D-70	Aluminum	0.44	0.3
H-60	E-Coli	5	180
D-70	E-Coli	568	120
H-60	Total Coliform	816	14000
D-70	Total Coliform	55	14000
* Yellow highlights increased values			

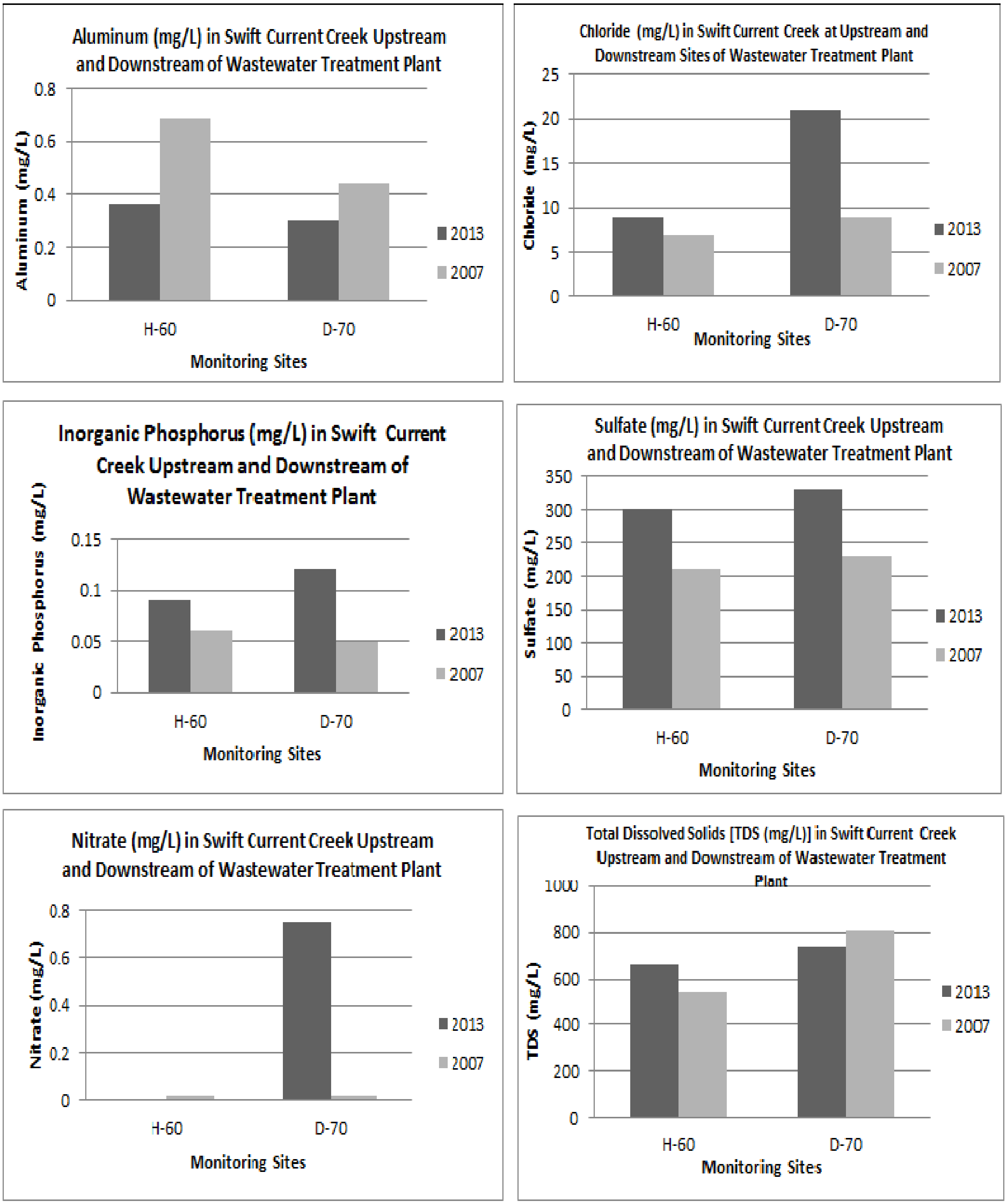

Figure 20- Comparison of watershed health indicators

c.) *Escherchia coli* and Total Coliforms

One of the most important indicators of watershed health and the well-being of water quality in all aspects is bacterial testing for fecal coliforms. Two types of coliforms were tested, *Escherchia coli* (E-Coli) and total coliforms. These indicate contamination by fecal matter; either by human, wildlife, or livestock (Tait 2008). E-Coli is an important indicator as it can indicate the presence of other microorganisms and pathogens such as salmonella which is also found in mammalian feces (SCCWS 2008). Contamination sources can include run-off (agricultural), storm sewer run-off, and untreated sewage. These all pose a risk to human health and according to Tait (2008) untreated waste can also deplete dissolved oxygen levels causing fish kills and lowering species diversity.

E-Coli in the past showed increased results at sites H-60 and D-70 due to the proximity of many point sources and lack of a wastewater treatment plant. Spikes in E-Coli levels occurred at D-70. 2013 levels decreased and continue to decrease from H-60- to D-70 which can suggest that the plant's operation has been successful, as seen in Figure 21.

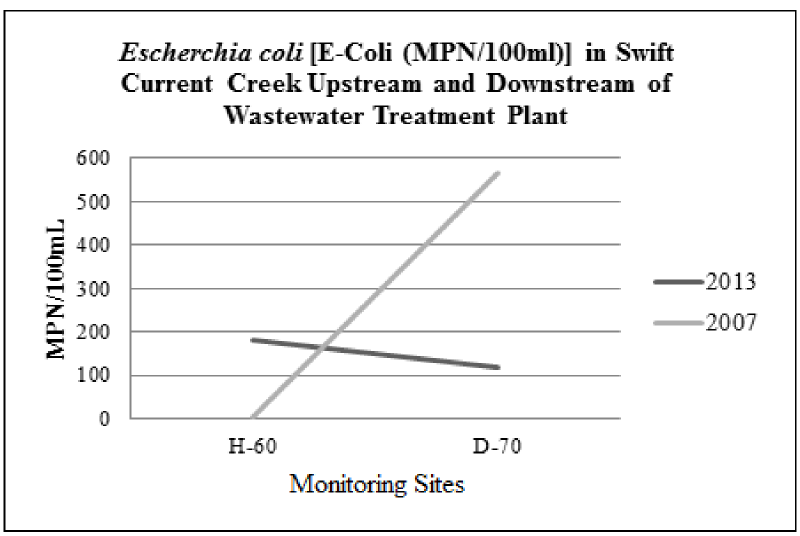

Figure 21- *Escherchia Coli* levels in Swift Current Creek pre and post wastewater plant

Total coliforms showed decreasing levels in 2007 moving downstream towards D-70. Interestingly the levels in 2013 show no change from upstream of the plant to downstream. Site counts were both the same (as seen in Figure 22). However these values are much higher than those of 2007 at 14000 MPN/100mL.

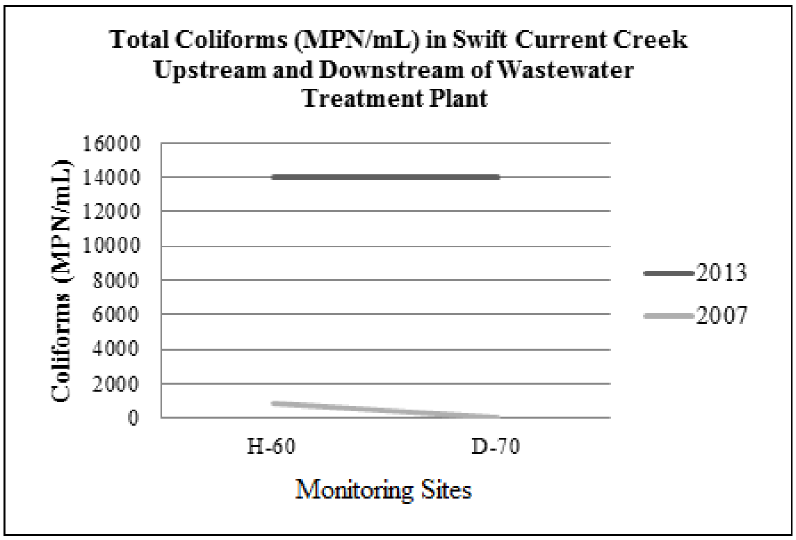

Figure 22- Total coliforms pre and post wastewater plant

3.3 Hydrometrics

The hydrologic cycle and water balance includes factors such as precipitation, evaporation, infiltration, snowmelt, and run off to name a few examples. Hydrometics is the measure of water levels and discharges or steam flow data based on hydrology (MOE 2009). According to Figure 23, Site H-60 has a fairly uniform velocity across the channel width with maximum peaks at 3 m. Site D-70 shows velocity at its highest around 3 m as well but an increasing then decreasing curve pattern is observed as compared to H-60. Depth across the channel is also fairly uniform at H-60. Depth follows a decreasing pattern from 1 m to 7 m across the channel. The depth and flow (velocity) factors may play a role in the distribution of aquatic macroinvertebrates as certain species prefer high velocity, shallow flows, and others prefer slower, deeper flows. See also Tables 1 and 2 for mean velocity (m/s) and discharge (m^3/s).

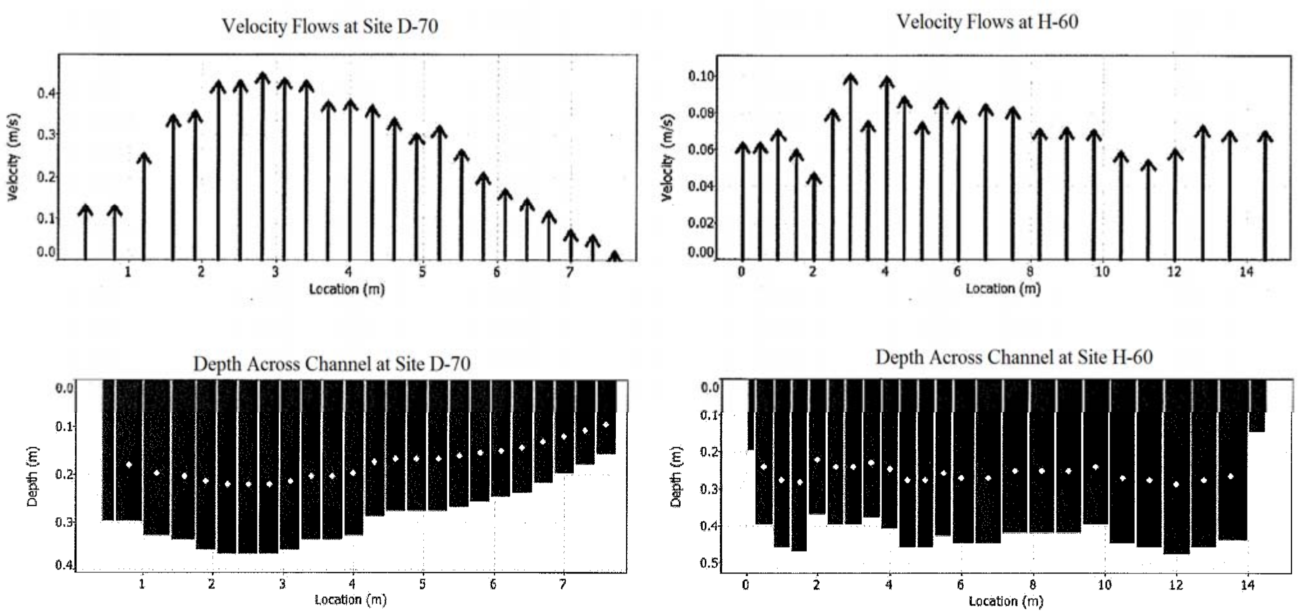

Figure 23-Comparison of velocity and depths for D-70 and H-60 (MacDonald 2013)

3.4 Bioassessments- Fish Survey

a.) Population Sampling

i. White Sucker

White sucker is a widespread shallow water species inhabiting rivers, streams, and lakes that can tolerate most environments (Nelson and Paetz 1992). Their diet is based on a bottom feeding behaviour and consists of insect larvae, molluscs, and algae (Nelson and Paetz 1992). Juveniles have three black spots that help distinguish them. Figure 24 is an illustration of the white sucker.

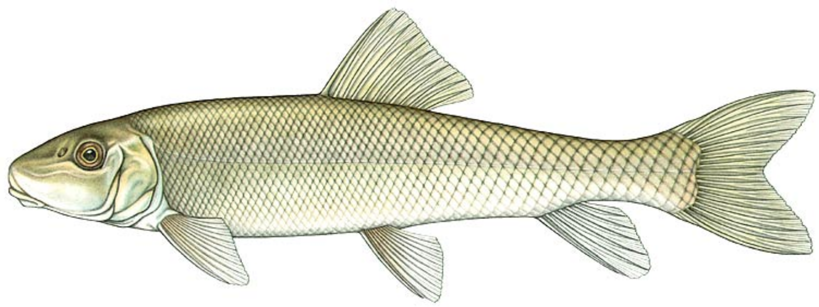

Figure 24- White Sucker (http://utahspecies.com/images/white_sucker800.jpg)

White sucker has always appeared to be an abundant species. Numbers for sentinel data were met at all sites during the 2007 collection. 2013 collection only had D-70 collect the minimum 100 individual requirement and nearly 100 at H-60. Body conditions comparing weight (g) against length (mm) (Figure 25) show similar results between the two sample sites. Data taken in 2007 from site C-50 (which was not included in this survey) shows that there is a gradual increase of relationship in white sucker up to D-70. H-60 with its 2013 debut in bioassessments may show a decrease from C-50 and then continued increase to D-70. This applies to total length, body weight, and condition.

Length frequency distributions were also conducted in white sucker. It was found that H-60 had smaller sizes of fish with two additional cohort sizes within approximately 50 and 125 mm in length respectively. This could also support the proposal that H-60 populations have a drop before rising again at D-70, as the trend indicated in 2007 from C-50 to D-70. Figure 26 shows length distributions of all white suckers, not selectively the YOY as previously analyzed.

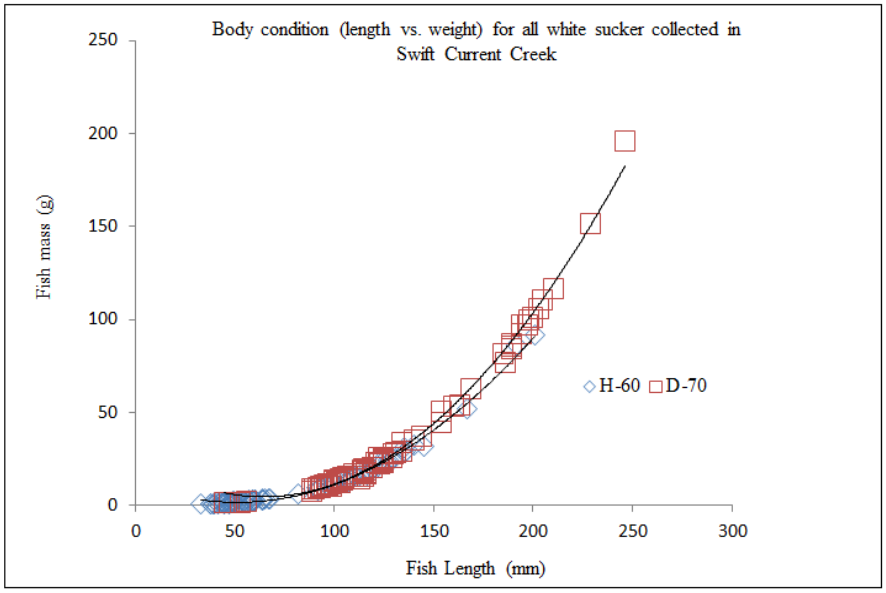

Figure 25- Body condition (length vs. weight) for all white sucker collected in Swift Current Creek (Sereda 2013)

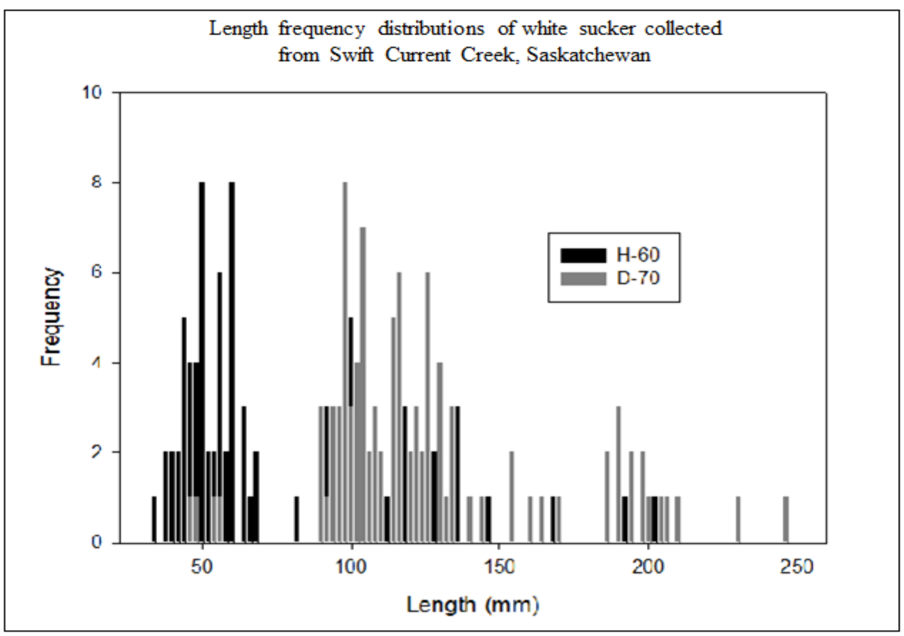

Figure 26- Length frequency distributions of white sucker collected from Swift Current Creek (Sereda 2013)

Smaller sizes in the population may suggest that YOY have moved downstream from spawning areas and are gradually working their way back upstream. Weights, lengths, and condition in 2007 all have the highest relationships at the most upstream sites. At C-50 numbers drop off and then increase gradually to D-70. H-60 data may help in future assessments to determine the cause of this community decrease in sizes, weights, and population numbers.

ii. Fathead Minnow

Fathead minnow feed on similar foods to that of the white sucker even though they tend to be more herbivorous. Nevertheless they will consume insect larvae, clams, other macroinvertebrates, as well as algae and small aquatic plants (Phillips et al. 1982). Fatheads exhibit sexual dimorphism with males having an enlarged section behind the head during the breeding season with rows of tubercles covering the head and face. Females do not show any change from their drab appearance (Phillips et al. 1982). Tolerance levels include low oxygen and fatheads can inhabitant stream or lake environments (Phillips et al. 1982).

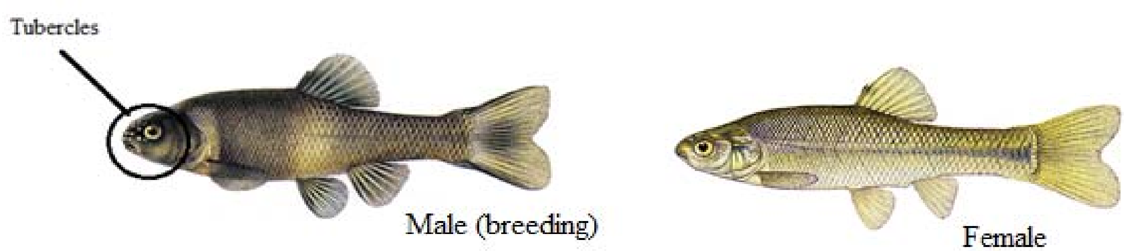

Figure 27- Fathead Minnow (http://aquaticpath.umd.edu/fhm/index.html)

Populations of fathead minnow were low at H-60. Maximum seine sweeps were done and only 12 individuals were captured. D-70 reached the 100 individual quota with a surplus catch. This trend was also present in 2007 with sites A-10 (upstream) and D-70 being the only two areas where 100 fathead minnows were captured. Populations therefore decrease downstream until D-70 is reached. The last downstream site (E-90) did not obtain 100 fathead minnows which poses an interest in reason why D-70 had the spike in population from A-10. Fatheads were nearly identical in size and mass at both sites, as shown in Figure 28 and summary Table 4 for white sucker and fathead minnow.

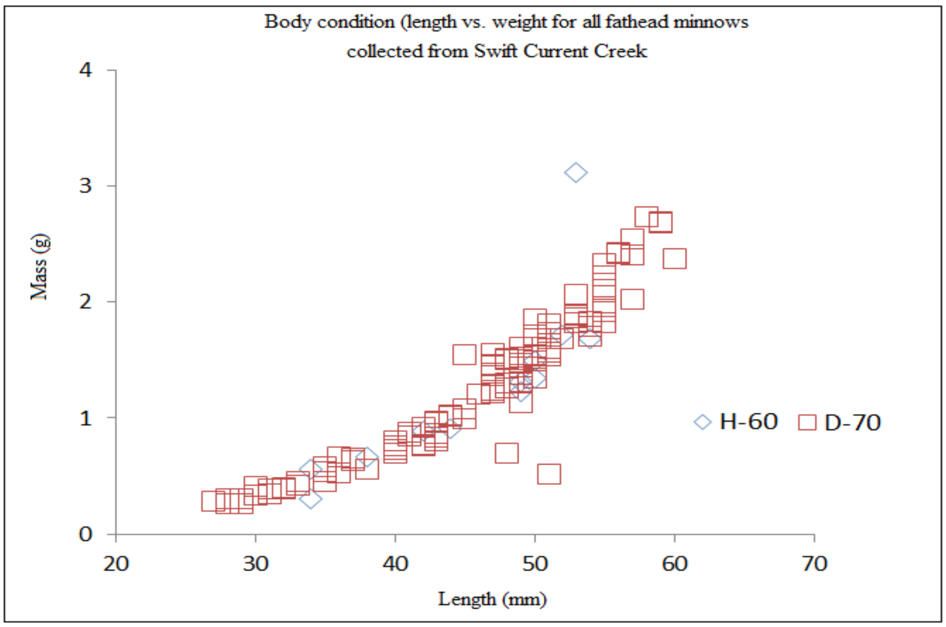

Figure 28- Body condition (length vs. weight for all fathead minnows collected from Swift Current Creek (Sereda 2013)

A large discrepancy in the number of fathead minnow collected at each site prevents a sound statistical analysis; however, fathead minnows are of virtually identical size and condition factor at each site (2013 E-mail communication from J Sereda). Fathead minnow were not analyzed statistically in 2007 due to low numbers to draw from to obtain good statistical values.

iii. Condition Factor for both White Sucker and Fathead Minnow

Condition factor (K) is a measure of weight and length and may be able to determine a fish's health and longevity (Tait 2008). There was not a significant difference in white sucker in 2007 but 2013 mean weights and lengths show significant difference. Fathead minnows showed an almost identical weight and size distribution at 1.27 and 1.28 g and 45.8 and 45.7 mm at H-60 and D-70 respectively. H-60 may be an establishing site and future monitoring here may begin to show a trend in its population, as it seems to be an anomaly site. Table 4 summarizes white sucker and fathead minnow mean data sets.

Table 4- Summary of mean weight, fork length, and condition factor (K) for white suckers and fathead minnows collected from 2 sites in Swift Current Creek (D-60 and D-70). Numbers in bold are significantly different at an alpha of 0.05 (one-way ANOVA) (Sereda 2013)

Species	Site	Mean Wt. ±SE (g)	Mean Fork Length ±SE (mm)	K±SE	N
White Sucker	H-60	**10.4±2.8**	**79.8±4.0**	1.26±0.02	97
	D-70	**32.3±2.7**	**124.6±3.9**	1.24±0.02	100
Fathead Minnow	H-60	1.27±0.7	45.8±7.2	1.20±0.31	12
	D-70	1.28±0.7	45.7±8.4	1.22±0.12	100

b.) Community Sampling

The community or diversity of fish present in a specific site along a water body can tell a lot about the water quality, habitat health, breeding areas, and food supply. Comparative data was used to assess site D-70 but H-60 had bioassessment collection conducted in the past. The results here will prove to be valuable in the years to come as to any changes that may occur. Nevertheless both sites showed surprising results that either proved well or caused concern.

The Simpson's index was calculated at D= 0.3821 with a species richness at 13. The index value is close to 0 indicating acceptable diversity. The higher species diversity suggests that the ecosystem is stable and species are successful in reproduction, the ecological niches for each species are available in abundance and lack hostilely in the environment, food webs are complex meaning more food consumption diversity, and the changes in environment may be less likely to damage the entire ecosystem (2013 E-mail communication from J Sereda). The total number of community species (including white sucker and fathead minnow) found at D-70 was nine in 2007. The most numerous was the fathead minnow at 366 individuals followed by the white sucker at 286. Both of these numbers dropped in 2013 to 109 fathead minnows and 136 white suckers. Decrease of numbers in other species included Johnny darter *(Etheostoma nigrum)*, Iowa darter *(Etheostoma exile)*, lake chub *(Couesius plumbeus)*, longnose dace *(Rhinichthys cataractae)*, river shiner *(Notropis blennius)*, and shorthead redhorse *(Moxostoma macrolepidotum)*. The shorthead redhorse, according to Ohio Department of Natural Resources Division of Wildlife (ODNR) (2013), is a key indicator of water quality. This species prefers shallow, fast moving water with clean sandy or gravel bottoms. Tolerance for pollution and turbidity is not high (ODNR 2013). At site D-70 the results of 2013 show that shorthead redhorse are no longer present in high numbers as they were from the previous collection. This drop in population after the operation of the WWTP is interesting as the water quality would be theoretically improved.

The remaining species in decline have similar biology backgrounds in terms of tolerances, breeding habitats, food selection, and water flow. These factors may be influenced in other ways downstream of the WWTP and therefore causing these species to migrate out, breed unsuccessfully, or even cause death. Tolerances for turbidity ranged from moderate to high. The Johnny darter, which ideally prefers clear water (Stewart and Watkinson 2004), is also the most tolerant to water pollution amongst all the darter species (Paulson and Hatch 2002). The only other species of darter found in 2007 was the Iowa darter and in 2013 was absent. Part of this could be due to the late summer sampling when water temperatures are generally a bit higher. Average water temperature in 2013 taken on September 4th was 21.1°C. The average water temperature during the same time period of September in 2007 was 18.4°C. Iowa daters have been known to leave a shallow area if water temperatures are too high, as well there was little preferred organic matter present (Montana Natural Heritage Program and Montana Fish, Wildlife, and Parks 2013).

Each of the species in decline all seem to have similar preferences in streambed sediment type, which is either sand or gravel (cobble and boulders for the longnose dace) and the key is it must be clean; free of sedimentation and silt. This keeps water clear for sight-feeders like the lake chub as well as ideal spawning areas (Natural Heritage Endangered Species Program 2008; Grabarkiewicz and Davis 2008; Paulson and Hatch 2002; ODNR 2013). Fish will migrate upstream to spawn and their offspring will tend to be carried downstream away from where they were hatched (2013 E-mail communication from J Sereda). Sedimentation may not be an issue at these two sites for spawning grounds. Perhaps the next best indicator to look at besides the shorthead redhorse is the longnose dace. Occurring mainly in shallow, moderately flowing creeks this species is known to have the ability to tolerate abrupt environmental changes in D.O, temperature, and turbidity for short periods of time (Grabarkiewicz and Davis 2008). According to Halliwell (1999) and Pirhalla (2004) as cited by Grabarkiewicz and Davis (2008) it is classified as a moderate to intermediate tolerance species.

The similarities between all these fish in decline may point towards an increase in sedimentation of the creek bottom, altered flows, or even a change in available food. Many minnow species consume a diet of algae, smaller fish, zooplankton, and macroinvertebrates in the form of insect larvae, worms, crustaceans, and molluscs (Phillips et al 1982; Nelson and Paetz 1992; Paulson and Hatch 2002; Montana Natural Heritage Program and Montana Fish, Wildlife, and Parks 2013; Natural Heritage Endangered Species Program 2008; Grabarkiewicz and Davis 2008). Macroinvertebrate results may also be playing a role in the community species of fish inhabiting this section of the Swift Current Creek.

Exciting results were also present at D-70 with the appearance of species previously not found or found in low numbers. Increases, as well as new species, included creek chub *(Semotilus atromaculatus)*, northern redbelly dace *(Phoxinus eos)*, emerald shiner *(Notropis atherinoides)*, the rare and protected brassy minnow *(Hybognathus hankinsoni),* yellow perch *(Perca flavescens),* quillback *(Carpiodes cyprinus),* northern pike *(Esox Lucius),* western silvery minnow *(Hybognathus argyritis),* and finescale dace *(Phoxinus neogaeus).* Brassy minnow (Figure 29) is a very exciting find for the SCCWS as it is a protected rare species occurring in the watershed. Each of these species also have very similar needs in diet; consuming much of the same foods as the declined species.

Figure 29- Brassy Minnow *(Hybognathus hankinsoni)*

Creek chubs feed on macroinvertebrates and even crayfish as well as smaller fish such as the Johnny darter; an important late-summer food supply (Stewart and Watkinson 2004). Creek chubs were found in great abundance at 131 individuals. Ideally, they also prefer clear water stream habitats with gravel bottoms, and have tolerance for some turbidity (Stewart and Watkinson 2004). These needs are identical to those of the declining species, and perhaps a shift in species composition is happening due to the large creek chub populations with a tolerance for some sedimentation. Species could also breed in other sites but feeding and water quality would be important factors at the D-70 sample site. The following Figure 30 and Table 5 summarizes community species numbers caught in 2007 and 2013.

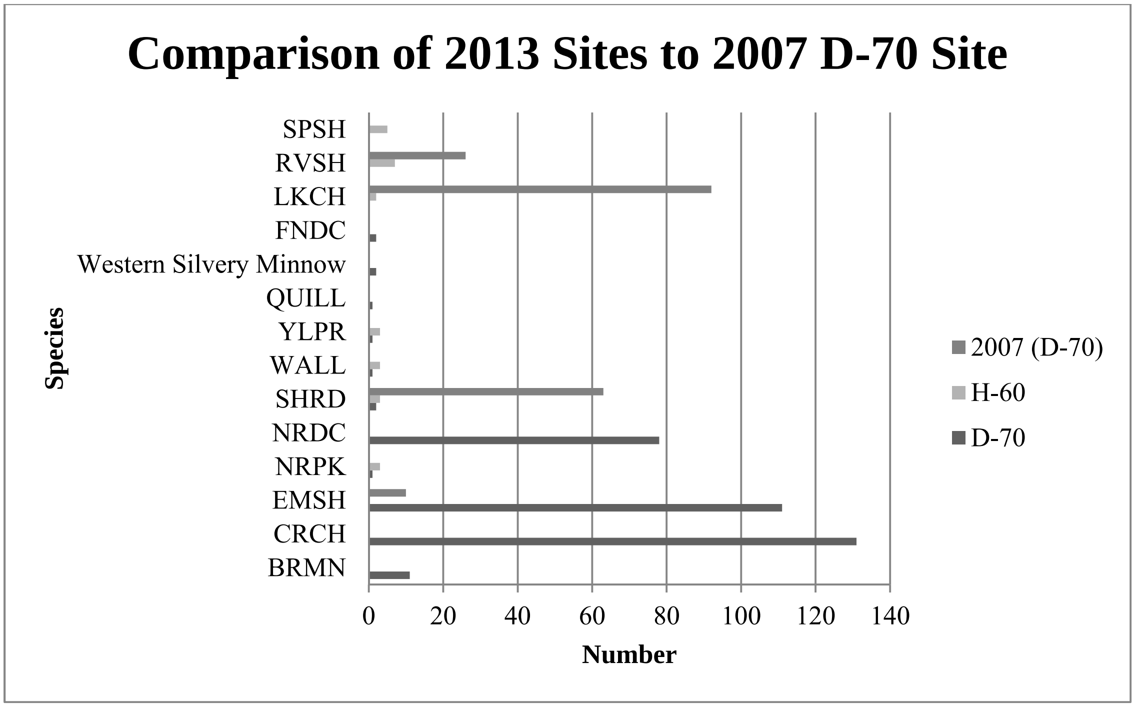

Figure 30- Comparison of 2013 sites to 2007 D-70 site

Table 5- Comparative data for fish community species at D-70 in 2007 and 2013

Fish Community Species at D-70		
Species	Sample Year	Total
Fathead Minnow (FTMN)	2007	366
	2013	109
White Sucker (WHSC)	2007	286
	2013	136
Johnny Darter (JHDR)	2007	1
	2013	0
Iowa Darter (IWDR)	2007	1
	2013	0
Shorthead Redhorse (SHRD)	2007	63
	2013	2
Creek Chub (CRCH)	2007	0
	2013	131
Lake Chub (LKCH)	2007	92
	2013	0
Longnose Dace (LNDC)	2007	35
	2013	0
Northen Redbelly Dace (NRDC)	2007	0
	2013	78
Emerald Shiner (EMSH)	2007	10
	2013	111
River Shiner (RVSH)	2007	26
	2013	0
Spottail Shiner (SPSH)	2007	0
	2013	1
Brassy Minnow (BRMN)	2007	0
	2013	11
Yellow Perch (YLPR)	2007	0
	2013	1
Quillback Carp Sucker (QUIL)	2007	0
	2013	1
Northern Pike (NRPK)	2007	0
	2013	1
Western Silvery Minnow	2007	0
	2013	2
Fine Scaled Dace (FNDC)	2007	0
	2013	2
	2007 Total:	850
	2013 Total:	586

Bioassessments in 2013 at H-60 were done for the first time in the monitoring project history. Results from 2013 will prove to be valuable for future comparative data. Overall the site did not appear healthy and able to sustain a diversity of fish species. Sentinels were low in numbers and did not reach the 100 individual mark, with only 12 fathead minnows and 97 white suckers caught. Excluding the fatheads and white suckers there were seven species caught and each had low occurring numbers. Simpson's Index totalled D= 1.054 and species richness at 9. This lower species diversity could suggest many are not breeding successfully, a stressful environment is present with few ecological niches per species, few species are capable of adaptation, food web is simplified, and any changes in the environment may have drastic effects (2013 E-mail communication from J Sereda). Sport fish were abundant with northern pike, yellow perch, and walleye *(Sander vitreus)* each at three individuals. The most abundant minnow (besides fathead) was the river shiner. Shorthead redhorse still appeared at this site, indicating that the water quality and turbidity may still be suitable for most species of fish (ODNR 2013). Table 6 summarizes the fish counts for H-60.

Table 6- Community species for site H-60

Fish Community Species at H-60 (September 2013)	
Species	Total
Fathead Minnow (FTMN)	12
White Sucker (WHSC)	97
Lake Chub (LKCH)	2
Northern Pike (NRPK)	3
River Shiner (RVSH)	7
Shorthead Redhorse (SHRD)	3
Spottail Shiner (SPSH)	5
Walleye (WALL)	3
Yellow Perch (YLPR)	3
	Total: 135

Previously mentioned in the water quality section, pH levels are suitable at both sites for aquatic wildlife. D.O is a measure of oxygen that is available in a form that aquatic organisms can use and it varies from low to high for all species of fish (Nelson and Paetz 1992; Cooke 2013). It is affected by factors such as temperature, time of day, and seasons (Nelson and Paetz 1992). The lowest levels of D.O, before causing stress and even death in fish is 5.0 mg/L (Cooke 2013). Levels at H-60 were above 5.0 mg/L at 6.55 mg/L with a water temperature at 19.9 °C. D-70 was slightly higher at 6.84 mg/L at 19.7 °C. Since D.O and pH are similar at both sites there may be underlying reasons that fish diversity and numbers were poor at H-60.

On site it was noted there were storm sewer discharge pipes emptying into the creek slightly upstream of the H-60 sample site. This is untreated water from city streets and can contain pollutants such as gasoline, oil, soaps, fertilizers, and litter. It was noted that a gasoline smell and oil slick appeared in the water after stirring up bottom sediments, and the site may have problems with urban run-off; as it is next to car dealerships, highways and roadways, and a maintained golf course. Other factors may include man-made barriers that prevent upstream and downstream migration for spawning; creating a separated population between the barriers.

3.5 Macroinvertebrate Survey

a.) Habitat Assessment

Habitat assessments were based on macroinvertebrate needs, tolerances, and preferred habitat types. As mentioned in the methods and materials section the basis of habitat assessment was done with a scoring system and protocols following the *Saskatchewan Northern Great Plains Ecosystem Health Assessment Manual 2012: Version 1.0* prepared by Hoemsen (2012).

Following, in Tables 7 and 8 are the condensed characteristics of the sites with each of the four transects used for sampling. These tables prove to contain important information as to the amount of species found, types, and community structures within the benthic environment (Figures 31 and 32).

Table 7- Habitat assessment of site H-60

H-60 Macroinvertebrate Habitat Assessment- Swift Current Creek 2013			
Transect number	Description of sediments	Description of vegetation and cover	Depth and reach type
1	silt dominant over sand, 80% silt, 15% sand, 3% gravel, 2% cobble, 0% boulder	No canopy cover, banks both fully vegetated. No macrophytes present, algae types were submerged, woody debris and detritus present	Run; average depth 35 cm, with deepest portion taken at 3/4 width of channel
2	Cobble dominant over sand, 40% silt, 10% sand, 10% gravel, 30% cobble, 10% boulder	No canopy cover, banks both fully vegetated. No macrophytes present, algae types were submerged, woody debris and detritus present	Riffle; average depth 47 cm, with deepest portion taken at 1/4 width of channel
3	Cobble dominant over silt, 30% silt, 10% sand, 20% gravel, 35% cobble, 5% boulder	No canopy cover, banks about 95% vegetated, emergent macrophytes present, submerged algae, woody debris, and detritus present	Run; average depth 37 cm, with deepest portion taken at 1/2 width of channel
4	Silt dominant over sand, 60% silt, 10%s and, 10% gravel, 15% cobble, 5% boulder	No canopy cover, fully vegetated banks, emergent macrophytes present with submerged algae, woody debris and detritus	Run; average depth 49 cm, with deepest portion at 1/2 channel width

Figure 31- Bottom substrate at transect 2 of D-70

All site data collected in regards to the habitat assessment for macroinvertebrates can be found in Appendix 8. Embeddedness ranged from optimal to poor at D-70 as well as H-60. Channel flow status at D-70 and H-60 stayed within optimal range with good scoring rates, and sediment deposition scored optimal to suboptimal at both sites as well. These indicate a fairly stable macroinvertebrate habitat according to Hoemsen (2012). H-60 comparison in the future will depict if there is an underlying cause for the limited biodiversity. A table summarizing the remaining parameters taken in field is listed in Table 9.

Figure 32- Site assessment at transect 2 of D-70 with extensive use by horses

Table 8- Habitat assessment of site D-70

D-70 Macroinvertebrate Habitat Assessment- Swift Current Creek 2013			
Transect number	Description of sediments	Description of vegetation and cover	Depth and reach type
1	Cobble dominant over sand20% silt, 20% sand, 15% gravel, 40% cobble, 5% boulder	No canopy cover, banks at 75 % vegetation, emergent macrophytes present, algae types were submerged, detritus present	Riffle; average depth 19 cm, with deepest portion taken at 1/2 width of channel
2	Sand dominant over cobble, 20% silt, 40%sand, 20% gravel, 19% cobble, 1% boulder	No canopy cover, banks 50 %vegetated. Emergent macrophytes present, algae types were submerged, detritus present	Run; average depth 38 cm, with deepest portion taken at 3/4 width of channel
3	Silt dominant over sand, 70% silt, 29% sand, 1% gravel, 0% cobble and boulder	No canopy cover, banks about 95% vegetated, emergent macrophytes present, submerged algae, and detritus present	Run; average depth 53 cm, with deepest portion taken at 1/2 width of channel
4	Silt dominant over sand, 50% silt, 10% sand, 30% gravel, 10% cobble, 0% boulder	No canopy cover, 95 % vegetated banks, emergent and free-floating macrophytes present with submerged algae and detritus	Run; average depth 42 cm, with deepest portion at 1/2 channel width

			Weather				Water			Embeddedness	Channel Flow	Sediment Depositation	Bank Stability	
Date	Site	Transect	Cloud cover	Precipitation	Air Temp. (°C)	Wind (km/hr)	Conductivity (uS/cm)	D.O (mg/L)	Water Temp (°C)				Left	Right
06/09/2013	D-70	1	Partial	1.9 mm rain	26.9	22	1091	8.32	22.7	18	16	16	8	9
06/09/2013	D-70	2								3	20	18		
06/09/2013	D-70	3								8	18	16		
06/09/2013	D-70	4								6	18	16		
05/09/2013	H-60	1	None to partial	None	30.8	5	966	8.28	23.7	5	18	14	9	8
05/09/2013	H-60	2								14	20	18		
05/09/2013	H-60	3								12	19	13		
05/09/2013	H-60	4								10	17	12		

Table 9- Field parameters taken at site D-70 and H-60

b.) Laboratory and Statistical Results

i. Collection Counts and Results from Laboratory Identification

Enumeration results from WSA showed an interesting answer to the question at hand in regards to WWTP operation. The overall rating of D-70 is healthy despite low diversity counts. The healthy rating of this years' macroinvertebrate community was not far off from 2007's healthy rating according to WSA. Once again H-60 has never been assessed so all data collected in 2013 is now available for future monitoring comparison. In regards to EPT species [Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies)], which act as intolerant indicators for water quality, there were double the number of species found at D-70 compared to H-60, with Trichoptera dominating this category at 161 specimens at D-70. H-60 only had one Trichoptera species found and none were documented in 2007 at D-70.

Trichoptera larvae encase themselves in cocoons constructed of organic debris, small pieces of gravel and even shells held together by silk they produce underwater. They are susceptible to low oxygen levels and different families have been used to classify water types, such as Hydropsychidae (common netspinners), which were found at D-70 (Higler and Tolkamp 1983 as cited by Reynoldson and Metcalfe-Smith 1992). Trichoptera are key indicators due to deviations in populations indicating pollution (Higler and Tolkamp 1983 as cited by Reynoldson and Metcalfe-Smith 1992). Figure 33 shows an example of Trichoptera species.

Figure 33- Trichoptera larvae in cocoon made of organic debris (SCCWS 2004)

The second EPT indicator species found was Ephemeroptera. These prefer fast flowing water that is clean but will tolerate slow moving standing water habitats as well. They can tolerate an average oxygen supply and were found at both sites in 2013 as well as D-70 in 2007 (De Lang 1994). There was a decrease in numbers at D-70 and H-60 had the highest counts.

Dominant families for both H-60 and D-70 included Diptera (flies) and Oligocheata (segmented worms). A new find with one occurrence, the Bryzoa group, was present at H-60. This is a group of marine and freshwater aquatic organisms that have the nickname “moss animals.” The most dominant groups found, have certain biological similarities in which they may be the most abundant. Diptera, family Chironomidae and Oligocheata communities are used to determine pollution assessments as well as trophic classifications (Reynoldson and Metcalfe-Smith 1992). Trophic levels among macroinvertebrates are important to fish as available food sources and the diversity indicates functional groups and roles in the ecosystem (Reynoldson and Metcalfe-Smith

1992). According to Peckarsky et al. (1990) as cited by De Lang (1994) insect larvae tend to be the most abundant in these communities and more polluted waters will have Oligocheata predominate with Diptera larvae. Oligocheata have a broad range of tolerances to organic pollution and certain chemicals, which make them a good potential species for bioassessments (Lang and Lang-Dobler 1979; Chapman et al. 1982 as cited by Reynoldson and Metcalfe-Smith 1992).

Another group that can withstand pollution and high TDS is Mollusca. Pelycypoda and Gastropoda were present at both sites but Pelycypoda was the most abundant. In cases where TDS is high and there is little light penetration the dominant community may shift to Diptera and Mollusca (De Lang 1994). This was apparent at site H-60 which has high numbers of Oligocheata, Diptera, and Pelycypoda. This site was indicated as bordering stressed and it is apparent by the type of community it is displaying. According to De Lang (1994) if a site is polluted over an extended timeframe then the community structure may simplify to favour the tolerant species and diversity will decrease, even if abundances of certain species increase. These species may also seek out poor conditions as they prefer them so the community may also shift in this way (De Lang 1994). Conditions may have improved for D-70 with an overall healthy status, according to WSA, but H-60 may be slipping into stressed populations for both fish and macroinvertebrates. A summary of counts compared with 2007 D-70 data can be seen in Table 10.

Table 10- Summary of counts taken from 2013 and comparative 2007 D-70 counts

Group	H-60	D-70 (2013)	D-70 (2007)
Amphipoda (side swimmers)	13	3	13
Annelids: Oligocheata (segmented worms)	149	73	70
Bryozoa (moss animals)	1	0	0
Coleoptera (beetles)	6	8	12
Decapoda (crayfish)	72	9	0
Diptera (flies)	110	285	92
Ephemeroptera (mayflies)	11	9	19
Gastropoda (snails and limpets)	4	12	3
Hemiptera (true bugs)	1	0	1
Nematoda (round worms)	0	6	0
Pelycyopoda (clams)	67	19	15
Trichoptera (caddisflies)	1	161	0
Totals:	435	585	225

ii. Statistical Results

Per cent EPT was calculated for the 2013 data to help further evaluate the health of the sites in question. EPT species are pollution intolerant species (as mentioned previously) and were calculated on a per cent scale. High values indicate good diversity and ecosystems, whereas low percentages do not. If one of the three EPT species is absent or has very low occurring numbers it can also indicate unhealthy systems (Tait 2008). H-60 has extremely low values of only two of the EPT, Ephemeroptera and Trichoptera at 2.53 per cent and 0.23 per cent respectively. D-70 had a higher percentage of Trichoptera at 27.52 per cent; 2007 had 0 per cent Trichoptera, which states improvement, and Ephemeroptera percentage at 1.54 which is based on lower counts in 2013 from 2007. Neither site has sustained Plectoptera. EPT in percentages are shown in Figures 34 and 35 for H-60 and D-70.

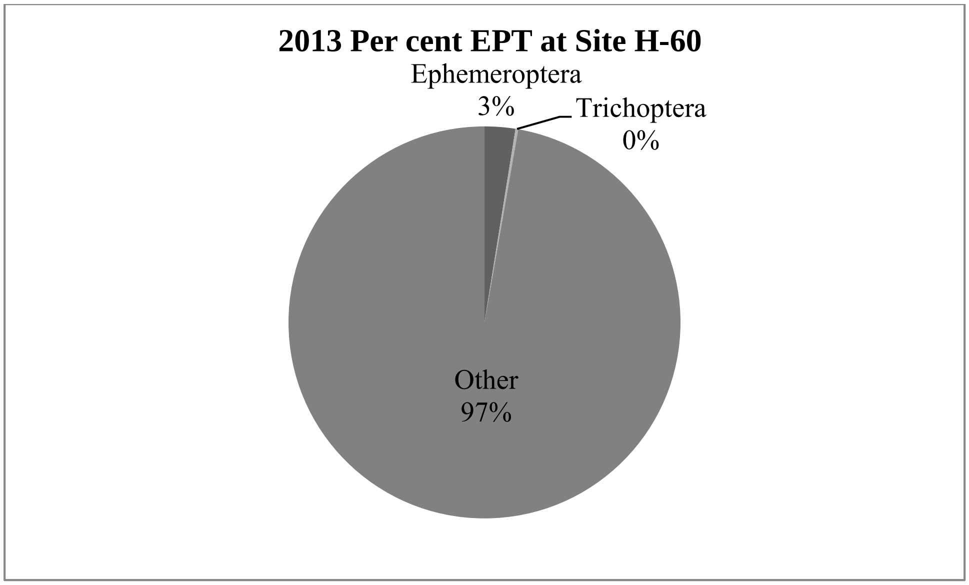

Figure 34- 2013 per cent EPT at site H-60

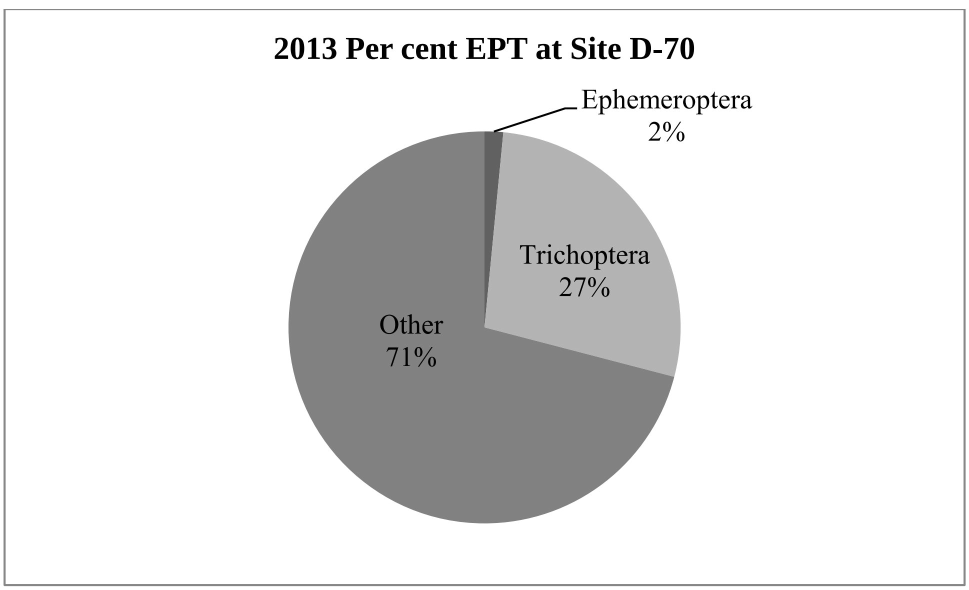

Figure 35- 2013 per cent EPT at site D-70

Due to the change of macroinvertebrate methodology following WSA protocol the statistical analysis conducted for 2013 data were not the same as the previous 2005-2007 analysis. However, based on the new indices used, SCCWS could still answer the question stated in the introduction with the protocols from WSA. The following Table 11 is an explanation to interpret the new data set.

Table 11- Values and indices used in 2013 macroinvertebrate data from WSA

Value	Description
S	Species richness
N	Total number per sample
d	Marjalef- Species diversity indicator. The higher the value, the greater the diversity
J'	Comparison of Shannon-Weiner index. If the values are close to 1 it indicates evenness. If it is close to 0, it is uneven
Lambda'	Simpson's Diversity Index
H'(loge)	Shannon-Weiner Index

Total Species Abundance (TSA) for D-70 was D=2.5 in a 95 per cent confidence interval for the site's biological grouping (p=0.97). This indicates an overall condition of good health at this site. The underlying factors which may be causing ecosystem stress may be the low number of species present, but it does not impair the results. In 2007, D-70 was also classified as healthy (according to WSA protocol) and assuming different methodology in collection. The TSA value was D=2.2 and also within the 95 per cent confidence interval in its biological grouping (p=0.99). Therefore the site has improved even though there is limited diversity.

H-60 overall condition ranked as unhealthy or stressed. TSA values here were D=2.7 outside of the 95 per cent confidence interval of biological site grouping (p=0.91). Simpson's Diversity

Index and number of species may be the foremost factor driving this site to stress; though the stress rating is border line to reference conditions and there is no impairment. Table 12 displays the remaining diversity indices taken at site D-70 and H-60 (2013 E-mail from I Phillips).

Table 12- Univariate diversity indices for sites D-70 and H-60 (Phillips 2013)

Sample	S	N	d	J'	H'(loge)	1-Lambda'
D-70_Sample 1	14	220	2.41	0.7342	1.938	0.8073
D-70_Sample 2	6	17	1.765	0.7955	1.425	0.7132
D-70_Sample 3	5	33	1.144	0.534	0.8594	0.4489
D-70_Sample 4	2	19	0.3396	0.2975	0.2062	0.1053
Average	6.75	72.25	1.41465	0.5903	1.10715	0.518675
H-60_Sample 1	7	46	1.567	0.5641	1.098	0.5246
H-60_Sample 2	5	36	1.116	0.3124	0.5029	0.2127
H-60_Sample 3	12	51	2.798	0.8123	2.019	0.8173
H-60_Sample 4	5	134	0.8167	0.3367	0.5419	0.2552
Average	7.25	66.75	1.574425	0.506375	1.04045	0.45245

4.0 Conclusion and Recommendations

4.1 Site Assessments- Riparian

Riparian assessments at both sites H-60 and D-70 scored 63% and 65% respectively. Both are healthy but with problems. There was a high density of invasive species and also disturbance induced species. Vegetation cover proved to be in good order with minimal erosion observed in the majority of the reach, however the ecological functions are compromised due to the invasive species and significant erosion upstream (Hansen 2013). A possible upstream indicator of erosion includes a ford water crossing. This crossing may be causing issues in increased erosion rates due to deposition of road gravel creating new currents in the creek, and altering the rate of incisement on the banks. A benefit to these areas would be woody species as they can be sustained but are lacking in numbers and desirability. Implanting a program to eradicate some invasive species and promote native growth may be a future recommendation as well as planting woody species to help sustain the banks from further erosion.

4.2 Water Quality and Hydrometrics

Overall water quality had increases in many chemical parameters and watershed health indicators. Arsenic was perhaps one of the most disappointing results with increases at both sites over acceptable limits. Causes of this may be the increases of flow, precipitation and the resulted charging of groundwater springs containing natural forms entering the creek. Increases in watershed health indicators also had disappointing finds with levels of chloride, sulfate, nitrate, and sodium higher than 2007. Most parameters increase greater in the reach from H-60 to D-70. E-coli and total coliforms were also on the rise even downstream at D-70. Improvements were seen in pH, TDS, and ammonia. Numerous urban sources of effluent discharges may be a key factor in the overall degradation of H-60. Since all the parameters can have drastic effects on the aquatic organisms further monitoring of the same parameters should be done annually at different times of the year to determine if levels are increasing at certain times of the season or if it is a general trend. Flow rates also affect aquatic organisms so hydrometric testing should also be done with water quality to see if seasonal trends are occurring. The addition of more urban monitoring sites upstream of H-60 would also benefit in tracking trends in water and biomonitoring assessments.

4.3 Fish Surveys-(a) Populations

Fathead minnow populations showed significant differences in numbers between the two sample sites. Without any previous data to compare H-60, based on what was found there is a lack of diversity and populations of fathead minnow and white sucker. Comparing to D-70 the fathead minnows were nearly identical in weights and lengths indicating possible YOY populations that are dominant at these sites. White sucker showed diversity in size and condition factors indicating both adult and YOY populations are present at both sites with almost equal population sizes. However, the minimum of 100 individuals of each species was not found at H-60. Previous studies by SCCWS used water quality (specifically metals) to compare to white sucker populations and sizes. SCCWS hoped to find effects on the white sucker but the data did not show enough variation to prove water quality was affecting the fish populations. Future testing at H-60 will bring to light more answers as to why the fish populations were so poor and then increase downstream at D-70. Water quality may indeed play a part in the fish population results but more data would have to be collected in all the parameters in order to sustain the theory.

The statistical testing of 2007 focused on YOY EEM endpoints for non-lethal sampling which included total length, weight, and body condition. While the background in statistics was sound, the emphasis on only YOY may not give a full picture of populations and one must be cautious in interpreting these results. Recommendations for future statistical testing, according to Sereda (2013) could be: 1) to test all fish in sentinel collections statistically using identical tests as were used in this project, 2) conduct biodiversity indices, and 3) the presence/absence of indicator species which is a similar approach used with benthic macroinveretebrates.

(b) Community

H-60 now has a record started on the community structure of fish. The diversity was poor with only seven species total, but sport fish such as walleye, yellow perch, and northern pike were found. The sentinel species, which should have the healthiest and most numerous population, both fell short of 100 individuals at the maximum number of seine net pulls. Water quality could indeed have an effect on the populations as there is evidence of extensive urban run-off. Oil and gas were both observed on the waters' surface and discharges out of the sediments as well as a strong odour at H-60. Roadways, car dealerships, and storm sewer run-off are all sources in close proximity to this site that may be causing excessive effluents into the creek. Diversity at D-70 flourished from that of H-60, but actually had a drop in numbers and number of species found from 2007. Species that were once present in good abundance were not found in 2013 or found in decreased numbers. No evidence of fish kills were present at either site but again water quality may be playing a factor in the declines of species. Shorthead redhorse is a fairly hardy species and indicates good water quality. Only a few were found at either site as opposed to over 60 found in 2007. Continued water sampling would benefit a background profile of the sites to compare if populations are changing naturally or being forced to change due to other factors. Factors may include new or existing barriers travelling upstream for spawning. If community changes drastically from H-60 to D-70 then perhaps a new trend in biodiversity is being created downstream due to these man-made barriers.

4.4 Macroinvertebrate Survey- Habitat and Species Diversity

Habitat types determine what groups will be present or the breakdown of each taxa group population. Both sites were similar in substrate, bank conditions, vegetation, and canopy cover. However D-70, being downstream of the WWTP has treated water flowing through the ecosystem, whereas H-60 does not. In fact H-60 has effluent discharges directly from storm sewer urban run-off. This could be one of the main factors in the poor conditions found for both macroinvertebrates and fish. Communities, according to Spellman (2009), can be grouped into three tolerance levels: Group 1 includes caddisflies and mayflies which are the most sensitive to polluted conditions. Group 2 includes beetle adults which showed low numbers and are moderately sensitive, and group 3 includes aquatic worms, Diptera, and snails which are tolerant to polluted conditions. Group 3 species were most abundant; however there were increases in Trichoptera at D-70, which is a fairly intolerant family. H-60 showed vast majority in Group 3. Little was found in Group 1 to indicate this site is healthy. However, the site is functional though it is border line stressed. D-70 had better results, in theory, due to water being treated and no urban run-off discharges at the site. Interesting projects to perhaps consider for future monitoring would be to establish urban monitoring sites within the city of Swift Current to determine the amount of urban pollution affecting the Swift Current Creek. In any case, the WWTP has indeed created some improvement and answered SCCWS questions. Future concerns that may arise for D-70 should include continued monitoring and more downstream locations to assess the extent of treated effluent water. Sustaining our resources in the Swift Current Creek should be the responsibility of the entire community, and perhaps now is the time to begin taking matters into hand.

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Appendix 1 (a) H-60 Fish Data

Site	H-60
Location	City property; Elmwood Golf Course and Regier Honda, GPS N 50°18'209" W 107°46'423"
Crew	SCCWS, PFRA, WWTP Staff, Kris Peters volunteer
Date	Sept. 3rd, 2013
Arrival Time	9:15
Departure Time	15:15
Weather Last 24 hrs.	Clear, sunny
Weather Now	Overcast
General Observations	Steep banks, grassy, oil/gas smell and sighted in water and sediments
Mean Velocity	0.073
Discharge	0.445
Elevation	2430 ft.
Valley Shape	Broad valley floodplain, partly altered due to golf course and municipal roadways
Channel Pattern	Single, straight to sinuous
Bank Stability	intact, fairly stable, some breakage

Land-Uses: Residential	Streamside	250 m	1 km					
	other	other	single-family living, apartment buildings, parking lot, other					
Commercial/Industrial	other	other	other					
Parkland	woods/greenway	woods/greenway	woods/greenway, cemetery					
Agricultural/Rural	other	other	other					

Estimated size of sediments silt/clay

In-Stream Measurements	Depth (m)	Conductivity (µS/cm)	D.O (mg/L)	Temperature (°C)
Left	0.6	959	8.28	21.8
Center	0.6	958	8.56	21.9
Right	0.6	905	8.35	21.5
Average	0.6	941	8.4	21.7
Wetted Width	18.3			
Salinity	0.5			

Notes:
Barrier nets had to be installed where widths were narrower than exactly 100 up and downstream of hub
Riparian veg. Mostly grasses, steep
Fish fins and tails were damaged and clipped off by massive amounts of crayfish in the net

Parameter	H-60	D-70
Date	Sept. 3rd, 2013	Sept. 4th, 2013
Weather		
Cloud Cover	Partial	Partial
Air Temp. (°C)	20	20
Precipitation	>1mm-none	None
Wind Speed (km/hr.)	ENE 26	S 11
In-Stream Measurements		
Velocity (m/s)	0.073	0.298
Depth (m)	0.6	0.51
pH		
Temp. (°C)	21.7	21.06
Conductivity (µ*S/cm*)	941	1080
Salinity (%)	0.5	0.5
D.O (ppm)	8.4	7.68

Species: FTMN **Site: H-60**

	Fork Length (mm)	Total Length (mm)	Weight (g)
1	52	58	1.71
2	50	53	1.49
3	38	43	0.66
4	53	65	3.11
5	54	57	1.68
6	34	35	0.56
7	44	46	0.91
8	49	52	1.23
9	42	46	0.89
10	34	36	0.3
11	49	54	1.31
12	50	53	1.34
13			
14			
15			
16			

Species: WHSC Site: H-60				Species: WHSC Site: H-60			
#	FL (mm)	TL (mm)	W (g)	#	FL (mm)	TL (mm)	W(g)
1	43	45	1.17	17	100	105	12.8
2	44	49	1.21	18	55	59	2.08
3	50	53	1.6	19	39	42	0.79
4	49	52	1.87	20	65	68	3.54
5	54	56	1.83	21	110	115	15.92
6	55	57	1.88	22	60	63	2.64
7	52	54	1.7	23	50	55	1.78
8	50	54	1.7	24	47	49	1
9	57	59	2.81	25	192	203	86.27
10	117	119	16.36	26	113	117	16.48
11	45	47	0.91	27	127	132	24.16
12	53	56	1.83	28	55	59	2.38
13	59	62	2.41	29	107	110	12.48
14	47	50	1.2	30	123	130	22.84
15	60	63	2.75	31	64	66	3
16	60	63	2.45	32	140	150	32.38
#	FL (mm)	TL (mm)	W (g)	#	FL (mm)	TL (mm)	W (g)
33	109	113	14.56	50	46	50	1.63
34	48	49	1.23	51	135	141	30.76
35	55	57	1.95	52	100	106	11.91
36	108	114	14.59	53	64	68	3.22
37	50	52	1.44	54	41	44	1.13
38	59	62	2.5	55	44	45	1.72
39	100	104	11.68	56	38	44	1.09
40	101	105	11.52	57	33	37	0.75
41	118	120	17.82	58	40	43	1.01
42	106	110	12.9	59	38	41	0.91
43	57	60	2.33	60	45	51	1.45
44	49	52	1.32	61	49	54	1.54
45	136	140	28.77	62	130	135	24.68
46	125	132	23.79	63	118	120	17.99
47	92	94	8.92	64	91	95	9.41
48	64	66	2.5	65	92	97	8.47
49	127	134	22.98	66	67	69	3.33

#	FL (mm)	TL (mm)	W (g)	#	FL (mm)	TL (mm)	W(g)
67	48	55	1.55	84	122	127	20.97
68	59	65	3.04	85	100	104	11.89
69	55	57	1.88	86	106	109	14.04
70	42	44	0.89	87	135	141	28.5
71	59	62	2.42	88	82	86	6.31
72	51	54	1.63	89	130	135	25.04
73	68	74	3.76	90	115	121	17.21
74	56	58	2.06	91	99	105	12.03
75	97	102	10.74	92	119	124	19.65
76	59	62	2.45	93	49	53	1.52
77	395	427	T/H	94	45	49	1.13
78	380	399	T/H	95	201	210	91.43
79	391	413	T/H	96	167	170	51.83
80	371	392	T/H	97	111	116	15.88
81	44	46	1.31	98			
82	145	153	31.99	99			
83	43	46	1.38	100			

Community **Site: H-60**	Total
Brassy Minnow *(Hybognathus hankinsoni)*	
Brook Stickleback *(Culaea inconstans)*	
Brook Trout *(Salvelinus fontalis)*	
Brown Trout *(Salmo trutta)*	
Creek Chub *(Semotilus atromaculatus)*	
Cutthroat Trout *(Oncorhynchus clarki)*	
Emerald Shiner *(Notropis atherinoides)*	
Iowa Darter *(Etheostoma exile)*	
Johnny Darter *(Etheostoma nigrum)*	
Lake Chub *(Couesius plumbeus)*	2
Longnose Dace *(Rhinichythys cataractae)*	
Longnose Sucker *(Catostomus catostomus)*	
Northern Pike *(Esox lucius)*	3
Northern Red-Belly Dace *(Phoxinus eos)*	
Rainbow Trout *(Oncorhynchus mykiss)*	
River Shiner *(Notropis blennius)*	7
Silver Redhorse Sucker *(Moxostoma anisurum)*	
Shorthead Redhorse Sucker *(Moxostoma macrolepidotum)*	3
Spottail Shiner *(Notropis hudsonius)*	5
Walleye *(Stizostedion vitreum vitreum)*	3
Yellow Perch *(Perca flavescens)*	3

Appendix 1 (b) H-60 Macroinvertebrate

Habitat Data

Swift Current Creek Watershed Stewards Benthic Macroinvertebrate Collection 2013

Site Number: H-60		Water quality:	
Stream: SCC		Water Temp (°C)	23.7
GPS Location: N 50°18'209" W 107°46'423"		D.O (mg/L)	8.28
Project: SCCMP 2013		Conductivity (µS/cm)	966
Location:	Elmwood Golf, Regier Honda	Velocity	0.073
Crew: Karlah Rudolph, Dallas Peters, Kris Peters			
Date: Sept. 5th, 2013			
Time: 13:49-15:35			

Benthoinvertebrate Collection							
Sample #	Habitat	Method	Replicates	Time	Area	Transect Depth (1/4, 1/2, 3/4)	
1	Run	TK/S	5	10 s	30 cmX30	25 cm, 30 cm, 49 cm	
2	Riffle	TK/S	5	10 s	30 cmX30	55.5 cm, 50.7 cm, 34 cm	
3	Run	TK/S	5	10 s	30 cmX30	30.3 cm, 55 cm, 25.5 cm	
4	Run	TK/S	5	10 s	30 cmX30	45.5 cm, 55.3 cm, 45 cm	
Habitat Type (%)	Mud	Sand	Gravel	Cobble	Boulder	Vegetated Banks	
1	80%	15%	3%	2%	0%	100%	
2	40	10	10	30	10	70	
3	30	10	20	35	5	95	
4	60	10	10	15	5	100	
Substrate (X/x)							
1	silt/sand						
2	cobble/sand						
3	cobble/silt						
4	silt/sand						

Embeddedness	5		
Substrate notes	sandy/silt with gravel		
Channel Flow Status	18		
Sediment Deposition Score	14		
Bank Stability	Left: 9	Right: 8	
Canopy cover (%)	Zone	Left	Right
	1.5-10 m	0-24	0-24
	10-30 m	0-24	0-24
	30-100 m	0-24	0-24
Riparian Veg. Community	3 (pasture) and 4 (scrubland)		

Aquatic Vegetation:	Macrophyte Types	Algae Type					
1	None	S					
2	None	S					
3	E	S					
4	E	S					
Woody Debris	Score		Macrophyte		Detritus		Algae
1	2		0		2		2
2	2		0		2		2
3	2		2		2		2
4	2		2		2		2
River Characterization	Perennial						
General Comments:							

City limits, oil/gas present in water and sediments, storm drain discharge u/s, golf course bordering creek, field and roadways, bridge

Appendix 2 (a) D-70 Fish Data

Site	D-70, SCC
Location (GPS)	N 50°19'513" W 107°44'640"
Crew	SCCWS, WWTP , PFRA Staff, volunteers
Date	Sept. 4th, 2013
Arrival	9:10
Departure	14:17
Weather in last 24 hrs.	Partly cloudy
Weather now	Overcast
General Observations	Erosion on upstream banks and gravel deposition/sedimentation. Sprinkle of rain, indications of beaver activity, muskrat and Northern Leopard frogs seen
Site elevation	2412 ft.
Valley shape	Open, gentle V
Channel Confinement	Mod. Confined
Floodplain width	less than 2X bankful
Channel pattern	single, sinuous
Bank stability	intact banks, minimal erosion
Mean Velocity	0.298 m/s
Discharge	0.642
Land-use	
Streamside	Single family housing (acreage)
250 m	other
1 km	other
Commercial/Industrial	
Streamside	other
250 m	other
1 km	other
Parkland	
Streamside	other
250 m	other
1 km	other

Agricultrual/rural	
Streamside	grazing land
250 m	grazing land, isolated farm
1 km	grazing land, cropland, old field, isolated farm

Estimated size of average bed particles	Silt/clay, sand

In-Stream Measurments				
	Depth (m)	Conductivity (µS/cm)	DO (mg/L)	Temp (°C)
Left	0.3	1080	7.58	21.6
Center	0.76	1080	7.72	20.9
Right	0.46	1080	7.75	20.7
Wetted Width	13.71			

Salinty=0.5

Species: FTMN Site: D-70				Species: FTMN Site:D-70			
#	FL (mm)	TL (mm)	W(g)	#	FL (mm)	TL (mm)	W(g)
1	40	44	0.7	17	45	47	1.54
2	49	50	1.13	18	60	63	2.37
3	50	53	1.34	19	49	53	1.44
4	54	56	1.79	20	51	55	1.68
5	51	52	1.53	21	54	58	1.83
6	29	32	0.3	22	51	56	1.57
7	54	59	1.7	23	40	43	0.76
8	43	47	0.97	24	40	43	0.73
9	48	52	1.26	25	50	58	1.85
10	47	50	1.37	26	47	51	1.22
11	47	50	1.24	27	42	44	0.77
12	41	43	0.88	28	48	50	0.7
13	47	51	1.56	29	42	45	0.92
14	43	45	0.8	30	33	35	0.42
15	45	47	1.08	31	49	53	1.31
16	53	56	1.88	32	49	52	1.47
#	FL (mm)	TL (mm)	W(g)	#	FL (mm)	TL (mm)	W(g)
33	55	58	1.92	50	50	54	1.71
34	43	45	0.87	51	32	34	0.39
35	55	60	1.82	52	53	56	1.86
36	44	46	1.03	53	48	51	1.51
37	48	50	1.3	54	33	35	0.45
38	43	46	0.96	55	46	50	1.21
39	51	55	1.6	56	52	56	1.68
40	40	43	0.8	57	55	60	2.11
41	41	44	0.85	58	51	55	1.81
42	47	51	1.36	59	35	36	0.54
43	42	44	0.76	60	32	34	0.4
44	38	40	0.56	61	53	55	1.9
45	35	38	0.58	62	50	52	1.54
46	45	49	0.99	63	59	62	2.69
47	40	44	0.76	64	53	56	2.06
48	50	53	1.53	65	57	61	2.54
49	57	61	2.02	66	59	62	2.68
#	FL (mm)	TL (mm)	W(g)	#	FL (mm)	TL (mm)	W(g)
67	55	59	2.22	84	55	60	1.96
68	37	39	0.65	85	50	52	1.49
69	44	47	1.02	86	27	30	0.28
70	49	51	1.52	87	29	32	0.26
71	58	61	2.73	88	28	31	0.3
72	49	53	1.38	89	28	30	0.26
73	51	54	1.74	90	30	34	0.41

74	57	60	2.4	91	31	34	0.39
75	56	60	2.42	92	37	40	0.63
76	47	51	1.46	93	55	56	2.33
77	48	52	1.5	94	31	33	0.35
78	51	54	0.52	95	56	61	2.43
79	50	53	1.61	96	35	37	0.45
80	49	53	1.61	97	47	50	1.45
81	53	58	1.82	98	36	38	0.53
82	43	46	0.83	99	36	41	0.66
83	30	32	0.34	100	49	54	1.5

SURPLUS D-70 FHMN

#	FL (mm)	TL (mm)	W(g)	#	FL (mm)	TL (mm)	W(g)
101	36	38	0.51	117			
102	39	41	0.66	118			
103	45	51	1.12	119			
104	38	40	0.67	120			
105	51	54	1.92	121			
106	54	57	1.82	122			
107	38	42	0.72	123			
108	49	53	1.51	124			
109	36	39	0.57	125			

Species: WHSC Site: D-70 **Species: WHSC Site:D-70**

#	FL (mm)	TL (mm)	W (g)	#	FL (mm)	TL (mm)	W(g)
1	103	107	12.38	17	189	197	84.24
2	169	175	62.4	18	194	205	92.28
3	93	96	9.74	19	210	224	116.57
4	144	150	36.91	20	189	200	87.09
5	116	121	17.64	21	200	212	100.87
6	115	120	15.3	22	198	210	99.56
7	89	93	8.74	23	194	206	97.3
8	116	122	18.66	24	134	140	28.99
9	95	99	10.92	25	125	132	25.51
10	368	390	T/H	26	103	106	12.31
11	336	360	T/H	27	115	121	19.52
12	285	302	T/H	28	89	94	7.77
13	189	201	85.66	29	101	104	12.7
14	185	196	81.3	30	102	108	13.43
15	205	219	110.49	31	129	135	25.43
16	229	243	151.22	32	110	115	15.89
#	FL (mm)	TL (mm)	W (g)	#	FL(mm)	TL (mm)	W (g)
33	102	107	12.52	50	121	126	22.74
34	186	194	76.51	51	119	123	19.99
35	114	119	16.84	52	97	102	11.64
36	98	102	11.25	53	123	130	22.5
37	130	136	27.72	54	122	131	25.71
38	97	104	11.49	55	95	100	10.27
39	123	126	22.39	56	104	108	13.97
40	107	113	15.8	57	47	50	1.41
41	90	94	8.71	58	116	120	16.7
42	154	163	50.89	59	107	113	15.55
43	107	112	15.54	60	105	111	15.12
44	99	102	10.32	61	97	104	11.43
45	103	106	13.89	62	114	118	18.25
46	96	101	10.97	63	125	132	22.82
47	115	121	19.15	64	97	104	11.17
48	102	104	12.21	65	45	49	1.21
49	119	125	20.07	66	113	117	14.45
#	FL (mm)	TL(mm)	W (g)	#	FL (mm)	TL (mm)	W (g)
67	97	102	11.73	84	100	105	13.12
68	94	98	10.38	85	104	109	14.6
69	134	140	29.18	86	105	110	14.34
70	134	144	33.87	87	163	174	54.13

71	93	98	9.89	88	130	139	27.47
72	125	130	23.97	89	100	106	13.24
73	110	115	16.9	90	130	137	27.62
74	114	119	18.97	91	104	109	13.54
75	246	260	195.84	92	103	107	13.35
76	160	170	53.42	93	125	130	24.11
77	203	215	105.71	94	92	96	9.55
78	197	210	96.91	95	121	127	22.69
79	131	137	28.53	96	97	102	10.86
80	140	147	35.2	97	125	132	24.59
81	56	60	2.26	98	154	161	44.45
82	53	55	1.73	99	97	101	11.24
83	125	133	25.22	100	114	120	18.45

SURPLUS D-70 WHSC

#	FL (mm)	TL (mm)	W (g)	#	FL (mm)	TL (mm)	W (g)
101	64	66	3.15	117	113	117	17.29
102	59	63	2.58	118	97	102	11.51
103	55	57	2.21	119	55	58	1.9
104	95	101	10.82	120	62	65	3.07
105	101	106	12.66	121	42	44	0.93
106	66	70	3.92	122	104	107	14.09
107	101	106	12.34	123	87	93	8.42
108	95	100	11.15	124	84	86	7.01
109	101	106	13.9	125	49	53	1.58
110	96	101	11.93	126	92	95	9.09
111	85	91	7.78	127	40	43	0.86
112	99	104	11.26	128	49	53	1.59
113	57	60	2.43	129	50	52	1.43
114	95	102	11.75	130	102	106	13.99
115	105	112	15.99	131	106	113	14.91
116	84	88	7.64	132	46	49	1.23
#	FL (mm)	TL (mm)	W (g)		FL (mm)	TL (mm)	W (g)
133	52	54	1.69	150			
134	104	110	14.35	151			
135	115	121	20.41	152			
136	66	69	3.99	153			

Community **Site: D-70**	Total
Brassy Minnow *(Hybognathus hankinsoni)*	11
Brook Stickleback *(Culaea inconstans)*	
Brook Trout *(Salvelinus fontalis)*	
Brown Trout *(Salmo trutta)*	
Creek Chub *(Semotilus atromaculatus)*	131
Cutthroat Trout *(Oncorhynchus clarki)*	
Emerald Shiner *(Notropis atherinoides)*	111
Iowa Darter *(Etheostoma exile)*	
Johnny Darter *(Etheostoma nigrum)*	
Lake Chub *(Couesius plumbeus)*	
Longnose Dace *(Rhinichythys cataractae)*	
Longnose Sucker *(Catostomus catostomus)*	
Northern Pike *(Esox lucius)*	1
Northern Red-Belly Dace *(Phoxinus eos)*	78
Rainbow Trout *(Oncorhynchus mykiss)*	
River Shiner *(Notropis blennius)*	
Silver Redhorse Sucker *(Moxostoma anisurum)*	
Shorthead Redhorse Sucker *(Moxostoma macrolepidotum)*	2
Spottail Shiner *(Notropis hudsonius)*	1
Walleye *(Stizostedion vitreum vitreum)*	
Yellow Perch *(Perca flavescens)*	1
Quillback Sucker	1
Western Silvery Minnow	2
Fine Scaled Dace	2

Appendix 2 (b) D-70 Macroinvertebrate Habitat Collection

Swift Current Creek Watershed Stewards Benthic Macroinvertebrate Collection 2013

Site Number: D-70	Water quality:	
Stream: SCC	Water Temp (°C)	22.7
GPS Location: N 50°19'513" W 107°44'640"	D.O (mg/L)	8.32
Project: SCCMP 2013	Conductivity (µS/cm)	1091
Location: McClelland Acreage	Velocity	0.298 m/s
Crew: Karlah Rudolph, Dallas Peters, Kris Peters		
Date: Sept. 6th, 2013		
Time: 14:00-15:50		

Benthoinvertebrate Collection						
Sample #	Habitat	Method	Replicates	Time	Area	Transect Depth (1/4, 1/2, 3/4)
1	Riffle	TK/S	5	10 s	30 cmX30 cm	15.3 cm, 25 cm, 15.7 cm
2	Run	TK/S	5	10 s	30 cmX30 cm	21 cm, 43.5 cm, 48 cm
3	Run	TK/S	5	10 s	30 cmX30 cm	53 cm, 62 cm, 42.5 cm
4	Run	TK/S	5	10 s	30 cmX30 cm	34 cm, 57 cm, 35 cm

Habitat Type (%)	Mud	Sand	Gravel	Cobble	Boulder	Vegetated Banks
1	20%	20%	15%	40%	5%	75%
2	20	40	20	19	1	50
3	70	29	1	0	0	95
4	50	10	30	10	0	95

Substrate (X/x)			
1	cobble/sand		
2	sand/cobble		
3	silt/sand		
4	silt/sand		
Embeddedness	3		
Substrate notes	cobbles and silt mainly		
Channel Flow Status	20		
Sediment Deposition Score	18		
Bank Stability	Left: 8	Right: 8	
Canopy cover (%)	Zone	Left	Right
	1.5-10 m	0-24	0-24
	10-30 m	0-24	0-24
	30-100 m	0-24	0-24
Riparian Veg. Community	3 (pasture) and 4 (scrubland)		

Aquatic Vegetation:	Macrophyte Types	Algae Type
1	None	S
2	E	S
3	E	S
4	E/FF	S

Woody Debris	Score	Macrophyte	Detritus	Algae
1	3	2	2	2
2	3	2	2	2
3	3	2	3	2
4	3	2	2	2

River Characterization	Perennial
General Comments:	
	Quicker flow, more submerged veg. than H-60 (Algae)

SWIFT CURRENT CREEK WATERSEHD
RIPARIAN HEALTH ASSESSMENTS
SUMMER 2013

PREPARED FOR:
THE SWIFT CURRENT CREEK WATERSHED STEWARDS

PREPARED BY: TRACY CHANIG HANSEN B.S.A. P. Ag.

September 5, 2013

1.0 Introduction

Tracy Hansen B.S.A. P. Ag. was retained by the Swift Current Creek Watershed Stewards during the summer of 2013 to conduct two riparian health assessments along the Swift Current Creek. The purpose of the following report is to summarize the results of these assessments. The following report goes into detail explaining assessment methodology and results. A comprehensive plant species lists for each site is included in the results section of the report. Site Photos are included in Appendix 1 and 2 of this report.

2.0 Methodology

The riparian health assessments were conducted in accordance to the workbook - *Riparian Health Assessment - Streams and Small Rivers* (Saskatchewan PCAP Greencover Committee, 2008). This workbook and methodology is used extensively throughout Saskatchewan, Alberta and Montana in order to determine the health of riparian areas. The sites were pre-determined by Swift Current Creek Watershed Stewards staff.

Riparian areas are transitional areas that exist between the aquatic ecosystem and the surrounding upland. (Saskatchewan PCAP Greencover Committee, 2008). There is considerable variation in riparian areas, where water, soil and vegetation interact. Common to all riparian areas are the following features:

- A combined presence and abundance of water, either on the surface or close to the surface.
- Vegetation that responds to, requires and survives well in abundant water.
- Soils that are often modified by abundant water (as in high water tables), stream processes (like sediment deposition) and lush, productive and diverse vegetation.

Riparian health refers to how well the riparian area (the entire stream or a portion of the stream) is functioning in regards to its' key ecological functions. Key ecological functions of a riparian include:

- Trap sediment
- Filter and buffer water
- Protect, build and maintain streambanks
- Store flood water and energy
- Recharge aquifers
- Reduce and dissipate stream energy
- Maintain biodiversity
- Create primary productivity

The functions that healthy riparian areas perform can be compared to the functions that the human body must perform. For example, the human body must be able to carry out the following functions properly in order for it to remain healthy - circulation, digestion, cell repair etc. The riparian health assessments can be compared to our physical medical examinations in that they determine health. If there are problems within our body our state of health declines, just as the health and functions of the riparian area will be compromised.

The riparian area receives a percentage score based on its' ability to perform these functions. The scores are:

- **80-100 % - Healthy (Proper functioning)**
- **60-79% - Healthy, with problems (Functioning @ risk)**
- **<60% - Unhealthy (Non-functional)**

Seven questions on the sites vegetation and five on soil/hydrology were considered. Each category was given a score to determine the total health rating. The following is a list of these questions with a description of the importance and rationale of each.

2.1 Vegetation

1. **How much of the riparian area is covered by Vegetation?**
    - Looks at the amount of vegetative cover throughout the entire assessment area. Vegetative cover is necessary to trap sediment and stabilize banks, absorb and recycle nutrients, reduce the rate of evaporation and provide shelter and forage value for wildlife.

2. **How much of the riparian area is covered by Invasive Species?**
    - Looks at the amount and distribution of plant species whose introduction does or is likely to cause economic or environmental harm. A large amount of invasive species indicates a degraded system. Some examples of invasive plant species include smooth brome (*Bromus inermis*) and Canada thistle (*Cirsium arvense*).

3. **How much of the riparian area is covered by Disturbance caused Vegetation?**
    - Looks at the abundance of species that are well adapted to an environment of continual stress, where the competitive advantage of better riparian species has been diminished. These species tend to be shallow rooted and less productive and have limited value for bank binding and erosion prevention. Some examples of disturbance caused species include dandelion (*Taraxacum officinale*) and Kentucky bluegrass (*Poa pratensis*).

4. **Is woody vegetation present and maintaining itself?**
    - This question looks at whether or not the riparian area can support woody vegetation. Not all riparian areas can support populations of trees and shrubs. This question looks at the abundance and age class of woody vegetation present within the riparian area. A good indicator of ecological stability of a riparian area is the presence of woody plants in all age classes, especially the younger age classes. Without signs of regeneration of preferred woody plants the long-term stability of the reach is compromised.

- Only ‘preferred’ trees and shrubs are considered in this question as not all trees and shrubs are equally important, useful or desirable for maintaining ecological function. Non-preferred woody species are not considered. These are species are generally small in height, have less shelter value and their root systems are not as capable of stabilizing banks and reducing erosion as preferred species. Non-preferred trees and shrubs are also more abundant on disturbed sites than are preferred woody species.

Preferred woody species – Willows, Silverberry, Saskatoon, Chokecherry
Non-preferred woody species – Snowberry, Rose, Russian olive

5. Is woody vegetation being used?

- This question looks at the amount of utilization of preferred woody species in regards to animal browse. Heavy browsing on woody species will weaken plants and if they are continually stressed they will eventually die. The amount of utilization is a good indicator as to whether these woody species will survive or be eliminated from the system.

6. How much dead wood is there?

- The amount of decadent and dead woody material can be a sign of declining health of a reach. The term decadent includes all age classes of woody species that are slowly dying. A high percentage of decadent and dead wood reflects declining vegetation health which reduces the ability of the riparian area to perform its’ functions.

7. Are the streambanks held together with deep-rooted vegetation?

- This question refers to whether the streambanks are held together with deep-rooted vegetation or not. The role of streamside vegetation is to maintain the integrity and structure of the streambank by dissipating energy, resisting erosion and trapping sediment to build and restore banks. The roots are the ‘glue’ of the streambank and stabilize the area. Vegetation with deep and binding roots best accomplish this function, especially if there is a diversity of these species found on the reach. Examples of deep-rooted vegetation include sedges, rushes, willows, and dogwoods.

2.2 Soil/Hydrology

8. How much of the riparian area has bareground caused by human activity?

- This question looks at the amount of bareground throughout the entire reach that is human caused. This is ground not covered by plants, litter, moss, downed wood or rocks larger than 6 cm. Significant amounts of bareground caused by human activity indicate a deterioration of riparian health. Bare ground resulting from natural causes such as deposition, landslides, wildlife, saline/alkaline areas and unvegetated channels in ephemeral streams, are not included. Human causes of bareground include livestock grazing, cultivation, recreation, urban development and industrial activities.

9. Have the streambanks been altered by human activity?

- Refers to alteration in the streambank that is human caused. These causes include: livestock/recreational trails, flood/erosion control methods, crossings/bridges, culverts, landscaping, irrigation diversions and channelization/drainage. Stable streambanks maintain channel configuration, integrity and bank shape. When streambanks are physically altered, erosion can increase, water quality can deteriorate and instability can occur within the area and downstream.

10. Are streambanks subject to active lateral cutting?

- Lateral cutting refers to streambank erosion in which the stream is actively eroding the outside curves. Lateral erosion is evident by the presence of bare soil or rock.

11. Is the reach compacted, bumpy or rutted from use?

- This question refers to human physical alterations to the reach (beyond the banks). Changes in floodplain profile, shape, contour and soil structure due to human activities will alter infiltration of water, increase soil compaction and changes the amount of sediment contributed to the water body.
- **Hummocking** and **pugging** result from livestock and horse hoof action (occasionally people or rarely wild ungulates). Pugs are the depressions left in soft soil; hummocks are the raised humps of soil that result from the soil being pushed up from the pug. **Rutting** is considered compacted trails or ruts, from people, vehicles or livestock.
- Measuring the amount of these disturbances indicates the degree of soil compaction. High amounts of soil compaction inhibit the reach's ability to perform certain functions and can limit vegetation growth.

12. Can the stream access its floodplain?

- Floodplains are the riparian area that reaches beyond the stream channel and they provide a safety valve that allows excess water to escape into a wider area. Floodplains provide temporary storage for high water and an opportunity to slow the water down, reducing energy. Incisement or downcutting can limit the ability of the stream to access its floodplain during high water events. Streams are incised when downcutting has significantly lowered the channel so that the average two-year flood cannot escape the existing channel.

Incisement can result from:

- Watershed, local or reach-scale changes including vegetation removal, dams, water additions, road and culvert installations occurring upstream of the reach which affect run-off.
- Natural events including landslides, beaver dam removals and extreme flood events.

Incisement can result in:

- A reduced water table that affects current vegetation.
- Increased stream energy with more erosion, sediment, and unstable banks.
- Reduced water storage and retention leading to lower flows.
- Impairment of the reach to rebound from natural and human damage.
- Decreased productivity, forage, shelter and biodiversity.

3.0 Why conduct riparian health assessments?

Riparian health assessments give a quick and dirty measure of riparian health, which provides indicators of problems and/or issues that may be present in the watershed. Riparian health assessments are not designed for an in-depth and comprehensive analysis and investigation of ecological processes and issues. They provide the first step in clarifying whether an issue or problem exists and in identifying areas of concerns. It should be noted that a single riparian health assessment provides a rating at only one point in time.

5.0 Results

The following section gives a brief description of the site along with some discussion regarding to vegetation and soil/hydrology results. A comprehensive list of all plant species found at each site is also included. The species are broken down into categories of:

- **Preferred trees and shrubs –** willows, saskatoon, chokecherry
- **Non-preferred trees and shrubs** - snowberry, rose, Russian olive
- **Native graminoids** – grasses, sedges and rushes native to Saskatchewan.
- **Native forbs** – flowers native to Saskatchewan.
- **Disturbance caused Species**
- **Invasive (Noxious) Weeds**
-

All sites were assessed by Tracy Hansen B.S.A. P.Ag. Tracy has several years experience conducting riparian health assessments within the Swift Current Creek Watershed and throughout the province of Saskatchewan.

5.1 McClelland Site – D-70

This site was assessed on July 31, 2013. The assessment area started at the low level crossing on the gravel road west of the McClelland yard site and continued downstream for approximately 400m. The dominant graminoids were Reed Canary Grass (*Phalaris arundinacea*), and Sedges (*Carex spp.)*. Snowberry (*Symphoricarpos occidentalis*) was the dominant shrub. Land use on the upland and riparian area is horse grazing. A total of 60 plant species were found.

GPS Co-ordinates: start – 13 U 0304887, 5578416
End – 13 U 0304617, 5578228 (NAD 83)

Vegetation rating: 70%
The assessment area generally has good vegetative cover. Desirable riparian species such as Cattails (*Typha latifolia*), Sedges (*Carex spp*.) and riparian grasses such as Reed Canary Grass (*Phalaris arundinacea*) and Manna Grass (*Glyceria striata*) were observed immediately along the water's edge. These species have excellent root binding abilities to help stabilize the streambank. Numerous invasive plant species were observed within the assessment area. Species such as common burdock (*Arctium minus*), Canada thistle (*Cirsium arvense*), scentless

chamomile (*Matricaria perforata*), absinth (*Artemesia absinthium*), smooth brome (*Bromus inermis*) and crested wheatgrass (*Agropyron cristatum*) were located. These species are invaders and indicate a degrading ecosystem. There were also numerous populations of disturbance increaser undesirable herbaceous species present such Bluegrasses (*Pos spp*.) and stinkweed (*Thalpsi arvense*). These species have shallow rooting systems and are unable to stabilize the streambank.

All age classes of preferred woody species were represented throughout the area. Seedlings, saplings and mature trees and shrubs were observed. There are more non-preferred woody species than preferred, however the abundance of woody species helps to provide good vegetative cover of the assessment area.

Please see the plant species table below for a comprehensive list of all species observed.

Soil/Hydrology Rating: 60%
Minimal bareground was observed throughout the assessment areas along horse trails and at the low level crossing. One portion of the area is experiencing extreme lateral cutting. The bank in this area is extremely steep and vegetation is void. The lateral cutting is progressively getting worse every year with the streambank being set back a little bit each year. Pugging and hummocking are present throughout the reach due to horse hoof activity.

Incisement varies throughout this reach with steep banks on outside meanders and minimal to adequate amounts of floodplain on inside meanders. Stream incisement would be classified as a Stage 2, which means the stream is slightly incised. The 1-2 year flows may access a narrow floodplain less than or equal to twice the bankfull channel width.

Total Rating – 65% - Healthy with Problems

Figure 1: Field Sheet for D-70

RIPARIAN HEALTH ASSESSMENT - FIELD SHEET

Landowner/lessee: McClelland Date: July 31 2013 Reach No: D-70

Stream/River: Swift Current Creek

Site Description: Assessment begins at low level crossing along gravel road and continues approximately 500 m downstream past second low level crossing.

Item						Scores or N/A: Actual	Possible
1. Vegetative Cover of Floodplain and Streambanks	6	4	2	0		4	6
2. Invasive Plant Species	3	2	1	0	(cover)	1	3
	3	2	1	0	(density)	1	3
3. Disturbance-increaser Undesirable Herbaceous Species	3	2	1	0		1	3
4. Preferred Tree and Shrub Establishment and Regeneration	6	4	2	0		4	6
5. Utilization of Preferred Trees and Shrubs	3	2	1	0		3	3
6. Standing Decadent and Dead Woody Material	3	2	1	0		3	3
7. Streambank Root Mass Protection	6	4	2	0		6	6
8. Human-Caused Bare Ground	6	4	2	0		2	6
9. Streambank Structurally Altered by Human Activity	6	4	2	0		4	6
10. Streambank Subject to Active Lateral Cutting	6	4	2	0		4	6
11. Reach Structurally Altered by Human Activity (excl. banks)	3	2	1	0		2	3
12. Stream Channel Incisement (vertical stability)	9	6	3	0		6	9
					TOTAL	41	63

Health Score = Total actual score / Total possible score = 65%

%	0-59	60-79	80-100
	◄ Unhealthy ►	◄ Healthy With Problems ►	◄ Healthy ►

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RIPARIAN HEALTH ASSESSMENT - FIELD SHEET

D-70 July 31 2013

Comments

1. Vegetative Cover of Floodplain and Streambanks

Generally good, numerous cattails, sedges and riparian grasses. - see photos

2. Invasive Plant Species

numerous - Scentless chamoile, Canada thistle, Burdock, Absinthe - see photos

3. Disturbance-Increaser Undesirable Herbaceous Species

numerous - Round-leaved mallow, Stinkweed, Bluegrasses - see photos

4. Preferred Tree and Shrub Establishment and Regeneration

All age classes of woody species represented - see photos

5. Utilization of Preferred Trees and Shrubs

nil - not much evidence of animal browse

6. Standing Decadent and Dead Woody Material

nil

7. Streambank Root Mass Protection

Cattails and Sedges present immediately at water's edge. Generally good root mass protection

8. Human-Caused Bare Ground

Some horse trails, low level crossing

9. Streambank Structurally Altered by Human Activity

Two low level crossings within assessment area.

10. Streambank Subject to Active Lateral Cutting

One portion subject to extreme lateral cutting. Progressively getting worse every year.

11. Pugging, Hummocking and/or Rutting

Pugging and hummocking present due to horse grazing activity.

12. Stream Channel Incisement (vertical stability)

Portions of reach are able to reach a wide floodplain on a yearly basis.

Sketch stream reach here	*Show photo locations*
N/A	Please see Appendix 1

Table 1: Plant Species List for D-70

Vegetation Type	Latin Name	Common Name
Preferred Trees and Shrubs		
	Acer negundo	Manitoba Maple
	Amelanchier alnifolia	Saskatoon
	Cornus stolonifera	Red Osier Dogwood
	Elaeagnus commutata	Wolf Willow
	Prunus virginiana	Chokecherry
	Salix spp.	Willow
Non-Preferred Trees and Shrubs		
	Rosa woodsii	Wood's Rose
	Symphoricarpos occidentalis	Western Snowberry
Invasive Species		
	Agropyron cristatum	Crested Wheatgrass
	Arctium minus	Common Burdock
	Artemesia absinthium	Absinth
	Bromus inermis	Smooth brome
	Cirsium arvense	Canada Thistle
	Matricaria perforata	Scentless chamomile
	Tanacetum vulgare	Tansy
Disturbance-increaser Undesirable Herbaceous Species		
	Amaranthus retroflexus	Redroot Pigweed
	Chenopodium album	Lamb's Quarters
	Cicuta maculata	Water hemlock
	Convulvulus sepium	Bindweed
	Erucastrum gallicum	Dog Mustard
	Hordeum jubatum	Foxtail Barley
	Lepedium densiflorum	Pepper grass
	Malva rotundifolia	Round Leaved Mallow
	Medicago lupulina	Black Medick
	Melilotus alba	Sweet White Clover
	Phalaris arundinacea	Reed Canary Grass
	Plantago spp.	Plantain
	Poa pratensis	Kentucky Blue Grass
	Polygonum arenastrum	Common Knotweed
	Polygonum coccineum	Marsh Smartweed
	Sisymbrium altissum	Tumbling Mustard
	Sonchus arvensis	Perennial Sow Thistle
	Taraxacum officinale	Dandelion
	Thalpsi arvense	Stinkweed
	Trifolium pratense	Clovers

	Urtica dioica	Stinging Nettle
	Xanthium strumarium	Cocklebur
Native Graminoids		
	Carex spp.	Sedge spp.
	Equisetum hyemale	Common Scouring Rush
	Glyceria striata	Fowl Manna Grass
	Juncus balticus	Baltic Rush
	Typha latifolia	Cattails
	Scirpus validus	Great Bulrush
	Carex aquatilus	Water Sedge
	Equisetum arvense	Common Horsetail
	Triglochin maritima	Seaside Arrow Grass
	Muhlenbergia richardsonis	Mat Muhly
Native Forbs		
	Artemesia frigida	Pasture Sage
	Artemesia ludoviciana	Prairie Sage
	Aster falcatus	Creeping White Prairie Aster
	Gaillardia aristata	Gaillardia
	Glycyrrhiza lepidota	Wild Licorice
	Helianthus spp.	Sunflower
	Lycopus uniflorus	Western Waterhound
	Mentha arvensis	Wild Mint
	Potentilla anserina	Silverweed
	Ranunculus cymbalaria	Seaside Buttercup
	Rumex crispus	Curled Dock
	Solidago canadensis	Canada Goldenrod
	Stachys palustris	Marsh Hedge Nettle

5.2 – Elmwood Golf Course Site – H-60

This site was assessed on July 31, 2013. The assessment area starts at the Honda dealership and continues downstream approximately 350m to the # 4 bridge. The dominant graminoids were Smooth Brome (*Bromus inermis*), and Common Reed Grass (*Phragmites communis*). Land use on the upland and riparian area is golf course activity on the south side. The north bank is mowed and serves as a buffer area between the service road and the flowing water. A total of 46 plant species were found.

Vegetation rating: 73%
The assessment area generally has good vegetative cover. Desirable riparian species such as cattails (*Typha latifolia*) and sedges (*Carex spp.*) were observed immediately along the water's edge. These species have excellent root binding abilities to help stabilize the streambank. Numerous invasive plant species were observed within the assessment area. Species such as common burdock (*Arctium minus*), Canada thistle (*Cirsium arvense*), baby's breath (*Gysophila*

paniculata), absinth (*Artemesia absinthium*) and smooth brome (*Bromus inermis*) were observed in dense populations throughout the area. These species are invaders and indicate a degrading ecosystem. There were also numerous populations of disturbance increaser undesirable herbaceous species present such Indian hemp (*Apocynum cannabium*), bindweed (*Convulvulus sepium*), sow thistle (*Sonchus arvensis*) and stinkweed (*Thalpsi arvense*). These species have shallow rooting systems and are unable to stabilize the streambank.

All age classes of woody species were represented throughout the area. Seedlings, saplings and mature trees and shrubs were observed. There are more non-preferred woody species than preferred, however the abundance of woody species helps to provide good vegetative cover of the assessment area.

Please see the plant species table below for a comprehensive list of all species present.

Soil/Hydrology Rating: 53%
Minimal bareground was observed throughout the assessment area. One portion of the area is experiencing extreme lateral cutting on the outer meander of the reach. The streambank in this area is extremely steep and vegetation is void. The lateral cutting is progressively getting worse every year with the streambank being set back a little bit each year.

The streambanks have been structurally altered due to storm drain construction, bridge construction, golf course activity and at one time rip rap was placed along the north bank. (Please see photos in Appendix 2).

Incisement varies throughout this reach with steep banks on outside meanders and minimal to adequate amounts of floodplain on inside meanders. Stream incisement would be classified as a Stage 3, which means the stream is moderately incised. The 1-2 year flows may not access the floodplain, but higher flows (less than a 5-10 year event)can access a narrow floodplain less than or equal to twice the bankfull channel width.

Total Rating – 63% - Healthy with Problems

Table 1 – Field Sheet for H-60

Elmwood Golf Cour:

RIPARIAN HEALTH ASSESSMENT - FIELD SHEET

Landowner/lessee: City of SC Date: July 31 2013 Reach No: H-60

Stream/River: Swift Current Creek

Site Description: Honda dealership to #4 bridge

Item	Choices (circled value in brackets)					Actual	Possible
1. Vegetative Cover of Floodplain and Streambanks	(6)	4	2	0		6	6
2. Invasive Plant Species	3	2	1	(0)	(cover)	0	3
	3	2	1	(0)	(density)	0	3
3. Disturbance-increaser Undesirable Herbaceous Species	3	(2)	1	0		2	3
4. Preferred Tree and Shrub Establishment and Regeneration	6	(4)	2	0		4	6
5. Utilization of Preferred Trees and Shrubs	(3)	2	1	0		3	3
6. Standing Decadent and Dead Woody Material	(3)	2	1	0		3	3
7. Streambank Root Mass Protection	(6)	4	2	0		6	6
8. Human-Caused Bare Ground	(6)	4	2	0		6	6
9. Streambank Structurally Altered by Human Activity	(6)	4	2	0		2	6
10. Streambank Subject to Active Lateral Cutting	6	(4)	2	0		4	6
11. Reach Structurally Altered by Human Activity (excl. banks)	3	2	(1)	0		1	3
12. Stream Channel Incisement (vertical stability)	9	6	(3)	0		3	9
					TOTAL	40	63

Health Score = Total actual score / Total possible score = 63%

%	0-59	60-79	80-100
	← Unhealthy →	← Healthy With Problems →	← Healthy →

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Elmwood Golf Course

RIPARIAN HEALTH ASSESSMENT - FIELD SHEET

Comments

1. Vegetative Cover of Floodplain and Streambanks

Generally good cover throughout the reach

2. Invasive Plant Species

Sporadic to dense populations of Smooth brome, Canada thistle, Burdock and Baby's breath

3. Disturbance-Increaser Undesirable Herbaceous Species

Small sporadic populations of Bindweed, Indian Hemp

4. Preferred Tree and Shrub Establishment and Regeneration

All age classes of woody species are represented

5. Utilization of Preferred Trees and Shrubs

nil

6. Standing Decadent and Dead Woody Material

nil

7. Streambank Root Mass Protection

Sedges, Cattails and riparian grasses present

8. Human-Caused Bare Ground

minimall bareground present

9. Streambank Structurally Altered by Human Activity

Riprap had been put in place at one time, storm drain construction

10. Streambank Subject to Active Lateral Cutting

Extreme lateral cutting by Honda dealership

11. Pugging, Hummocking and/or Rutting

Golf Course maintenance and activity, bridge construction

12. Stream Channel Incisement (vertical stability)

Portions of reach are able to reach Floodplain on a yearly basis.

Sketch stream reach here	*Show photo locations*
N/A	Please see Appendix 2

Table 3: Plant Species List for H-60

Vegetation Type	Latin Name	Common Name
Preferred Trees and Shrubs		
	Acer negundo	Manitoba Maple
	Amelanchier alnifolia	Saskatoon
	Cornus stolonifera	Red Osier Dogwood
	Elaeagnus commutata	Wolf Willow
	Prunus virginiana	Chokecherry
	Salix spp.	Willow
	Shepherdia canadensis	Canada Buffaloberry
Non-Preferred Trees and Shrubs		
	Rosa woodsii	Wood's Rose
	Symphoricarpos occidentalis	Western Snowberry
Invasive (Noxious) Weeds		
	Arctium minus	Common Burdock
	Artemesia absinthium	Absinth
	Bromus inermis	Smooth Brome
	Cirsium arvense	Canada Thistle
	Gysophila paniculata	Baby's Breath
	Sonchus arvensis	Perennial Sow Thistle
Disturbance-increaser Undesirable Herbaceous Species		
	Convulvulus spp.	Bindweed
	Descurainia sophia	Flixweed
	Echinocystis lobata	Wild Cucumber
	Melilotus alba	Sweet White Clover
	Phalaris arundinacea	Reed Canary Grass
	Sonchus arvensis	Sow Thistle
	Thalpsi arvense	Stinkweed
	Tragopogon dubius	Goat's Beard
	Urtica dioica	Stinging Nettle
Native Graminoids		
	Carex aquatilus	Water Sedge
	Carex spp.	Sedge spp.
	Glyceria grandis	Tall Manna Grass
	Phragmites communis	Common Reed Grass
	Scirpus validus	Common Great Bulrush
	Scirpus microcarpus	Small-fruited Bulrush
	Typha latifolia	Cattails
Native Forbs		

	Apocynum cannabinum	Indian Hemp
	Artemesia ludoviciana	Prairie Sage
	Aster cilioatus	Lindley's Aster
	Aster spp.	Aster
	Chenopodium freemonti	Freemont's Goosefoot
	Cicuta maculata	Spotted Water Hemlock
	Galium boreale	Indian Bedstraw
	Glycyrrhiza lepidota	Wild Licorice
	Mentha arvensis	Wild Mint
	Monarda fistulosa	Wild Bergamot
	Oenothera biennis	Yellow Evening Primrose
	Polygonum spp.	Knotweed
	Rumex crispus	Curled Dock
	Smilacina stellata	Star-flowered Solomon's Seal
	Solidago canadensis	Canada Goldenrod

6.0 Conclusion

A summary of the health scores is as follows:

MCCLELLAND SITE – 65% - Healthy with Problems
ELMWOOD GOLF COURSE SITE – 63% - Healthy with Problems

Generally, it is the high density and numerous populations of invasive and disturbance induced species that contribute to the compromised ecological functions of these two areas along the Swift Current Creek. Overall vegetation cover was excellent, with minimal streambank erosion and bareground issues. Streambanks have been altered moderately and incisement ranges from slight to moderate. Generally flood (1-2 year and 5-10 year) events can reach the floodplain.

The watershed can sustain woody species, however these two sites lack large population size and density.

7.0 References

Saskatchewan PCAP Greencover Committee. 2008. **Riparian Health Assessment Streams and Small Rivers**. Prairie Conservation Action Plan (new components). Regina, Saskatchewan. Cows and Fish (Alberta Riparian Habitat Management Society) (original document)

Fitch, L., B.W. Adams and G. Hale. 2001. **Caring for the Green Zone - Riparian Health Assessment for Streams and Small Rivers – Field Workbook**. Lethbridge, AB. Cows and Fish Program. 90 pp.

Rosgen, D.L. and H.L. Silvey. 1998. **Field Guide for Stream Classification**. Wildland Hydrology. Pagosa Springs, Colorado. 193 pp.

APPENDIX 1

SITE D-70 PHOTOS

Photo 1 – Facing upstream. Photo showing good vegetative cover. Slight incisement with water being able to access the floodplain on inside meander.

Photo 2 – Facing upstream. Photo showing where water can easily reach floodplain on inside meander. Active lateral cutting and slumping on outside meander.

Photo 3 – Showing vegetative cover along streambank. Cattails and sedges present along the water's edge provide excellent stabilizing properties.

Photo 4 – Facing upstream. Photo showing good vegetative cover. Water levels can easily reach floodplain on east bank.

Photo 5 – Willlow sapling

Photo 6 – Facing upstream. Showing area where horses cross.

Photo 7 – Common Burdock (*Arctium minimus*) present along streambank

Photo 8 – Absinth (*Artemesia absinthium*). Invasive weed present along streambank.

Photo 9 – Photo showing active lateral cutting on outside meander.

Photo 10 – Photo showing active lateral cutting and rip rap that was brought in.

APPENDIX 2

SITE H-60 PHOTOS

Photo 1 – Facing upstream. Photo showing good vegetative cover. Storm drain construction has altered stream bank.

Photo 2 – Facing downstream. Photo showing good vegetative cover. Woody species present. Golf Course activity on south bank and no active use on north bank.


Photo 3 – Showing rip rap that was placed along north bank of Swift Current Creek.


Photo 4 – Facing downstream towards #4 highway bridge. The assessment area ends at the bridge.

Photo 5 – Facing upstream. Good vegetative cover, minimal bareground, moderate incisement. Water level can reach floodplain on north bank.

Photo 6 – Photo showing adequate vegetative cover.

Appendix 4 Water Quality (D-70 and H-60) and SWQI

Water Quality Data and Parameters			
Parameters	E-Coli (MPN/100mL)	Total Coliforms (MPN 100mL)	Bicarbonate (mg/L)
	Date mm/dd/yyyy		
H-60	09/11/2013: 180	09/11/2013: 14000	09/05/2013: 251
D-70	09/11/2013: 120	09/11/2013: 14000	09/05/2013: 264
Parameters	Total Nitrogen (mg/L)	Fluoride (mg/L)	Total Dissolved Solids (mg/L)
	Date mm/dd/yyyy		
H-60	09/05/2013: 0.97	09/05/2013: 0.22	09/05/2013: 662
D-70	09/05/2013: 1.4	09/05/2013: 0.24	09/05/2013: 740

Parameters	Carbonate (mg/L)	Chloride (mg/L)	Hydroxide (mg/L)
H-60	09/05/2013: 4	09/05/2013: 9	09/05/2013: <1
D-70	09/05/2013: 2	09/05/2013: 21	09/05/2013: <1
Parameters	Calcium (mg/L)	Magnesium (mg/L)	Potassium (mg/L)
H-60	09/05/2013: 66	09/05/2013: 46	09/05/2013: 9.9
D-70	09/05/2013: 71	09/05/2013: 54	09/05/2013: 10

Parameters	P.Alkalinity (mg/L)	pH (pH units)	Specific Condictivity (uS/cm)
H-60	09/05/2013: 3	09/05/2013: 8.35	09/05/2013: 965
D-70	09/05/2013: 2	09/05/2013: 8.32	09/05/2013: 1070
Parameters	Sodium (mg/L)	Sulfate (mg/L)	Dissolved Phosphorus (mg/L)
H-60	09/05/2013: 81	09/05/2013: 300	09/05/2013: 0.07
D-70	09/05/2013: 92	09/05/2013: 330	09/05/2013: 0.10

Parameters	Sum of Ions (mg/L)	Total Alkalinity (mg/L)	Total Hardness (mg/L)
H-60	09/05/2013: 767	09/05/2013: 212	09/05/2013: 354
D-70	09/05/2013: 845	09/05/2013: 220	09/05/2013: 399
Parameters	Aluminum (mg/L)	Arsenic (ug/L)	Boron (mg/L)
H-60	09/05/2013: 0.36	09/05/2013: 5.5	09/05/2013: 0.07
D-70	09/05/2013: 0.30	09/05/2013: 6.2	09/05/2013: 0.08

Parameters	Ammonia as Nitrogen (mg/L)		Inorganic Phosphorus (mg/L)
H-60	09/05/2013: 0.03		09/05/2013: 0.09
D-70	09/05/2013: 0.04		09/05/2013: 0.12
Parameters	Chromium (mg/L)	Copper (mg/L)	Mercury (ug/L)
H-60	09/05/2013: <0.0005	09/05/2013: 0.0005	09/05/2013: <0.01
D-70	09/05/2013: <0.0005	09/05/2013: 0.0008	09/05/2013: <0.01

Parameters	Nitrate (mg/L)	Total Kjeldahl Nitrogen (mg/L)
H-60	09/05/2013: <0.04	09/05/2013: 0.97
D-70	09/05/2013: 0.75	09/05/2013: 1.2

Site	Date	Water Temperature (°C)	Dissolved Oxygen (mg/L)
H-60	09/05/2013	19.9	6.66
D-70	09/05/2013	19.7	6.84

Saskatchewan Water Quality Index (SWQI)

Index Range	Rating	Water Quality is…
0-44	Poor	Almost always threatened or impaired; conditions usually depart from natural or desirable levels
45-64	Marginal	Frequently threatened or impaired; conditions often depart from natural or desirable levels
65-79	Fair	Usually protected but occasionally threatened or impaired; conditions sometimes depart from natural or desirable levels
80-94	Good	Protected with only a minor threat or impairment; conditions rarely depart from natural or desirable levels
95-100	Excellent	Protected with a virtual absence of threat or impairment; conditions are very close to pristine or natural levels

Appendix 5 Hydrometrics (a) D-70

Discharge Measurement Summary

Date Generated: Fri Oct 11 2013

File Information	
File Name	D70.WAD
Start Date and Time	2013/09/05 11:03:20

Site Details	
Site Name	SWIFT CR
Operator(s)	CM

System Information	
Sensor Type	FlowTracker
Serial #	P1549
CPU Firmware Version	3.9
Software Ver	2.30
Mounting Correction	0.0%

Units	**(Metric Units)**
Distance	m
Velocity	m/s
Area	m^2
Discharge	m^3/s

Discharge Uncertainty		
Category	**ISO**	**Stats**
Accuracy	1.0%	1.0%
Depth	0.2%	0.4%
Velocity	0.7%	1.1%
Width	0.1%	0.1%
Method	1.8%	-
# Stations	2.0%	-
Overall	**3.0%**	**1.5%**

Summary			
Averaging Int.	40	# Stations	25
Start Edge	LEW	Total Width	7.500
Mean SNR	28.9 dB	Total Area	2.156
Mean Temp	20.37 °C	Mean Depth	0.287
Disch. Equation	Mid-Section	Mean Velocity	0.2976
		Total Discharge	**0.6417**

Measurement Results

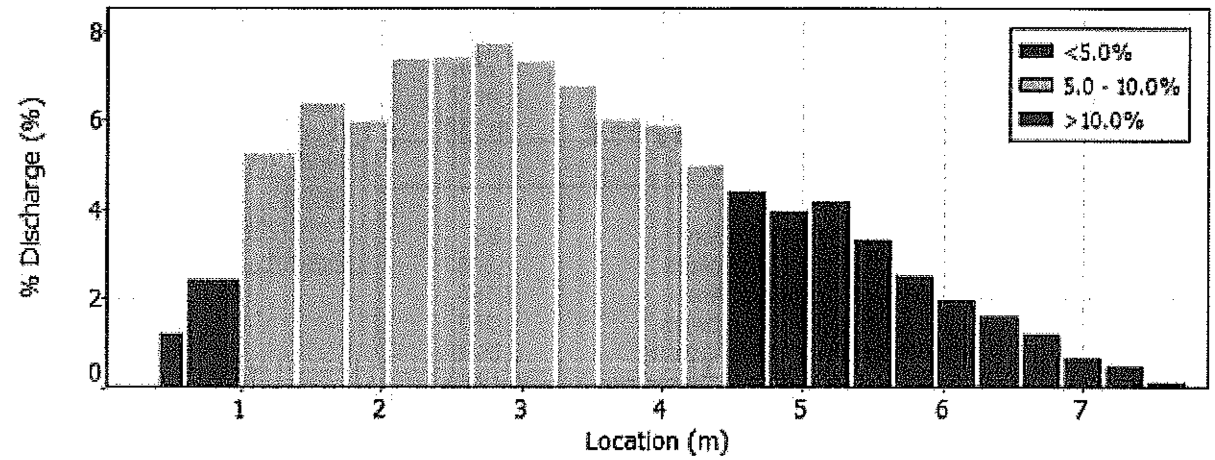
St	Clock	Loc	Method	Depth	%Dep	MeasD	Vel	CorrFact	MeanV	Area	Flow	%Q
0	11:03	0.40	None	0.300	0.0	0.0	0.0000	1.00	0.1319	0.060	0.0079	1.2
1	11:03	0.80	0.6	0.300	0.6	0.120	0.1319	1.00	0.1319	0.120	0.0158	2.5
2	11:04	1.20	0.6	0.330	0.6	0.132	0.2572	1.00	0.2572	0.132	0.0340	5.3
3	11:05	1.60	0.6	0.340	0.6	0.136	0.3471	1.00	0.3471	0.119	0.0413	6.4
4	11:06	1.90	0.6	0.360	0.6	0.144	0.3571	1.00	0.3571	0.108	0.0386	6.0
5	11:07	2.20	0.6	0.370	0.6	0.148	0.4273	1.00	0.4273	0.111	0.0474	7.4
6	11:08	2.50	0.6	0.370	0.6	0.148	0.4298	1.00	0.4298	0.111	0.0477	7.4
7	11:09	2.80	0.6	0.370	0.6	0.148	0.4499	1.00	0.4499	0.111	0.0499	7.8
8	11:10	3.10	0.6	0.360	0.6	0.144	0.4369	1.00	0.4369	0.108	0.0472	7.4
9	11:11	3.40	0.6	0.340	0.6	0.136	0.4305	1.00	0.4305	0.102	0.0439	6.8
10	11:11	3.70	0.6	0.340	0.6	0.136	0.3819	1.00	0.3819	0.102	0.0390	6.1
11	11:12	4.00	0.6	0.330	0.6	0.132	0.3854	1.00	0.3854	0.099	0.0382	5.9
12	11:13	4.30	0.6	0.290	0.6	0.116	0.3707	1.00	0.3707	0.087	0.0323	5.0
13	11:14	4.60	0.6	0.280	0.6	0.112	0.3396	1.00	0.3396	0.084	0.0285	4.4
14	11:15	4.90	0.6	0.280	0.6	0.112	0.3047	1.00	0.3047	0.084	0.0256	4.0
15	11:16	5.20	0.6	0.280	0.6	0.112	0.3204	1.00	0.3204	0.084	0.0269	4.2
16	11:17	5.50	0.6	0.270	0.6	0.108	0.2644	1.00	0.2644	0.081	0.0214	3.3
17	11:18	5.80	0.6	0.260	0.6	0.104	0.2087	1.00	0.2087	0.078	0.0163	2.5
18	11:19	6.10	0.6	0.250	0.6	0.100	0.1710	1.00	0.1710	0.075	0.0128	2.0
19	11:20	6.40	0.6	0.240	0.6	0.096	0.1468	1.00	0.1468	0.072	0.0106	1.6
20	11:21	6.70	0.6	0.220	0.6	0.088	0.1185	1.00	0.1185	0.066	0.0078	1.2
21	11:22	7.00	0.6	0.200	0.6	0.080	0.0734	1.00	0.0734	0.060	0.0044	0.7
22	11:23	7.30	0.6	0.180	0.6	0.072	0.0600	1.00	0.0600	0.054	0.0032	0.5
23	*11:24*	*7.60*	*0.6*	*0.160*	*0.6*	*0.064*	*0.0216*	*1.00*	*0.0216*	*0.048*	*0.0010*	*0.2*
24	11:24	7.90	None	0.000	0.0	0.0	0.0000	1.00	0.0000	0.000	0.0000	0.0

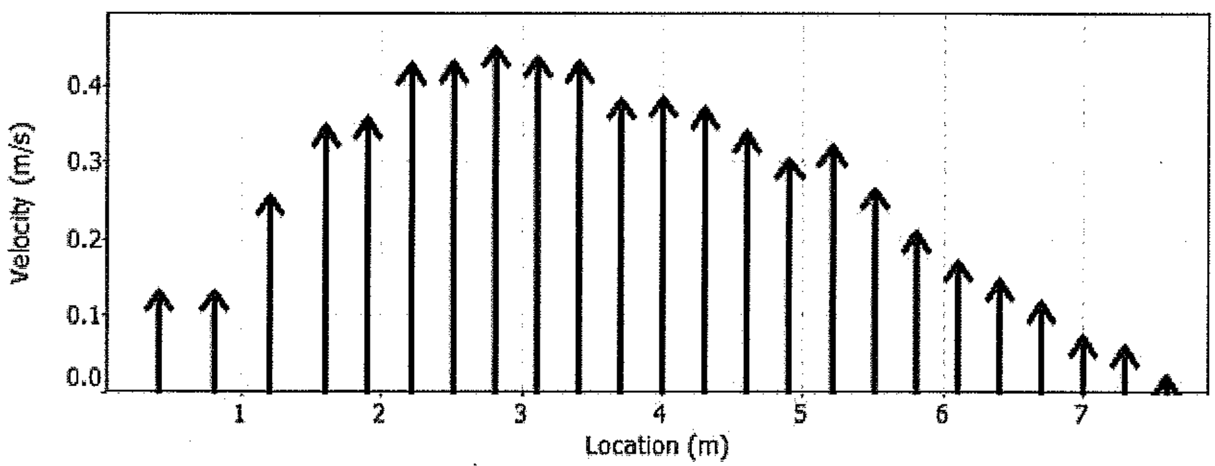
Rows in italics indicate a QC warning. See the Quality Control page of this report for more information.

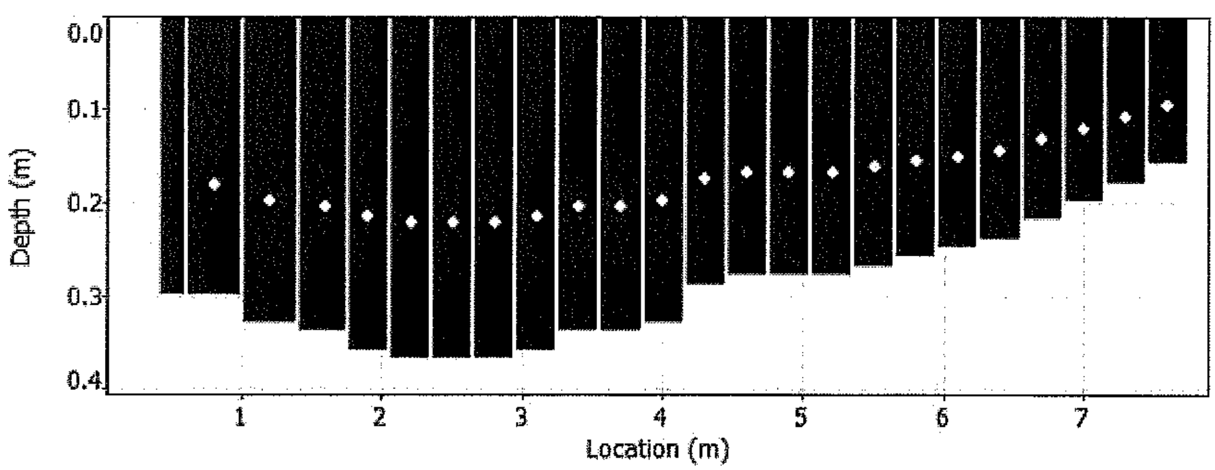
Discharge Measurement Summary

Date Generated: Fri Oct 11 2013

File Information		Site Details	
File Name	D70.WAD	Site Name	SWIFT CR
Start Date and Time	2013/09/05 11:03:20	Operator(s)	CM







Discharge Measurement Summary

Date Generated: Fri Oct 11 2013

File Information

File Name	H60.WAD
Start Date and Time	2013/09/05 11:49:19

Site Details

Site Name	SWIFT
Operator(s)	CM

System Information

Sensor Type	FlowTracker
Serial #	P1549
CPU Firmware Version	3.9
Software Ver	2.30
Mounting Correction	0.0%

Units (Metric Units)

Distance	m
Velocity	m/s
Area	m^2
Discharge	m^3/s

Discharge Uncertainty

Category	ISO	Stats
Accuracy	1.0%	1.0%
Depth	0.1%	1.0%
Velocity	0.5%	2.8%
Width	0.1%	0.1%
Method	1.6%	-
# Stations	2.1%	-
Overall	**2.9%**	**3.1%**

Summary

Averaging Int.	40	# Stations	24
Start Edge	REW	Total Width	14.500
Mean SNR	30.0 dB	Total Area	6.081
Mean Temp	21.03 °C	Mean Depth	0.419
Disch. Equation	Mid-Section	Mean Velocity	0.0732
		Total Discharge	**0.4452**

Measurement Results

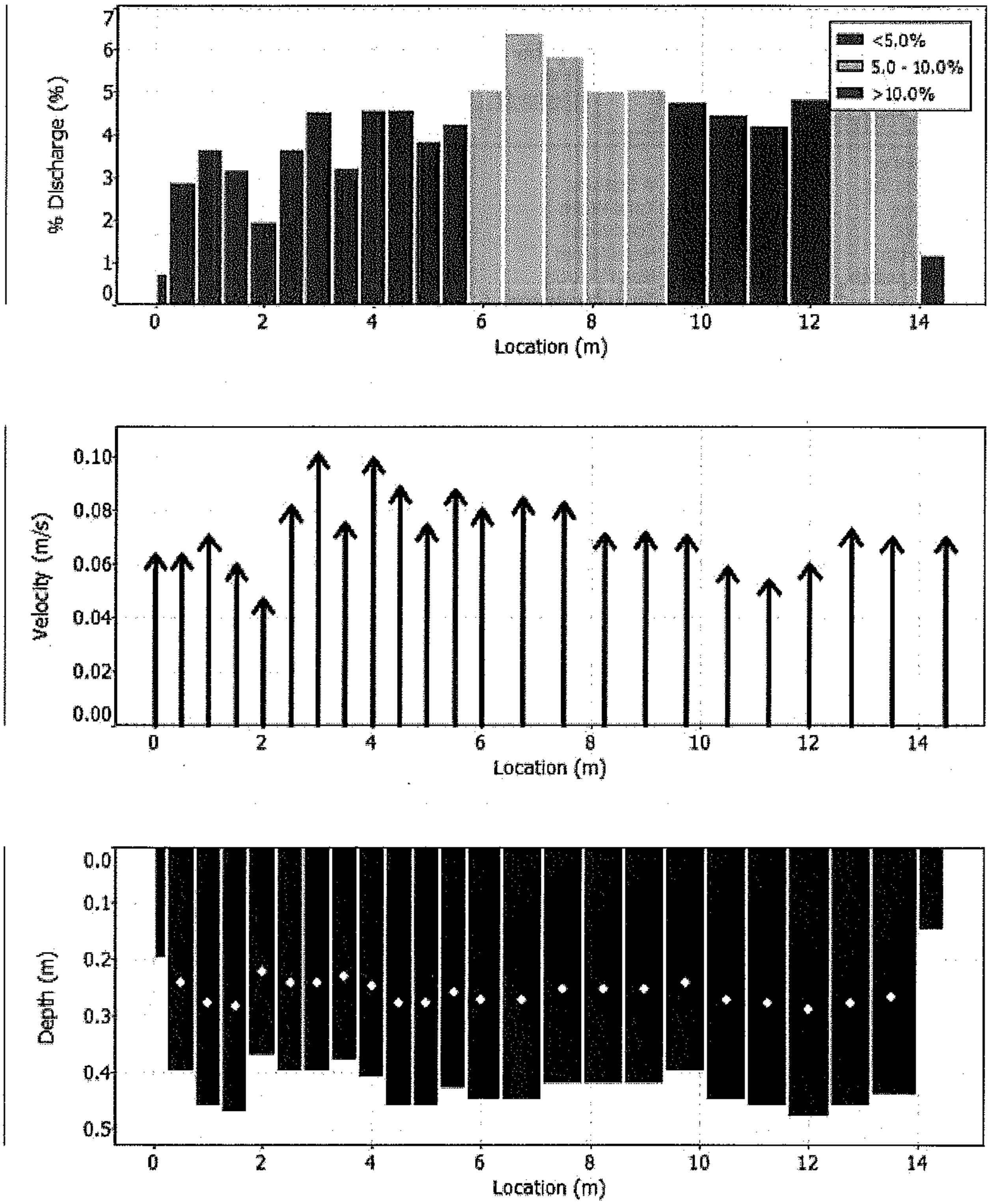
St	Clock	Loc	Method	Depth	%Dep	MeasD	Vel	CorrFact	MeanV	Area	Flow	%Q
0	11:49	0.00	None	0.200	0.0	0.0	0.0000	1.00	0.0640	0.050	0.0032	0.7
1	*11:49*	*0.50*	*0.6*	*0.400*	*0.6*	*0.160*	*0.0640*	*1.00*	*0.0640*	*0.200*	*0.0128*	*2.9*
2	*11:50*	*1.00*	*0.6*	*0.460*	*0.6*	*0.184*	*0.0710*	*1.00*	*0.0710*	*0.230*	*0.0163*	*3.7*
3	11:51	1.50	0.6	0.470	0.6	0.188	0.0601	1.00	0.0601	0.235	0.0141	3.2
4	11:52	2.00	0.6	0.370	0.6	0.148	0.0475	1.00	0.0475	0.185	0.0088	2.0
5	11:53	2.50	0.6	0.400	0.6	0.160	0.0819	1.00	0.0819	0.200	0.0164	3.7
6	11:53	3.00	0.6	0.400	0.6	0.160	0.1015	1.00	0.1015	0.200	0.0203	4.6
7	11:54	3.50	0.6	0.380	0.6	0.152	0.0756	1.00	0.0756	0.190	0.0144	3.2
8	11:55	4.00	0.6	0.410	0.6	0.164	0.0997	1.00	0.0997	0.205	0.0204	4.6
9	11:56	4.50	0.6	0.460	0.6	0.184	0.0888	1.00	0.0888	0.230	0.0204	4.6
10	11:57	5.00	0.6	0.460	0.6	0.184	0.0748	1.00	0.0748	0.230	0.0172	3.9
11	11:58	5.50	0.6	0.430	0.6	0.172	0.0881	1.00	0.0881	0.215	0.0189	4.3
12	11:59	6.00	0.6	0.450	0.6	0.180	0.0806	1.00	0.0806	0.281	0.0227	5.1
13	12:00	6.75	0.6	0.450	0.6	0.180	0.0849	1.00	0.0849	0.338	0.0287	6.4
14	12:01	7.50	0.6	0.420	0.6	0.168	0.0829	1.00	0.0829	0.315	0.0261	5.9
15	12:02	8.25	0.6	0.420	0.6	0.168	0.0716	1.00	0.0716	0.315	0.0226	5.1
16	12:03	9.00	0.6	0.420	0.6	0.168	0.0719	1.00	0.0719	0.315	0.0226	5.1
17	12:04	9.75	0.6	0.400	0.6	0.160	0.0709	1.00	0.0709	0.300	0.0213	4.8
18	12:05	10.50	0.6	0.450	0.6	0.180	0.0592	1.00	0.0592	0.338	0.0200	4.5
19	12:06	11.25	0.6	0.460	0.6	0.184	0.0546	1.00	0.0546	0.345	0.0188	4.2
20	12:07	12.00	0.6	0.480	0.6	0.192	0.0603	1.00	0.0603	0.360	0.0217	4.9
21	12:08	12.75	0.6	0.460	0.6	0.184	0.0729	1.00	0.0729	0.345	0.0252	5.6
22	12:09	13.50	0.6	0.440	0.6	0.176	0.0703	1.00	0.0703	0.385	0.0271	6.1
23	12:09	14.50	None	0.150	0.0	0.0	0.0000	1.00	0.0703	0.075	0.0053	1.2

Rows in italics indicate a QC warning. See the Quality Control page of this report for more information.

Discharge Measurement Summary

Date Generated: Fri Oct 11 2013

File Information		**Site Details**	
File Name	H60.WAD	Site Name	SWIFT
Start Date and Time	2013/09/05 11:49:19	Operator(s)	CM



Appendix 6 Macroinvertebrate Collection Methodology and Overall Results

Saskatchewan Northern Great Plains Ecosystem Health Assessment Manual 2012

Prepared for the Saskatchewan Ministry of Environment, outlining the benthic macroinvertebrate collection methods used by the Saskatchewan Watershed Authority.

Brittney Hoemsen

3/31/2012

Version 1.0

Saskatchewan Ministry of Environment

Prepared by:
Brittney M. Hoemsen
#130-615 Stensrud Road
Saskatoon, SK
S7W 0A2
On behalf of Ministry of Environment and Saskatchewan Watershed Authority

Photo Credits:
Cover photo; Kevin Kirkham in Belanger Creek, Saskatchewan Fall 2009, picture I. Phillips.
Following page photo; Bridge over Qu'Appelle River near Highway 56, Katepwa site, Saskatchewan 2007, picture I. Phillips.
Page 5; Amphipod common in aquatic environments, www.manandwater.com/r%C3%A4ka.htm
Page 6; Chironomids emerged from aquatic environment, picture I. Phillips 2007.
Page 9; White heelsplitter mussel, picture I. Phillips 2007.

Proper Citation
MoE and SWA. 2012. Saskatchewan Northern Great Plains Ecosystem Health Assessment Manual 2012, Version 1.0. Saskatchewan Ministry of Environment, Regina, Saskatchewan, Canada.

Executive Summary

This manual outlines the reference site based research tool used to assess ecosystem health, which has been developed by the Saskatchewan Watershed Authority based on benthic macroinvertebrates. The manual provides detailed instructions on the collection, processing and preparation of benthic macroinvertebrate samples for identification and analysis for collaborative projects between the Ministry of Environment and Saskatchewan Watershed Authority beginning with site assessments in 2012.

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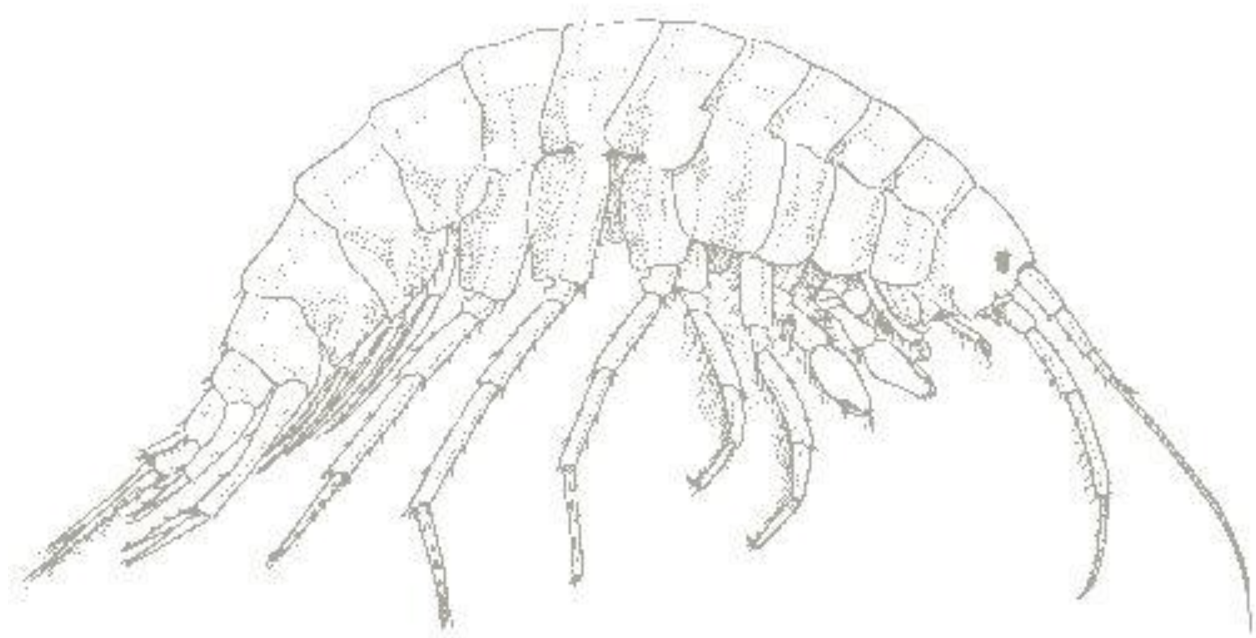
List of Figures

List of Appendices



Introduction

Benthic macroinvertebrates have unique ecological functions, environmental needs and tolerances of disturbance and pollution, allowing them to be good indicators of ecosystem health. Their communities are a product of physicochemical parameters of their environment, being affected by water quality, habitat structure, hydrological regime, energy flow and biological interactions, among others. However, these relationships are also mutual, with aquatic macroinvertebrate communities affecting their surrounding environment. They are an integral part of an ecosystem, acting as biofilters and molding the quality of habitat surrounding them by recycling decaying plant and animal material into the food web. They represent a highly diverse group of organisms, with over 1200 species of aquatic insects known in Saskatchewan alone (Parker, aquatax.com). Each species reacts to pollutants in a characteristic manner, responding quickly and they lead relatively sedentary lifestyles so they are confined to a given area where they are useful in reflecting conditions at a specific site in a river (Rosenburg and Resh, 1993). As such, biomonitoring protocols are using benthic macroinvertebrates as the most common indicator of water quality (Hawkes, 1979). In particular, Saskatchewan Watershed Authority uses benthic macroinvertebrates as a reference site-based research tool to compare impacted to reference conditions and provide indications as to which streams need to be managed to reduce impact and monitored for any improvements.

This manual describes macroinvertebrate sampling using active methods used by Saskatchewan Watershed Authority throughout the province. Benefits of an active sampling protocol are that they require one trip to the sample site, thereby reducing travel cost and effort over passive methods. In addition, these methods focus on measuring or characterizing the existing macroinvertebrate assemblage at a site rather than colonization potential. Disadvantages include a generally high degree of sample variability and high sample debris accumulation that increases sample-processing time. Difficulties also arise in benthic macroinvertebrates sampling when ecological principles are not fully understood and are poorly incorporated in the study design (Rosenburg and Resh, 1993). This sampling protocol designed to minimize these difficulties.

This manual is organized in attempts to follow the logical progression and sequence of events including detailed instruction to proceed with collection, processing and analysis of benthic macroinvertebrate data at selected sites in Central and Southern Saskatchewan as developed by the benthic laboratory at the Saskatchewan Watershed Authority. This includes the location, timing and methods to collect proper data on benthic macroinvertebrates to be used as biological an indication of ecosystem health. Three major sections include:

- **Site Description:** physical characteristics and maps of sites targeted by the Saskatchewan Ministry of Environment in 2012
- **Data collection:** protocol for collection of benthic macroinvertebrate samples in wadeable and non-wadeable samples including instructions on proper habitat assessment
- **Laboratory processing:** detailed description of the handling of samples, subsampling, chain of custody assignment, sorting of samples, identification and preparation of voucher specimens.

A coarse timeline for fall sampling using the described methods is shown in Figure 1. Using the following methods described, the collected field and laboratory data can be then be transferred to an Aquatic Macroinvertebrate Ecologist for analysis and a proper assessment of ecosystem health.

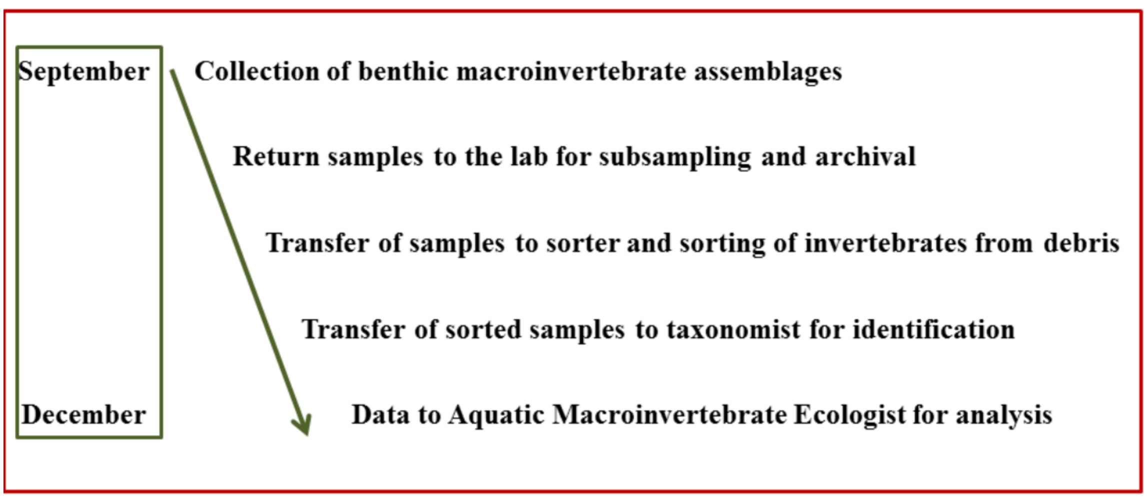


Figure 1. Flowchart of processes and coarse timeline for the collection and preparation of benthic macroinvertebrate samples as part of an ecosystem health assessment.

In preparation of this manual many biomonitoring texts and programs were reviewed. In particular, the following sources provided great assistance: Environment Canada's CABIN program developed by Reynoldson et al. (2002), the US EPA Rapid Biomonitoring Program developed by Barbour et al. (1999) and the biomonitoring protocol developed by Rosenberg and Resh (1993).

Ministry of Environment 2012 Site Descriptions

Physical characteristics at selected primary sites and selection of appropriate sampling methods

Sites selected for ecosystem health and isotope sampling are in central and southern Saskatchewan. Waterbodies to be sampled are Qu'Appelle, Wascana, Moose Jaw, Souris and Assiniboine rivers. They are sites targeted by the Ministry of Environment and Saskatchewan Watershed Authority for current efforts to reduce human impact and to monitor their recovery as they were classified as stressed or impacted in the 2010 State of Watershed Report (SWA, 2010).

A full description of each site is found in Appendix A. Most of the sites can be accessed by a bridge and sampling should be done ~100m upstream unless otherwise noted. The majority of sites are in the moist mixed grasslands ecoregion with sites 1, 5 and 17 in Aspen Parkland. All sites are characterized as wadeable streams as the depths in the middle of the channels are all below 2 m. To sample benthic macroinvertebrates, use field methods for wadeable streams described in detail starting on page 4. This includes taking 4 sample transects ~100 m apart at each site, each with 5 replicates along each transect, to sample as many habitats as possible. If flows are unusually high, this method can be adapted to deeper waters by performing a kick sweep while submerged for ten seconds, if possible. Isotopic sampling is suggested for sites 6-11. This protocol is described starting on page 9.

The available hydrometric data for the sites are described in Appendix A, including median annual flow (dam^3), 5 year median peak flow (m^3/s) and 5 year median minimum flow (m^3/s). Fall sampling of these sites is recommended (early September to early October) when flows will be at their lowest. This gives the most accurate picture of a stable benthic macroinvertebrate community and allows samples to be collected in a short span, allowing data from the sites to be comparable to each other.

Maps leading to each site were made from Google Maps/Earth and the full map is available at http://g.co/maps/eyduq. All historical site images are taken by I. Phillips at the SWA BENT lab from 2007-2010. Hydrometric graphs showing historical daily discharge values at hydrometric stations near sample sites were obtained from Environment Canada's website at:
http://www.wsc.ec.gc.ca/applications/H2O/index-eng.cfm

Field Data Collection

Benthic macroinvertebrate collection in wadeable streams

The travelling kick and sweep sampling method described in this section allows the maximization of the types of habitats sampled at a position in a reach (i.e., riffles, pools, runs, banks, snags, mid-width soft sediment, thalweg etc.) while minimizing the amount of debris collected by sampling for 10 seconds at each position. This kick and sweep method, if done systematically as described below, is a pseudo-quantitative method of sampling benthic macroinvertebrates and allows comparison of benthic communities relative to other sites in rivers and streams throughout south and central Saskatchewan.

Equipment Checklist

- GPS unit
- YSI water chemistry meter for Conductivity, Specific Conductivity, Temperature, % Dissolved Oxygen, concentration Dissolved Oxygen, and Salinity.
- Conventional D-frame net (base of 30 cm, 500 µm mesh)
- Large funnel
- Stopwatch
- Sample jar/container
- Forceps
- 95% ethanol
- Wash bottle
- Waterproof Chest waders and boots
- Labels (Appendix B)
- Pencil (for waterproof labels)
- Sharpie® indelible marker (for labeling jars)

Step in performing travelling kick and sweep of multiple habitats:

1. Set a sample location at the downstream end of the reach, or portion of the stream that is to be studied using GPS coordinates. The reach should be at least 100m upstream of any road or bridge to minimize the effects of varying stream velocity, depth and habitat quality. Refer to Appendix A for information related to specific sites. If the location of study is not listed, define a Proportional Distance Reach (Barbour et al. 1999). Specifically, this requires a standard number of stream "widths" is used to define the reach. This approach allows for variation in reach length according to the size of the stream. An optimal reach for these methods would be a linear section of run habitat of > 300 m. However, often site-specific constraints require a run with some degree of sinuosity or riffle presence. Be sure to make resolute description of each sample habitat on the site field sheet.

2. Sample four transects along the reach at 100 m intervals traveling upstream. Each sample is a combination of 5 sampling positions along the transect (i.e. 5 replicates per sample). The positions are at the left bank (1/5 of the stream), left center (2/5th), center (1/2), right center (3/5th) and right bank (4/5th). All 5 position sweeps are integrated into a single sample for each sample.

3. Each position should cover ~30 cm by 30 cm. Using a conventional D-frame net (base of 30 cm, 500µm mesh) held downstream of the collector, catch dislodged or escaping organisms with the

net. The net should be kept moving forward while sampling and lifted out of the water between sweeps to prevent organisms from escaping. If sample debris from each sample is clogging the net's efficiency whatsoever each sweep should be deposited in the sample jar for that transect between sweeps. Appropriate sampling time is 10 seconds for each position in the transect and should be monitored with a stopwatch. If there is little or no flow, then sweep the net in a figure-8 motion above the collector's feet while kicking up sediment to a depth of ~5cm and collect dislodged or escaping organisms. Repeat procedure at the remaining four positions.

4. Transfer sample from D-frame net into jars using a funnel if necessary and preserve with 95% ethanol. Final concentration of EtOH in the sample should be approximated to be 70% considering the amount of water and vegetation in the sample. Large objects in the sample (e.g., rocks, woody debris) should not be preserved, but rather inspected thoroughly and attached invertebrates picked and deposited in the sample, then the objects returned to the river. Rinsing with water from a wash bottle or removal with forceps may be needed to transfer the entirety of the sample. Place a waterproof Rite-in-the-Rain label, following the format shown in Appendix B in each sample container. This is in addition to labeling the outside of the sample container with the same information using an indelible black marker.

Summary of Sampling Procedure: Wadeable Streams

- Set the target sample location using GPS coordinates at the downstream end of the reach.
- Sample at downstream transect, moving upstream at ~100m intervals.
- Sample 5 positions on a transect, performing a 10 second kicksweep at each position
- Combine organisms from each position into one sample per transect into a jar.
- Label jar with sample code, site number, the waterbody, sample date and collector's initials. A waterproof label with the same information should be placed inside the container as well.

Benthic macroinvertebrate collection in non-wadeable large rivers

Depending on the purpose of the study, different organisms and the habitats in which they dwell may be targeted. To provide a thorough assessment of the assemblages of aquatic organisms in various substrates and water depths in large, non-wadeable streams, multiple habitats must be sampled (Blocksom and Flotemersh, 2005).Therefore, benthic macroinvertebrates are collected using multiple techniques, each specific to the habitat and organisms sought. Blocksom and Flotemersch (2005) found a combination of sampling methods provies the most complete BMI data as metrics significantly correlated with habitat and abiotic factors vary among sampling methods used. This permits the sampling of a larger proportion of the taxa present at a site (Vinson and Hawkins 1996) and allows all organisms to be collected for different purposes of studies. Sampling of a large non-wadeable stream includes Hess sampling of riffles, Peterson Dredge sampling of deep, fine substrate and qualitative D-frame net sampling for multiple habitats, ensuring proper site characterization and biodiversity description. Collection methods are as follows:

Equipment Checklist

- GPS unit
- Chest waders and boots
- Hess Sampler
- Peterson Dredge
- Conventional D-frame net (base of 30 cm, 500um mesh)
- YSI water chemistry meter for Conductivity, Specific Conductivity, Temperature, % Dissolved Oxygen, concentration Dissolved Oxygen, and Salinity.
- Large funnel (for transferring sample from net to jar)
- Pencil (for waterproof labels)
- Sharpie® indelible marker (for labeling jars)
- 20L bucket
- 95% ethanol
- Sample jar/container
- Forceps
- Wash bottle
- Waterproof labels
- A boat to sample from

A. Travelling Kick and Sweep of multiple habitats (standard) with D-frame net

A conventional D-frame net (base of 30 cm, 500 µm mesh) is used to collect a single qualitative assemblage sample from each site. It is comprised of 12 transect sweeps based off the Large River Bioassessment Protocol (LR-BP) developed Flotemersch et al. (2006) and covered as one of the recommended options for large non-wadeable river assessment by the United States Environmental Protection Agency (Johnson et al. 2006).

Steps in performing travelling kick and sweep using a D-frame net:

1. At each site, there are a total of six transects. Sample transects are separated by 100 m intervals traveling upstream. Each transect consists of a 10-m sample length (5.0 m on each bank), and the sample length extends from the bank to the mid-point of the river or until depth exceeds 1.0 m.

2. In each the 10 m sample zone, six sweeps will be made. In each sweep, the net is dragged 0.5 m upstream over the course of 1 minute timed sweeping. Each sweep covers 0.15 m^2 of substrate (i.e., net width of 0.3 m and a 0.5 m length of pass); therefore, six sweeps will cover an approximate area

of 0.9 m^2. The six sweeps are proportionately allocated based on available habitat within the 10-m sample zone (e.g., snags, macrophytes, cobble). D- frame samples from the entire reach are combined into a single sample. This results in each sample containing debris and organisms from 12 separate zones (total of ~12.0 m^2) that represent the 500-m reach.

3. When large sediment rich samples are obtained use a swirling technique over a 20 L bucket, to decant of organic matter and sand. Large objects (e.g., rocks, woody debris) are inspected, attached invertebrates are picked from them, and the objects are returned to the river. Transfer the sample from the net into the sample jar using a funnel, if necessary. Organisms are stored in 95% ethanol. Label the container with sample code, site number, the waterbody, sample date and collector's initials. A waterproof label specific to benthic macroinvertebrate collection with the same information should also be placed inside the container (See Appendix B for sample Labels).

B. Hess sampling (or Surber sampling) of riffles

The Hess sampler is used to assess benthic fauna in coarse substrates such as gravel, cobble, small boulders and sand that make up riffles at shallow depths (<1m). A Hess sampler is a metal cylinder approximately 0.5 in diameter and samples an area 0.8m^2. It is placed horizontally on cobble substrate to delineate collection. A vertical section of the frame has the net attached and captures the dislodged organisms from the sampling area. Its design allows it to capture riffle-dwelling organisms while preventing their escape and any contamination from drift. The following protocol is adapted from Alberta Environment field sampling methods (2006).

Steps in Hess (or Surber) sampling:

1. Collect at 5 separate locations in the reach, starting sampling downstream and working upstream, for a total of 5 samples at transects ~100 m apart.

2. Attach sample bottle securely at the end of the net. Press the sampler into the substrate with opening opposite the net facing upstream and ensure the cylinder is anchored firmly in place. Using a kick net or small shovel, jab at the substrate near opening for ~1 minute. Ensure the collecting net does not clog but holding it straight. After one minute lift the cylinder out of the water. Draw the organisms to the collection jay by repeatedly plunging the net in and out of the water ensuring no organisms escape from the net.

3. Transfer sample into the sample jar using a funnel, washing any clinging organisms on the net with a washbottle as to not exclude any organisms. Fill with 95% ethanol. Label exterior of jar and place a waterproof label inside the jar following Appendix B.

C. Peterson sampling of soft sediment

The Peterson dredge is used to assess the benthic fauna of soft sediment such as sand or silt in pools of deeper waters. Five benthic grab samples are collected, each sample a product of three integrated grabs, using a Peterson Dredge (base = ~0.022 m^2) or other bottom grab sampling devices described by Klemm et al. (1990) (e.g., Peterson, Ponar, Ekman, van Veen samples). These samplers are specifically designed for sampling less-stable substrates (e.g., sand, silt) usually found in depositional areas. Grab samplers are lowered to the bottom and penetrate the sediments under their own weight. Jaws of the samplers are forced shut by weights, levers, springs or cables to retrieve samples from a known surface area. The following protocol is adapted from Alberta Environment field sampling methods (2006).

Steps in using a Peterson sampling of soft riffles:

1. Collect at 5 separate locations in the reach, starting downstream and working upstream, for a total of 5 samples at transects ~100m apart.

2. Ensure the dredge jaws open and close properly and lock the dredge jaws in the open position. Send dredge down slowly and carefully so it rests on the bottom surface. Pull cables to trigger the jaws to close or send down messenger to release the closing mechanism, depending on the model of the dredge. Pull the dredge up slowly and hold over a 20 L bucket as soon as it reaches the surface. Open the dredge and wash off any substrate or organisms still attached to the dredge. The sample is considered a success if the jaws remained fully closed for the sample and no substrate is lost on the way up. Pour contents of bucket over a conventional D-frame net or sieve, careful as to not let any organisms escape. Decant any sediment by carefully swirling the net.

3. Transfer sample into the sample jar using a funnel, washing any clinging organisms on the net with a washbottle as to not exclude any organisms. Fill with 95% ethanol. Label exterior of jar and place a waterproof label inside the jar following labels in Appendix B.

Summary of Procedure: Non-Wadeable Streams

Travelling kick and sweep of multiple habitats using a D-frame net:

- Set the target sample location using GPS coordinates at the downstream end of the reach.
- Make six sweeps (each 0.5 m) in each sample zone with sweeps representing available habitats
- Moving upstream, sampling both banks of the six transects, for a total of 12 separate zones.
- Compile the samples in an appropriate jar and fill container with 95% ethanol.
- Label jar with sample code, site number, the waterbody and sample date. A waterproof label with the same information should be placed inside the container.

Hess (or Surber) sampling of riffles:

- Sample 5 riffles throughout the reach, starting at the furthest point downstream.
- Press sampler firmly into the substrate and perturb sediment for ~ 1 minute
- Transfer sample into a jar. Label jar and waterproof label with sample code, site number, the waterbody and sample date.

Peterson sampling of soft sediment:

- Sample at 5 locations throughout the reach, starting at the furthest point downstream
- Send dredge down and fire mechanism to close jaws when sampler reaches the bottom substrate
- Open jaws of dredge over a 20L bucket and transfer sample from bucket into a D-frame net
- Transfer sample into a jar. Label jar and waterproof label jar with sample code, site number, the waterbody, sample date.

<u>Benthic macroinvertebrate collection for isotopic analysis</u>

Sampling for isotopic analysis involves sampling primary consumers in communities filling the scraper or filterer functional feeding groups in benthic invertebrate communities. This is made up primarily of snails and mussels respectively in Northern Great Plains streams. Andersen and Cabana (2005) found that variation within functional feeding groups was small relative to among-site variation, thus supporting the use of $\delta^{15}N$ values of primary consumers (benthic invertebrates) as landscape integrators. As such, at sites where isotope samples are required the workers will collect five samples of snails or mussels as they are available. The most common gastropods found in Saskatchewan are the white heelsplitter mussel (*Lasmigona complamata*, Barnes), giant floater mussel (*Pyganodon grandis)*,fatmucket clam (*Lampsilis siliquiodea*, Barnes) and physid snails. It would be preferable to obtain five snail and five mussel specimens per site if available, but it is sufficient to have at least five of one group as there is a correction factor between scraper and filter feeder groups for Southern Saskatchewan, thus can adjust the isotope values depending on the taxa collected.

Steps in benthic macroinvertebrate collection for isotopic analysis:

1. Collect snails by overturning rocks and searching macrophytes along the submerged banks of the river and dive for mussels in the benthic regions.

2. Once collected, snails and/or mussels should be placed in a plastic container, with a “MoE Isotope Collection Label” printed on Rite-in-the-Rain paper and filled out for the particular site information (Appendix B for label).

3. Samples must then be frozen AND NOT PRESERVED IN ethanol! If freezing facilities (such as a portable vehicular freezer) are not available, then it is sufficient to keep the specimens on ice until they are returned to the lab where they can be frozen and retained for analysis.

4. In addition, 1 Litre of water should be collected in a clean plastic container, labeled and frozen as well for Particulate Organic Matter (POM) isotope analysis. This will provide an indication of the in-stream N and C isotopic values to standardize between waterbodies. At this stage the samples will be transferred to a University or Government laboratory for analysis. As with benthic macroinvertebrate samples, isotope samples have specific labels (above), and their own sample log-in sheet available in Appendix B.

White heelsplitter (*Lasmygona complimata*)

Habitat assessment and site data collection

A complete sampling program incorporates multiple levels of habitat characterization from the water chemistry and physical structure (substrate type, depth and primary productivity), to riparian-landscape scale variables. The chemical and physical characteristics of a stream determine the type and quality of habitat available for organisms, providing a template within which biologic communities develop (Southwood 1977). The available habitat strongly affects the structure and function of a stream community, therefore a description and assessment of these characteristics, or habitat assessment, is critical in understanding ecosystem health.

This assessment is a visual-based qualitative description of physical habitat in the stream sampling reach and its surrounding riparian area. The amount of resources and time necessary to quantify the abiotic variables of a site can grow quite quickly as one considers more variables, therefore to maximize program efficiency, this manual includes only parameters used in data analysis. Variables assessed include those proposed by NWHI and represent best the ecological integrity of the site (Wilhelm et al. 2005).The assessment follows the field data collection sheet template found in Appendix B including site description, the condition assessment and certain aspects of water quality along with riparian health and photo protocol.

A. Benthic Macroinvertebrate Field Data Collection Sheet

Site sheets used to perform habitat assessments are found in Appendix B.
Fill with date, stream name, location, investigators and the date and time of sampling. Each reach is given a code including the sampling organization, year and site number (i.e., MoE_2012_01 for the first site visited in the 2012 season).

a) **Identify Location:** The exact point of sampling is crucial for temporal replication and if multiple parties involved in sampling. Site locations should be determined (or verified) using a geographical positioning system (GPS) and recorded in Zone 13 standardized, Universal Transverse Mercator (UTM) North America Datum (NAD) 1983. For instructions on using commercial GPS devices or entering a waypoint refer to SWA (2011).

- The GPS should be set to use UTM Extended Zone 13 coordinate system. The settings should be as follows:
- Longitude of origin: W105°00.000’
- Scale: +0.999600
- False Easting: +500000.0m
- False Northing: 0.0m
- Ensure “Map Datum” is set to “NAD83”
- Write the UTM on the sheet.

b) **Water chemistry:** collected at each site, and the fields for this physiochemical parameter are found immediately below the site location information. Standing away from the bank towards the main channel, place a YSI Multifunctional Water Quality Meter or other calibrated water quality instrument at least 10 cm below water surface to collect water temperature (°C), salinity (ppt), conductivity (µS/cm), specific conductivity (Sp µS/cm, %

dissolved oxygen, dissolved oxygen (mg/L) and turbidity (NTU's) data and record on the field sheet. Calibrate the water chemistry meter before field data collection, referencing the instructions specific to the meter you have.

c) **Benthos habitat characterization:** A description of the flow type and substrate in the reach indicates which groups of organisms can colonize that area.

   i. **Flow types:** The mixture of flow, depth and substrate provide a variety of natural habitats in the streams. Areas are categorized into riffle, pools and runs, with a diagram shown below as well as definitions. Note the dominant habitats in the reach and in areas which were sampled.

      Riffle: A shallow area where stream velocity is high and the water is agitated by rocks. Expect to see organisms that prefer cobble and high velocities such as clingers. Caddisflies, stoneflies, and some mayflies occupy this niche well.
      Pool: A deeper area that have been carved out by the vertical force of water falling down on the opposite side of the stream. Organisms here are typically burrowers in soft sediment and free-swimming organisms.
      Run: Shallow areas where stream velocity is high but with no obstructions. Typically, this describes the main body of water with downstream movement. Organisms found here are

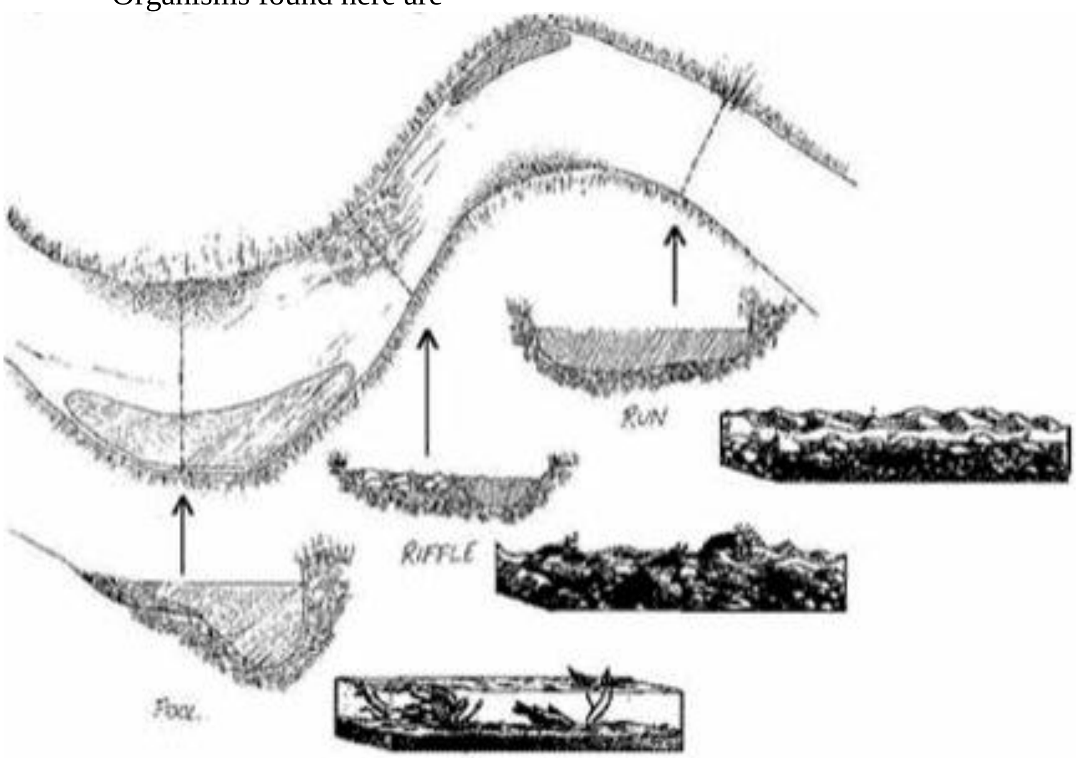


Figure 2: Diagram of components of the stream including a riffle, run and pool. A pool is deep and slow moving water whereas a riffle and run are shallow and fast moving. A riffle has cobble and a run has no obstructions. Image credit: http://www.lakesuperiorstreams.org/understanding/riffle_run_pool.htm

ii. **Habitat Type:** The stream bottom or substrate is classified based on its material. Silt, clay, mud and sand bottom are typically areas of low velocity and low gradient. Rocky bottoms i.e., gravel, cobble, boulders and bedrock usually form riffle areas. Note the percent composition of the following as well as the dominant substrate class and second dominant class for each sample.

1. **Clay-**hard pan, fine particles hold a lot of water in the spaces between particles, giving a stick feeling.
2. **Silt (<0.6 mm)-** gritty feeling.
3. **Sand (0.6-2 mm)-** tiny, grainy particles less than a grain of rice
4. **Gravel (2-65 mm)-** stones ranging from rice size to ping pong ball size
5. **Cobbles (65- 350 mm)-** this includes rocks the size of a ping pong ball to a basketball.
6. **Boulders (greater than 250 mm)-** this includes rocks greater than the size of a basketball
7. **Bedrock-** The stream bottom is solid rock with no distinction between rocks.

d) **Physical characteristics:** Stream velocity is estimated as it plays a large role in determining the types of organisms that can live in the stream. Some organisms thrive in fast-flowing areas and others need calm pools. Velocity also affects the amount of silt and sediment that is deposited in the stream, with particles being suspended in the water column longer in fast-flowing areas. Dissolved oxygen also tends to be higher in fast-flowing streams.

The stream velocity is measured once at the most downstream transect as stream velocity should be relatively similar throughout the reach, as a characteristic of a properly selected run-reach. Choose an area within the reach that has few bends and pools. Use the most sophisticated flow-velocity meter available, but barring access to a digital flow meter then it is sufficient to use rapid assessment of velocity using a semi-buoyant object and measuring tape as described below.

Steps in measuring velocity:

1. Measure out 5.0 m with a measuring tape. One individual stands at the upstream end and the other at the downstream end.

2. Using a floating object (preferably an orange,) measure the time of travel in that 5 m with a stopwatch.

3. This procedure should be repeated for a total of three times and the average "time of travel" is recorded on the field sheet. Also note the actual distance the object travels, keeping in mind it should be ~5.0 m.

e) **Stream characterization & condition assessment:**
The following characterize the type of stream and the state of the reach. These can indicate anthropogenic disturbance from natural variation.

i. **Embeddedness:** the extent to which rocks (gravel, cobbles, and boulders) are buried by silt, sand, or mud on the stream bottom. Optimally, the layering of rocks provides diversity of niche space. However, high erosion of stream banks can lead to sediment loading and a high degree of embeddedness. This leads to less rock surface area for macroinvertebrate habitat. **Scoring:** estimate the amount of silt or finer sediments overlying, in between, and surrounding the rocks (see Figure 3) and use scoring chart for details on the scoring criteria, from the EPA Rapid Bioassessment protocols for Use in Streams and Wadeable Rivers by Barbour et al. (1999)

Optimal Range (William Taft, MI DNR)

Poor Range (William Taft, MI DNR)

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
2.a Embeddedness (high gradient)	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Figure 3: Range in embedded conditions, and associated scoring from optimal conditions with low embeddedness and high score (20) to poor conditions with high embeddedness and low score (to 0). This scoring and figure has been reproduced from Barbour et al. 1999.

ii. **Substrate Notes:** Note any additional comments on the primary substrates found in the reach.

iii. **Channel flow status:** the degree to which the channel is filled with water. The water level will increase as the channel enlarges in an actively widening channel, or decrease as a result of obstructions upstream or drought. Less water in the channel limits the available habitat for macroinvertebrates to colonize. This observation can be important when interpreting biological assemblages under abnormal or lowered flow conditions and when sampling times are inconsistent between seasons. **Scoring:** note the channel flow status from 1-20, with 20 being the most optimal condition, on the field data sheet (Figure 4). Also note channel alterations. That is any large-scale changes in the shape of the stream channel due to urban or agriculture alterations.

Optimal Range

Poor Range *(James Stahl, IN DEM)*

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
5. Channel Flow Status **(high and low gradient)**	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Figure 4: Range for channel flow status, and associated scoring from optimal condition with high channel flow and high score (20) to poor conditions with little channel flow and low score (0). The scoring and figure is reproduced from Barbour et al. 1999.

iv. **Sediment deposition:** Not to be confused with embeddedness, sediment deposition describes the accumulation of sediment in pools and how this sediment alters the bottom of the stream**.** **Scoring:** observe the formation of islands indicating heavy deposition of fine sediment. Figure 5 shows examples of each and the definitions for optimal to poor conditions. For complete guide of soil phase, including water and water erosion, refer to Hayes (1998).

Optimal Range

Poor Range
(arrows pointing to sediment deposition)

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
4. Sediment Deposition **(high and low gradient)**	Little or no enlargement of islands or point bars and less than 5% (<20% for low-gradient streams) of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% (20-50% for low-gradient) of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% (50-80% for low-gradient) of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% (80% for low-gradient) of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Figure 5: Range for sediment deposition condition, and associated scoring from optimal condition with little or no increased sediment deposition with high score (20) to heavy deposits of sediment with a low score (0). Scoring and figure reproduced from Barbour et al. 1999.

v. **Bank Stability Score:** A measure of the condition of the banks, whether they are eroded or have the potential for erosion. Signs of erosion include exposed tree roots, non-vegetated banks. Steep banks have a higher potential to erode than shallow sloping or even overhanging banks. **Scoring:** The right and left banks (facing downstream) are scored independently and given a score from 1-10, from the EPA Rapid Boassessment protocols for Use in Streams and Wadeable Rivers. Scoring details and examples illustrating optimal and poor range are shown in figure 6 below.

Optimal Range *(Peggy Morgan, FL DEP)*

Poor Range
(arrow highlighting unstable streambanks)

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
8. Bank Stability (score each bank) **Note: determine left or right side by facing downstream** **(high and low gradient)**	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Figure 6: Range of bank stability condition, and associated scoring from optimal conditions with highly stable banks and a high score on the left and right banks (10, 10) to a poor bank stability with a low score on the left and right banks (0.0). Scoring and figure reproduced from Barbour et al. 1999.

vi. **Instream Canopy Cover:** Influences the type of organisms in the area by altering the relative amount of external and internal organic matter that enters the stream. Canopy cover prevents temperature and oxygen stress by providing shade.

Estimate the percentage of the stream that is covered by overhanging vegetation. It is easiest to do so by imagining the reach from a bird's eye view (Figure 7).

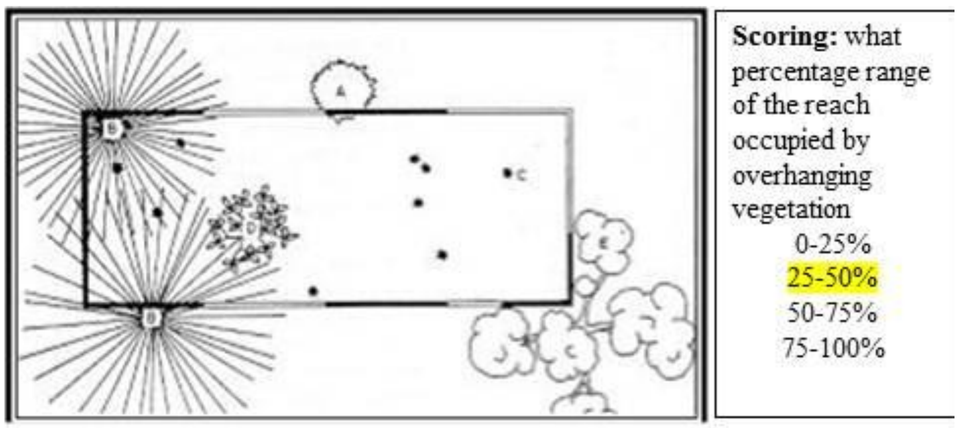


Figure 7: Estimation of vegetative canopy cover. This inner rectangle represents the area considered canopy cover in habitat assessment. This would be scored in the range of 25-50% canopy cover. Photo credit: PCAP riparian health assessment.

f) **Riparian Vegetation:** can help stabilize banks, decreasing erosion and run off into instream community. Facing downstream, note the vegetative community found in three zones (1.5-10 m from water edge, 10-30m from water edge and 30-100 m from water edge). **Scoring:** 1 (None), 2 (cultivated), 3 (pasture), 4 (scrubland), 5 (forest, coniferous), 6 (forest, deciduous).

g) **Aquatic Vegetation Characterization:** Aquatic plants and algae provide food and cover for aquatic organisms. They are associated with slower flow conditions and higher nutrient levels and can be indicators of water quality. **Scoring:** Estimate the percentage of the wetted channel covered by emergent (E), rooted floating (RF), submergent (S) and free-floating (FF) macrophytes and algae at each transect along the reach.

h) **Abundance of Woody Debris, Detritus Macrophytes and Algae:** Presence of woody debris and detritus in streams can provide an important habitat and nutritional source. The abundance of aquatic vegetation can be an indicator of water quality. Note the quantity of these nutritional and habitat sources for organisms with 1= Abundant, 2- Present and 3=Absent at each transect along the reach.

i) **River Characterization:** Note if the stream is intermittent of perennial.The sites proposed by Ministry of Environment for Ecosystem Health Assessment in 2012 all fall under the perennial category.

B. Riparian Area Assessment

The riparian area is the transitional area between aquatic and terrestrial ecosystems. This area includes terrestrial areas that are influenced by flooding or elevated water levers. An example of the riparian area is shown in Figure 8, below. There is considerable variation in the width and the components of riparian areas, in how the soil, water and vegetation interact. However, all riparian areas share the following common features:

- combined presence of aquatic and terrestrial ecosystems
- vegetation adapted to surviving with fluctuations in water abundance
- soils are modified by stream processes such as sediment deposition and nutrient cycling.

Riparian health describes whether the area can support proper ecosystem function such as sediment trapping and storing, maintenance of banks and shores, storage of water and energy, filtering and buffering entering water. This important area provides resiliency, stability and supports key ecological services.

Assessment relies heavily on vegetative characteristics of the riparian area as they reflect various physical interactions with soil and hydrological features. Plants and their characteristics are seen and interpreted more easily than physical features and as such plants act as visible indicators riparian health. A keen eye for identification of common riparian area plants is needed in this assessment as well as knowledge about invasive species in Saskatchewan. A complete list and description of invasive species present in riparian areas of Saskatchewan can be found in the Saskatchewan Invasive Plant Species Identification Guide, by Prairie Conservation Action Plan 2010 available at http://www.swa.ca/Publications/Default.asp?type=Stewardship

Health is a function or a result of previous or current activity. It is important to note any changes upstream from a reach or indications of any previous management activities in the area. These indicators can include:

- Invasive or disturbance species
- Eroding or slumping banks
- Low shelter or habitat
- Low fish and wildlife use

The assessment makes the vegetative and physical observations into a format that allows one to understand the significance of site changes and measure the condition of a reach against a standard. The Prairie Conservation Action Plan (PCAP) developed a Riparian Health Assessment Manual for Streams and Small Rivers in 2008 and it is currently used across the province to compare areas. It is available through the Saskatchewan Watershed Authority website (www.swa.ca) or at http://www.swa.ca/Publications/Documents/StreamsandSmallRiversRiparianHealthFWbook.pdf

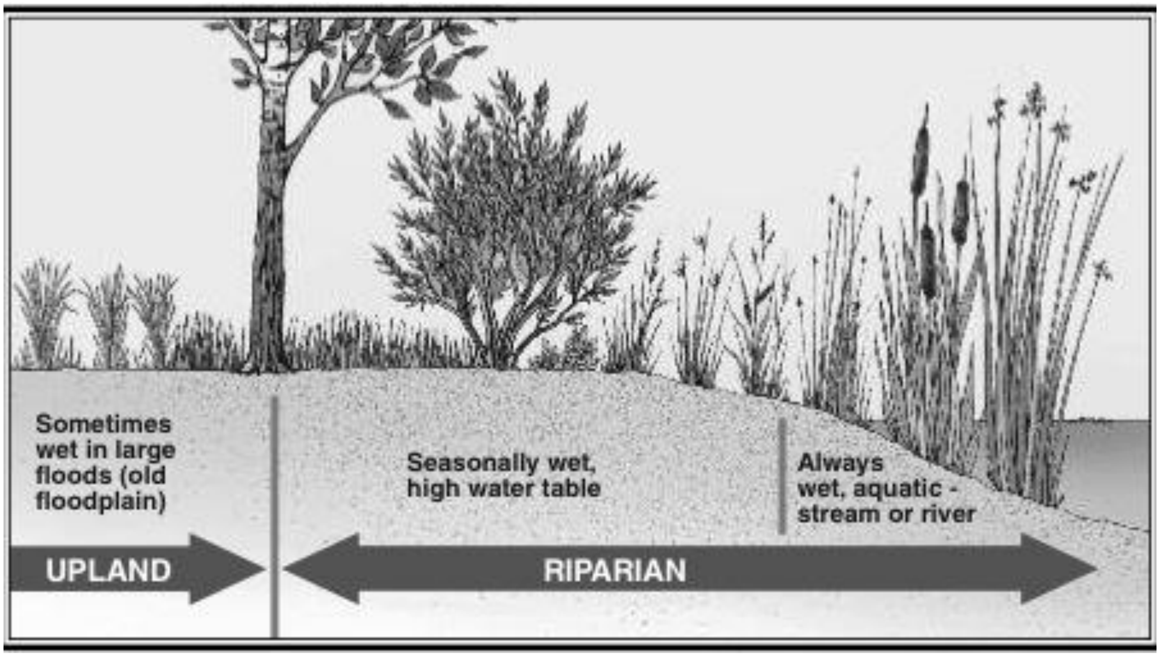


Figure 8: Illustration of riparian and upland area Photo credit: Prairie Conservation Action Plan, 2008.

C. Photo protocol

At each position on the reach take the following photographs to provide a record of the conditions at the site. If possible, include a recognizable landmark to return the same site and take the same photograph in subsequent years.

Steps in proper site photography:

1. Take a photograph of the field sheet with the site number on it to identify the ensuing series of photographs.

2. Take a picture upstream, downstream and across the stream

3. Take a picture of the main substrate in the area where the sample will be collected. Include a meter stick or pencil in the picture to denote scale.

4. Be sure to label all pictures with site code, waterbody number, date, and picture number.

Laboratory Processing

Laboratory processing for macroinvertebrate samples

All samples collected in the field are best processed in the laboratory under controlled conditions. Laboratory processing includes subsampling, sorting and identification of organisms and at each step proper records need to be kept. When samples are first brought into the lab they must be logged into the Benthic Macroinvertebrate Sample Log-in Sheet (Appendix B).

A. Sub-sampling and archival of samples

Sorting and identification of large samples can be lengthy when samples have high macroinvertebrate abundance or have a large amount of associated macrophyte material. Sub-sampling to fractions of the sample can reduce the time and effort required to sample aquatic systems, increasing the coverage of biological monitoring programs and improving the feasibility of studies. The optimal subsample size is the minimum effort required to achieve a proper representation of the community structure however, it is necessary to have a count of >300 individuals in each sample for analysis

a) BENT Lab Splitter

The Saskatchewan Watershed Authority's Benthic Lab (BENT Lab) sample splitter (Figure 9) functions in a similar manner to the aforementioned Folsom plankton sampler in that it is designed to split a sorted sample in half, however it is used when the Folsom Plankton Splitter would be foiled by excess sample debris. (e.g., macrophytes). The sample is deposited in the main chamber of the sample splitter, the lid screwed on, inverted so that the lid is on the bottom and the spigot is up, the unit is swirled for ~ 30s, then tipped along the axis that would have the dividing plate in the sample splitter cut the sample in half and inverted so that the lid is now on top (see Figure 10). Unscrew the top, and cut any macrophytes with a razor or scissors along the dividing blade. One half fraction is removed by then un-screwing the spigot half of the splitter and forcing the sample through with a rod, then rinsing. The second half of the sample is then poured out from the remaining chamber in the splitter. A coin should then be used, to decide which half will be retained as an archive sample, and which sent for sorting.

Figure 9. BENT Lab benthos sample splitter from side view with lid in the fore middle of the picture, and the spigot cap to the fore left in the picture (photo by I. Phillips).

Figure 10. BENT Lab sample splitter from top view. Note the spigot outlet on the left, the dividing plexiglass in the middle, and the closed half chamber on the right (photo by I. Phillips).

b) **Folsom Plankton Splitter**

This subsampling apparatus was originally designed by Dr. Folsom of the Scripps Institute to split samples (zooplankton or macroinvertebrates) into two equal parts (McEwen et al., 1954). It consists of a hollow drum mounted to turn on a horizontal axis and vertical semi-circular septum or cutting edge in the middle of the drum as shown in Figure 11, below.

Steps in splitting a sample by volume:

1. Rotate the top of the drum forward so it is above the septum and pour the sample in. The drum fits approximately 1 L.

2. Rotate the drum backward so the septum separates the sample. Slightly rotate the drum back and forth so no organisms are caught on the side of the drum.

3. Rotate the drum forward so the two separate samples empty into the clear polycarbonate subsample trays.

4. Emptying one tray and repeating steps 1 through 3 can obtain smaller samples. This will separate portions of ½, ¼. and 1/8 of a sample. Multiplying each count in the m^{th} fraction by 2^m gives an estimate to the number in the original sample.

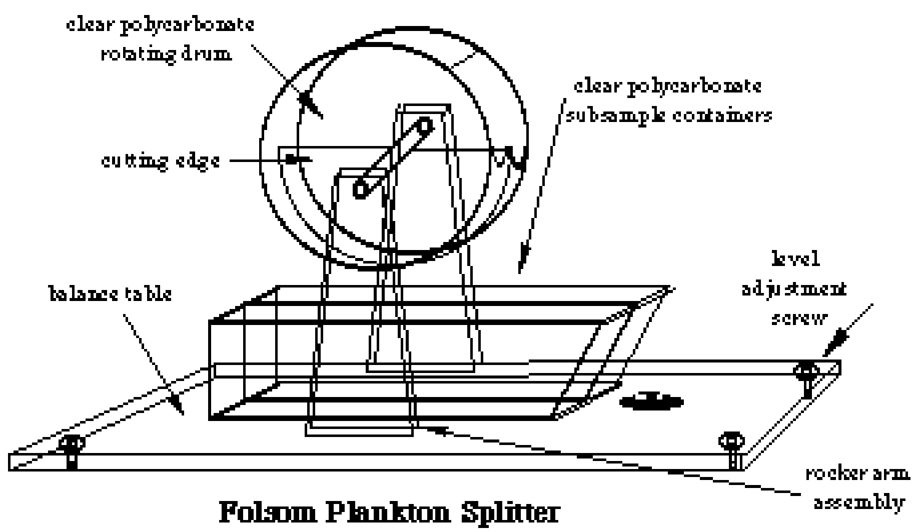


Figure 11: Folsom Plankton Splitter and its Components. Photo Credit: http://www.aquaticresearch.com/folsom_plankton_splitter.htm

c) **Weight Fractionalization**

A subsampling technique developed by Sebastien et al. (1988) for unsorted samples containing large amounts of filamentous and extraneous debris. The organisms in these samples will be entangled in the debris, making volumetric subsampling difficult.

Steps in splitting a sample by weight:

1. Pour unsorted sample onto a pre-weighed sieve (200µm mesh) and allow to stand until excess preservative has drained (~15 minutes)
2. Stir moist sample again while on sieve and weigh on electric pan balance to the nearest 0.1g.
3. Remove a fraction of the sample (typically 25% of the sample) and weigh each sample to the nearest 0.1g.
4. Sort and identify the subsample while noting the fraction on the laboratory data sheet.
5. A grid system can be used as part of subsampling and sorting, as recommended by the EPA. The entire sample is spread out on a pan marked with grids 6cm x 6cm. A random numbers table is used to select four numbers corresponding to grids within the pan. Remove all organisms in those four grids and place into a shallow white pan for sorting.

d) **Serial Number Assignment**

Once samples have been returned and logged-in at the laboratory they are split at SWA and each fraction is then assigned a serial number. The serial number is comprised of the prefix SWA_BENT, a number relevant to that site and sample, a suffix denoting whether that fraction will remain an archive (labeled Arch. 1 or Arch. 2) or sent for sorting (label Sort/id). An example is shown in Appendix B which shows info about the site and in particular the sorted fraction. If the sample does not require subsampling then a serial number is assigned with the suffix SORT/ID, serial number attached and sent for sorting. If a sample is found to have <300 organisms after it has been identified, then archived fractions can be processed according to the required number of organisms to meet the 300 organism threshold. Archive samples are stored for 5 years, space permitting.

B. Chain-of-custody recording

The chain of custody system is set in place as to not confuse samples. It is a record that follows the samples in each step of laboratory processing. Most important information includes the serial number, waterbody and date sent out for records at the laboratory, while the sample is being processed Appendix B shows the format for this sheet. A photocopy can be taken for the organization’s personal records marked draft prior to the sample being sent out to a contractor for subsampling, sorting or identification as the chain of custody sheet is sent with the sample.

C. Sorting benthic macroinvertebrate samples

Samples must be sorted to separate organisms from detritus, sand and mud. It is a lengthy, tedious process to remove and separate every organism in a sample and is typically contracted out to a professional contractor. For details regarding sorting contracts refer to section F, following.

Steps in sorting a sample:

1. Thoroughly rinse sample in a 500 um-mesh sieve to remove preservative and fine sediment. Large organic material not removed in the field is removed and visually inspected for organisms. If the sample was in more than one container, combined all containers into one sample.

2. There are several techniques to be used, however the most common technique involves placing a small amount of the sample in a plastic petri dish and systematically removing each organism from the sample using forceps. This process should be completed under a 10-power dissecting scope and should be sorted twice to ensure all organisms are removed. Keeping the samples wet while sorting makes it easier to view the organisms and prevents them from drying out.

3. If the sample contains large amounts coarse sediment grains, floating the sample in a large flat tray followed by sieving the suspended organic material, arthropods and soft-bodied organisms, can be an effective way of sorting from the coarse debris. Be sure to inspect the sediment left behind for invertebrates (snails, mussels, and some Trichoptera sometimes have negatively buoyant cases causing them to be retained in the sediment).

4. Place sorted organisms in small vials with 70% alcohol preservative so they will not become brittle. Rubber stoppers or screw-capped vials with plastic inner seals prevent the alcohol from evaporating. A label of the location, collection date and name of collector is included in each of the vials with the name of the specimen if it has been identified (Appendix B)

D. Appropriate taxonomic resolution, keys, and preparation of voucher specimens

In ecosystem health assessment using benthic macroinvertebrates, organisms are the raw material of the study. They act as biological indicators of health with the understanding of individual species' habitats, needs and biological functions they perform. Ecosystem health assessments require a significant investment of time, effort and money, but without proper identification of organisms there is great potential for that investment to be wasted.

Taxonomic resolution should be determined based on the objectives of the research and find a balance between information (gain or loss) and available time, budget and expertise (Bouchard et al. 2005). The taxonomic identification of each organism to genus or species level provides the most accurate information about sensitivity, tolerance, and ecological conditions. Species in a given area carry their own set of environmental requirements, life history traits and sensitivities, however they may not common to all members of that genus. Genus/species identifications improve assessments using richness values or metrics as key endpoints (Lenat and Resh, 2001). Family level identification generally requires less effort and less expertise. However, in Saskatchewan it is valuable to identify to the lowest possible taxon (usually genus or species). It is important to find taxonomic sufficiency, or a meaningful compromise that allows the extraction of all pertinent biological and diversity information with accuracy and without ecological redundancies. This is considered identification to the lowest possible taxon. Of the most commonly occurring taxa in the current biomonitoring program used developed by SWA and reported in the State of the Watershed Report (2010), Oligochaeta are identified to subclass, Nematoda to phylum, and Nematomorpha to phylum. Hirudinea are identified to species where possible. All Gastropoda are identified to lowest possible designation; however, the Sphaeridae are maintained at genera. Malacostracans are identified to species, and most Insecta are identified to lowest possible designation (typically Genus or species), with the exception of the Chironomidae which are identified to family.

Principal resources for aquatic macroinvertebrates include Merritt and Cummins (1996) and Clifford (1991) and Dale Parker's www.aquatax.ca offers great keys and pictures. Both texts act as good introductions to order and family level identifications and offer a great starting point for identifications to further taxonomic levels. Unfortunately, using textbooks as the sole taxonomic resource is insufficient for the following reasons. Firstly, the texts are not written exclusively for Saskatchewan so they contain families and genera not found here and can make identification confusing. Regional keys may provide shortcuts in identification of commonly found macroinvertebrates. Secondly, the texts may exclude some taxa found in the province. Lastly, they are not always up to date and do not incorporate taxonomic and ecological advances. For information on variations within a genus and species level identifications more specialized books and primary literature must be consulted to ensure the initial genus or family level identification is correct. For these reasons a library of taxonomic literature is essential in aiding identification of specimens and should be maintained and updated as needed.

Taxa that often require further investigation are Diptera, Tricoptera, Plecoptera, Hemiptera. Appropriate literature for these identifications includes, but is not limited to, the following primary literature. For mayflies (Ephemeroptera) use Webb (2002) and Webb et al. (2004). Hemiptera is described by Brooks and Kelton (1967). To identify beetles (Coleoptera) to genera use Arnett et al. (2000) and Smetana (1988). For the family Dytiscidae Larson et al. (2000) and Zimmerman (1970) provide good keys for Canadian predaceous diving beetles. Stonefly (Plecoptera) literature includes Dosdall and Lehmkuhl (1979), Hitchcock (1974), and Szczytko and Stewart (1979). The family Chironomidae (Order: Diptera) are highly diverse in Saskatchewan and identification to species level is quite difficult, often having to mount insects on slides. Literature used to identify down to genera and species include Bode (1983), Hansen and Cook (1976), Oliver and Roussel (1983) and Simpson (1982). The black flies or Simulidae family (Order: Diptera) are described by Peterson (1970 and Adler et al (2004). Horseflies and other dipterans are described by Pechuman et al. (1983) and Teskey (1990). Literature used in the identification of caddisflies (Tichoptera) is vast, including Floyd (1995), Glover (1996), Schmid (1970), Schmid (1980), Smith, (1984), Wiggins, (1996 and 1997). Assignment of functional feeding groups and tolerance values are done using Merritt and Cummins (1996), Thorp and Covich (2001) and Barbour et al. (1999).

Problems arise in taxonomy identification even with the proper resources. Sometimes the sample may be damaged or the sample may be missing a critical part for identification. Also, some taxa are best identified at certain life stages. Species level identifications may require adult stages, and these are often not collected in normal sampling procedures. It may be necessary to rear larvae to their adult form to positively associate the two life stages. For these reasons, taxonomists have to be highly skilled in identification and participate in training courses. It is often in the best interest of the investigator to hire a professional taxonomist, as taxonomic identification is a difficult and evolving field and a proper identification is essential to any research project.

E. Instructions on the preparation of voucher specimens

The value of a project involving benthic macroinvertebrates relies heavily on the proper identification of specimens, as described in the previous section. One way of verifying that the species collected and studied are the species named in the report is in the preparation of voucher specimens. These are representatives of each identified taxon that are kept under long-term care and are available tor subsequent examination and verification. Locations of these collections in Saskatchewan include Saskatchewan Watershed Authority Invertebrate Voucher Collection (Saskatoon, Saskatchewan) and the Royal Saskatchewan Museum (Regina, Saskatchewan). This can be organized through Dale Parker at AquaTax, or Iain Phillips with SWA.

Deposition of voucher series permits long-term studies using the same organisms and allows for the correction of published errors if new genetic information is released. Voucher series also prevent subsequent recognition of multiple species in a series of closely related species, subsequent recognition of errors or omissions in taxonomic keys and misidentification of an organism by poorly trained taxonomists.

To prepare a proper voucher series, at the very least one organism of every taxon identified should be preserved in 70% ethanol and placed in a vial, or pinned if they are a hard-bodied organism such as an adult beetle or hemipteran. Each specimen requires a clear label describing the collection date, location, stream and sample number as well as identification information such as taxonomist and specified taxon. Any specimens removed from the sample and placed in reference collection should be noted, (the species and number) on the sample identification sheet.

For further information and detailed guidelines and recommendations on the collection, preparation and labeling of specimens, refer to Martin 1977, Huber 1998, Wheeler et al. 2001.

F. Instruction on preparation of sorting and identification contracts (e.g., cost, duration, list of contractors, etc.)

Sorting and identifying contractors in Saskatchewan are Janet Halpin and Dale Parker from Aquatax Consulting. Further information on services and contact information consult www.aquatax.ca. Shown below are the average sorting and identification durations and costs for macroinvertebrates, including an approximate for the Ecosystem Health Assessment Manual project initiated by Ministry of Environment 2012.

a. Average Sorting Rates
   i. Duration =2 hours per sample
   ii. Cost= $60 per sample

b. Average Identification Rates
   i. Duration= 2 hours per sample
   ii. Cost= $260 per sample
      1. With 17 proposed sites by the Ministry of Environment and 4 samples at each location (assuming using a non-wadeable sampling method)

c. Approximate Sorting Cost for entire project
   i. Duration= 17 sites X 4 samples/site X 2 hours/sample = 136 hours
   ii. Cost= 136 hours @ $30/ hour = $4,080

d. Approximate Identification Cost for entire project
   i. Duration= 17 sites X 4 samples/site X 2 hours/sample = 136 hours
   ii. Cost= 136 hours @ $130/hour = $17,680

Quality Assessment/ Quality Control (QA/QC)

Measures are taken at multiple levels to ensure a high caliber project and a certain degree of confidence in the work. QA/QC measures are performed in the field, during sorting and identification, data entry and the deposition of voucher series in proper locations. The following is a list of QA/QC structured into the methods described previously as well as further methods used during data analysis.

- Keeping detailed field notes and following proper photo protocol organizes a project
- Four sample replication at each site allows the study of within-site variability
- Site sheet data entered into computer in duplicate and cross-referenced.
- Chain of custody forms follow the sample throughout laboratory processing
- 10% of sorted material resorted as an estimate to the number of organisms missed in a sample
- Archived fractions saved for 5 years, depending on space, and 10% are resorted
- During taxonomic identification, no pertinent information is given to the taxonomist regarding location of the site or habitat from which the sample was collected as this may bias the taxonomist's identification of the sample.
- Submission of macroinvertebrate voucher series to Saskatchewan Watershed Authority and Royal Saskatchewan Museum, mussels are submitted to the Canadian Museum of Nature.

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Appendix A) Physical characteristics at selected primary sites and selection of appropriate sampling methods

Sites for Ecosystem Health (EH) and Isotope (Iso) sampling in 2012

Waterbody & Location	Latitude	Longitude	UTM n	UTM e	EH	Iso
1. Qu'Appelle: Highway 56 DS of Bridge	50.65055	103.5876	5611918.1	400153.2	Yes	No
2. Qu'Appelle: Highway 19	50.98326	106.416	5648918.2	599396.6	Yes	No
3. Qu'Appelle: Lumsden (MoE Primary Site)	50.654183	104.886334	5611376	508035	Yes	No
4. Qu'Appelle: Above Wascana Creek	50.63611	104.93889	5609227.4	489495.4	Yes	No
5. Qu'Appelle: Edenwold bridge	50.4716	104.1656	5591400.3	440788.4	Yes	No
6. Wascana: Sidmar Crossing - DS RSTP	50.48472	104.77778	5571068.2	461818.5	Yes	Yes
7. Wascana: Battered Bridge	50.57278	50.57278	5576798.6	464457.1	Yes	Yes
8. Wascana: Above Qu'Appelle	50.63556	104.90944	5914738	466774.1	Yes	Yes
9. Wascana: Above Regina	50.30917	104.36527	5565716.5	450127.8	Yes	Yes
10. Wascana: Above SWTP	50.47639	104.73194	5570344.7	458927.8	Yes	Yes
11. Moose Jaw: Above QR, South of BPWTP	50.3228	105.1715	5574536.2	512208.4	Yes	Yes
12. Souris: Highway 39 at Roche Percee	49.07061	102.8087	5437619	339955	Yes	No
13. Souris: Nickle Lake Discharge	49.57861	103.77500	5466867.8	388358.9	Yes	No
14. Souris: West of Halbrite	49.49306	103.66250	5461324.2	383263.5	Yes	No
15. Assiniboine: Kamsack (PPWB site)	N/A	N/A	721784	5707536	Yes	No
16. Qu'Appelle: Welby (PPWB site)	50.5120404	102.35762	5598899.2	687340	Yes	No
17. Moose Jaw : Roleau (MoA ref site)	50.191598	104.98596	5559934	501002	Yes	No

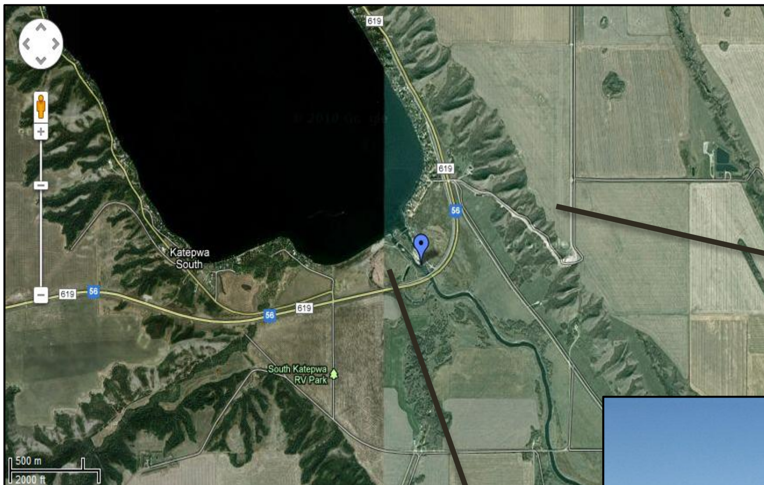
1. Qu'Appelle River: at Highway 56

Lat/ Lon = 50.65055N, 103.5876W
UTM= 5611918.1n 400153.2e

Site Notes:

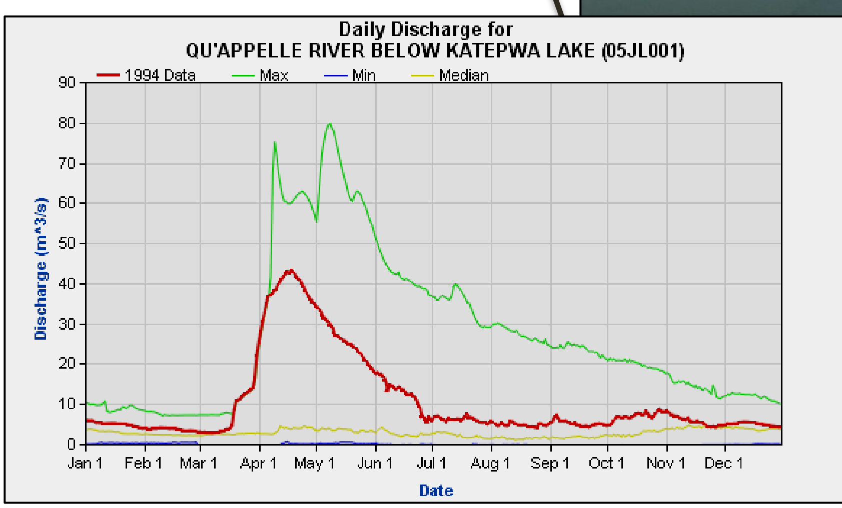
- To access the site follow Highway 56 from Fort Qu'Appelle along Katepwa lakes and sample ~100 downstream of the bridge on Highway 56 to avoid influences of the water control structure.
- The site has shallow banks and is easily accessible from the bridge.

Location:



Site Image:

Hydrometric Data:

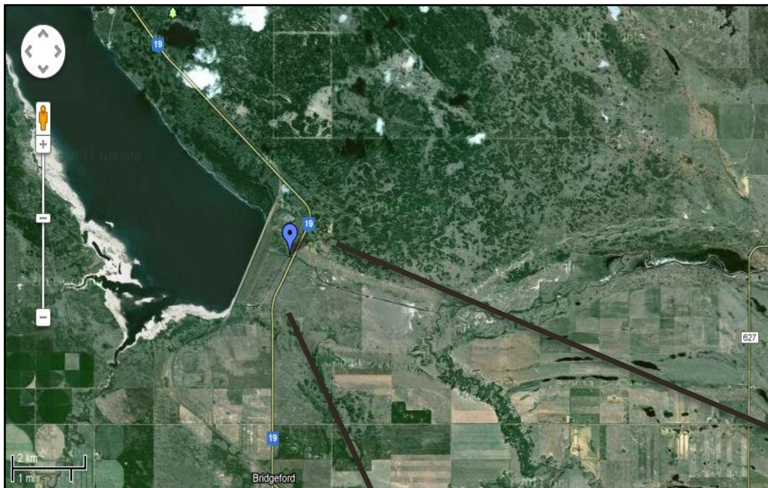


Historical daily discharge from Qu'Appelle River below Katepwa Lake hydrometric station. Statistics corresponding to 31 years of data recorded from 1955 to 1994. http://www.wsc.ec.gc.ca/applications/H2O/graph-eng.cfm?station=05JL001&report=daily&data=fl

2. Qu'Appelle: Highway 19

Lat/Lon=50.98326N, 106.416W
UTM= 5648918.2n 599396.6e

Location:

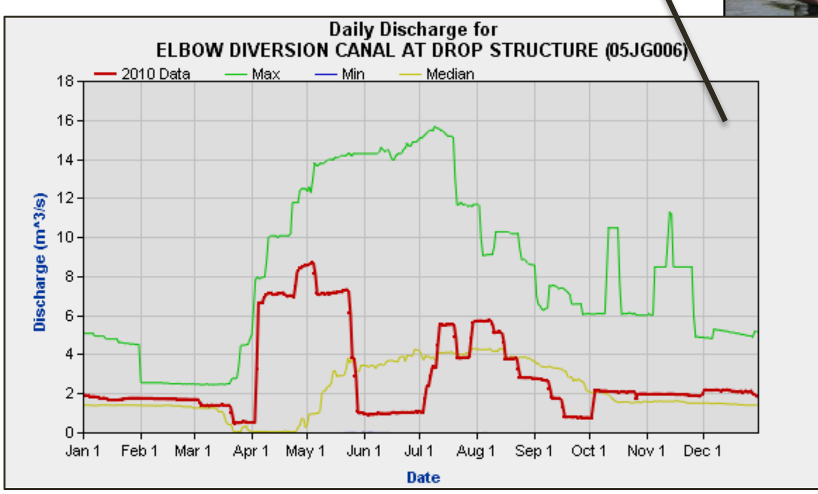


Site Notes:

- The site is located ~100 m upstream from the bridge of Highway 19 over the Qu'Appelle River, north of Bridgeford, SK.
- It is characterized as a highly vegetated area with many submerged macrophytes and a muddy bottom. It is easily accessed upstream of the bridge.
- -The reach has low flow with median annual volume 70500 dam^3, median peak flow 6.6 m^3/s, and minimum peak flow 0.05 m^3/s.

Site Image:

Hydrometric Data:



Historical daily discharges for elbow diversion canal at drop structure hydrometric station. Statistics corresponding to 53 years of data recorded from 1958 to 2010. http://www.wsc.ec.gc.ca/applications/H2O/graph-eng.cfm?station=05JG006&report=daily&data=flow&year=2010

3. Qu'Appelle: Lumsden (MoE Primary site)

Lat/Long= 50.6541826387101N, -104.88633455073507W
UTM= 5611376.0n, 508035.0e

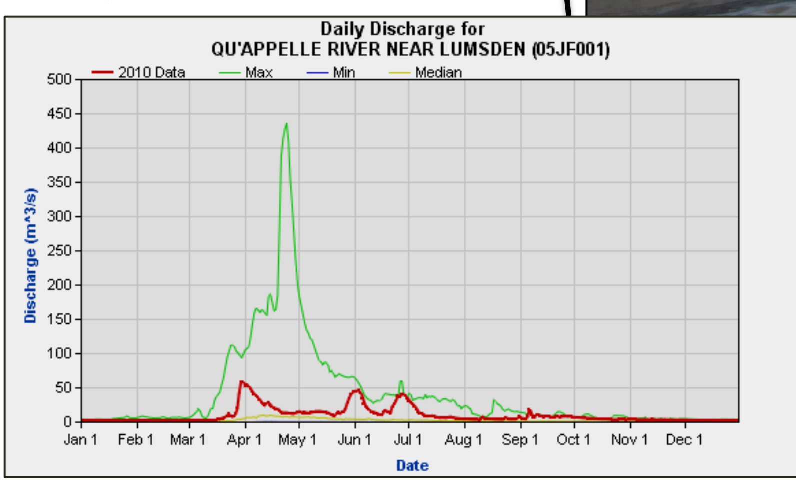
Location:

Site Notes:

- This site is located under the overpass of Highway 11
- This site has highly vegetated and steep banks with a mostly muddy bottom. The reach is accessible by walking along the bank under the bridge.
- At this site the median annual discharge is 122932.4256 dam^3, median peak flow is 26.5 m^3/s and the median minimum flow is 0.264 m^3/s.

Site Image:

Hydrometric Data:

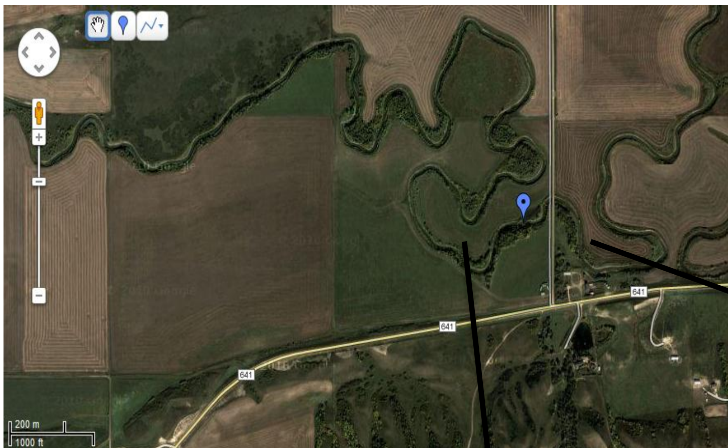


Historical data from Qu'Appelle River near Lumsden hydrometric station. Statistics corresponding to 84 years of data recorded from 1911 to 2010. http://www.wsc.ec.gc.ca/applications/H2O/graph-eng.cfm?station=05JF001&report=daily&data=flow&year=2010

4. Qu'Appelle River: Above Wascana

Lat/Lon= = 50.63611N, 104.93889W
UTM: 5609227.4n 489495.4e

Location:

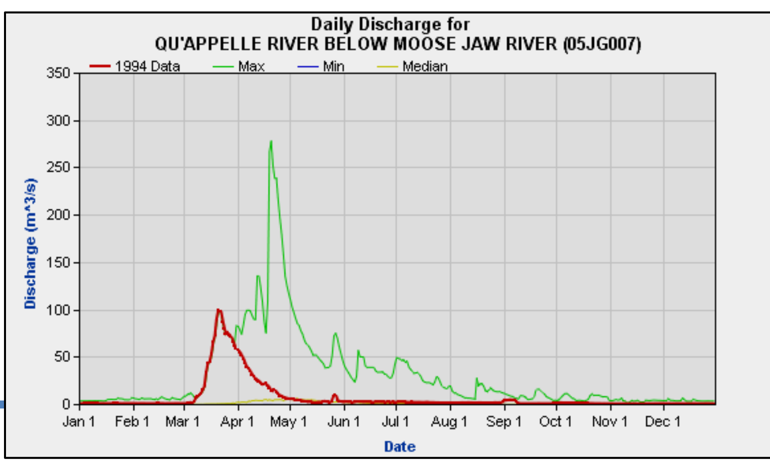


Site notes:

- Heading west of Lumsden on Qu'Appelle Drive (Grid 641), turn right on the continuation of Grid 54. The site is immediately upstream the bridge on Grid 54.
- The site is has vegetated and shallow banks. It is easily accessible by walking along the bank 100m upstream from the bridge.
- From available hydrometric data for this site the median annual discharge is 91390.9 dam^3, the median peak flow is 18.55 m^3/s and the median minimum flow is

Site Image:

Hydrometric Data:

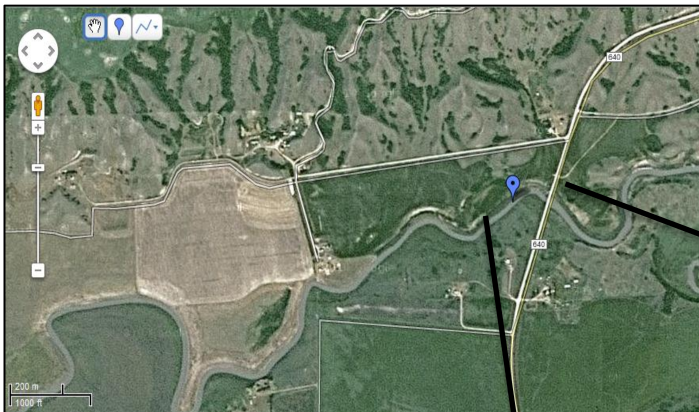


Historical daily discharges for Qu'Appelle River below Moose Jaw River hydrometric station. Statistics corresponding to 51 years of data recorded from 1944 to 1994. http://www.wsc.ec.gc.ca/applications/H2O/graph-eng.cfm?station=05JG007&report=daily&data=flow&year=1994

5. Qu'Appelle River: Edenwold bridge

Lat/Lon= 50.4716N, 104.1656W
UTM= 5591400.3n 440788.4e

Location:

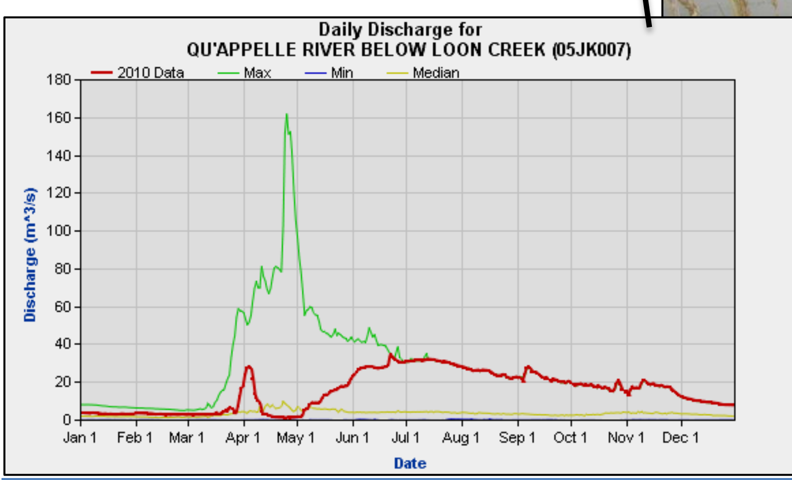


Site notes:

- Site is located immediately upstream, or west, of the crossing of Grid 640 and the Qu'Appelle River north of Edenwold.
- Highly vegetated, steep banks. Access by climbing down along the bridge abutment, and walking upstream along the slump above the bank.
- At this site, mean annual discharge is 124516.8288, dam^3, median peak flow is 18.1 m^3/s and 5-year median minimum flow is 0.418 m^3/s.

Site Image:

Hydrometric Data:



Historical daily discharges from Qu'Appelle River below Loon Creek hydrometric station. Statistics corresponding to 45 years of data recorded from 1955 to 2010. http://www.wsc.ec.gc.ca/applications/H2O/graph-eng.cfm?station=05JK007&-report=daily&year=201

6. Wascana Creek: Sidmar Crossing

Lat/Lon= 50.48472N, 104.77778W
UTM=5571068.2n 461818.5e

Site Notes:

- The site is located downstream of Regina's wastewater treatment plant. From Regina, exit Dewdney Avenue to Grid 730. Turn north on the grid just east of the Sherwood Forest grid to Sidmar Crossing.
- It is a shallow, narrow location with highly vegetated, steep banks.
- Hydrometric data shows the median annual discharge is 2941.7472 dam^3, median peak flow is 2.41 m^3/s and median minimum flow is 0 m^3/s.
- **Collect isotopic data at this site**

Location:

Site Image:

*Hydrometric graph unavailable

7. Wascana Creek: Battered Bridge Crossing

Lat/Lon= 50.57278N, 104.83472W
UTM= 5576798.6n 464457.1e

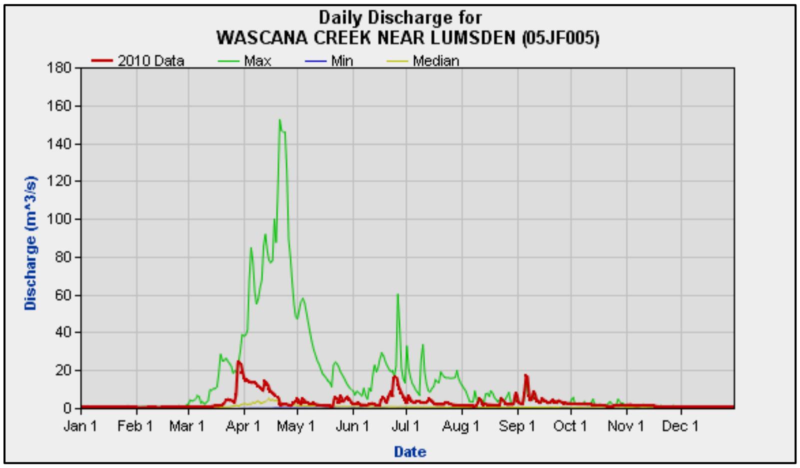
Site Notes:

- Follow Grid 734 and head straight West, do not follow the curve north continuing Grid 734, to the Wascana Creek in the Wascana Creek Valley. Access the site just upstream of the Battered Bridge crossing.
- This site is characterized by highly vegetated banks and large amounts of submerged macrophytes.
- Hydrometric data shows the median annual discharge is 2941.7472 dam^3, median peak flow is 2.41m^3/sand median minimum flow is 0 m^3/s.
- **Collect isotopic data at this site**

Location:

*Historical site image unavailable

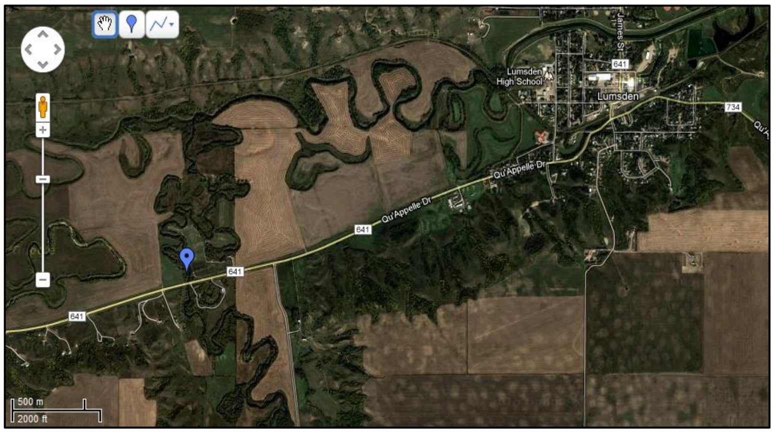
Hydrometric Data:



Historical daily discharge from Wascana Creek near Lumsden hydrometric station. Statistics corresponding to 66 years of data recorded from 1945 to 2010. http://www.wsc.ec.gc.ca/applications/H2O/graph-eng.cfm?station=05JF005&report=daily&data=flow&year=20

8. Wascana Creek: Above Qu'Appelle

Lat/Lon= 50.63556N, 104.90944W
UTM= 5914738.0n   466774.1e
Location:

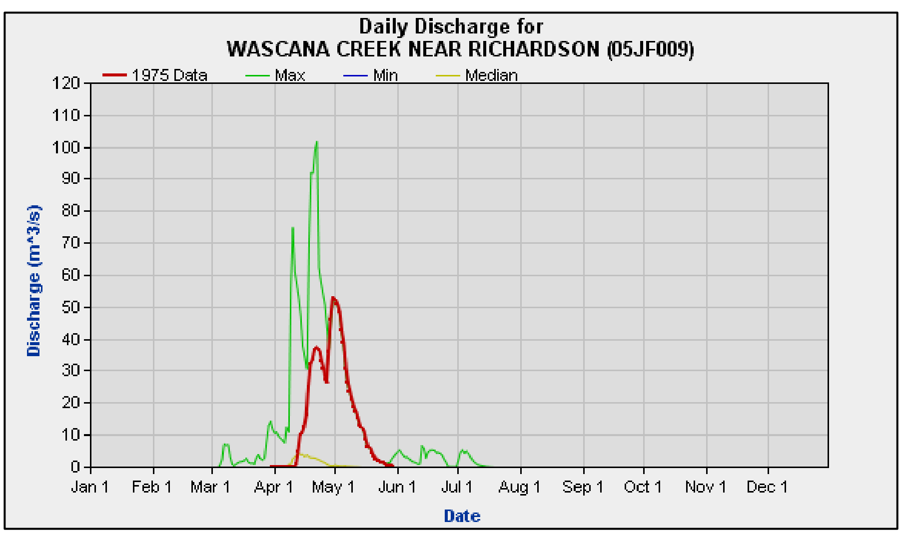


Site Notes:

- This site is upstream from the Qu'Appelle River input, off Grid 641 near Lumsden and is located close to site 4.
- This site has highly vegetated banks with lots of canopy cover.
- **Collect isotopic data at this site following Section 4.**

*Historical site picture unavailable

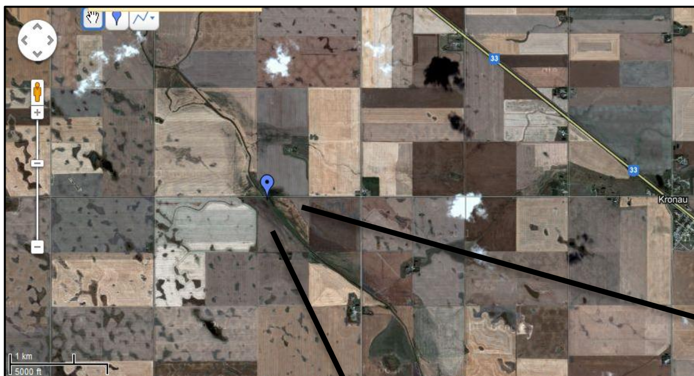
Hydrometric Data:



Historical daily discharge from Wascana Creek near Lumsden hydrometric station. Statistics corresponding to 15 years of data recorded from 1943 to 1975. http://www.wsc.ec.gc.ca/applications/H2O/graph-eng.cfm?station=05JF009&report=daily&year=1975

9. Wascana Creek: Above Regina

Lat/Lon= 50.30917N, 104.36527W
UTM= 5565716.5n   450127.8e
Location:

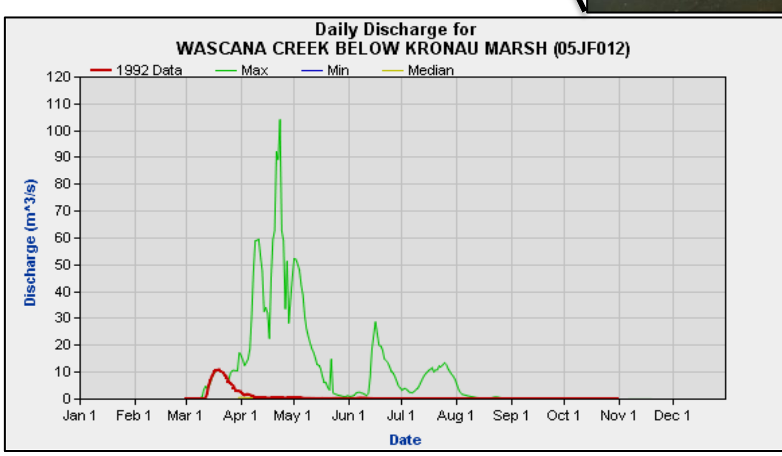


Site Notes:

- Site located off Highway 33 and is located directly west of Kronau, SK.
- This narrow stretch of Wascana Creek is located in an agriculturally- dominated area with a small riparian area.
- Median annual flow is 13970.448 dam^3, median peak flow is 11.9 m^3/s and median minimum flow is 0 m^3/s.
- **Collect isotopic data at this site following Section 4.**

Site Image:

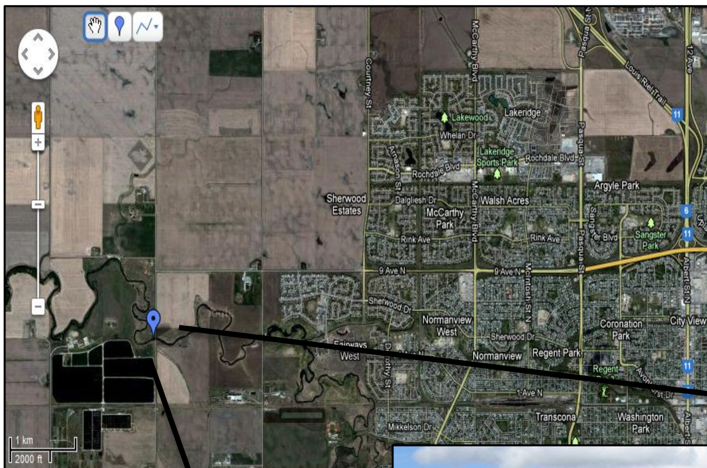
Hydrometric Data:



Historical daily discharges from Wascana Creek below Kronau Marsh hydrometric station. Statistics corresponding to 19 years of data recorded from 1974 to 1992. http://www.wsc.ec.gc.ca/applications/H2O/graph-eng.cfm?station=05JF012&report=daily&year=1992

10. Wascana Creek: Above SWTP Riske's Crossing

Lat/Lon= 50.47639N, 104.73194W
UTM=5570344.7n 458927.8e
Location:



Site Notes:

- Upstream of the Regina Sewage Water Treatment Plant. From Regina, exit Dewdney Avenue to Grid 730. Turn north on the grid just east of the Sherwood Forest grid to Riske's Crossing.
- This site has muddy banks and a primarily mud substrate.
- Median annual discharge is 2941.7472, median peak flow is 2.41 and median minimum flow is 0.
- **Collect isotopic data at this site following Section 4.**

Site Image:

*Hydrometric graph unavailable

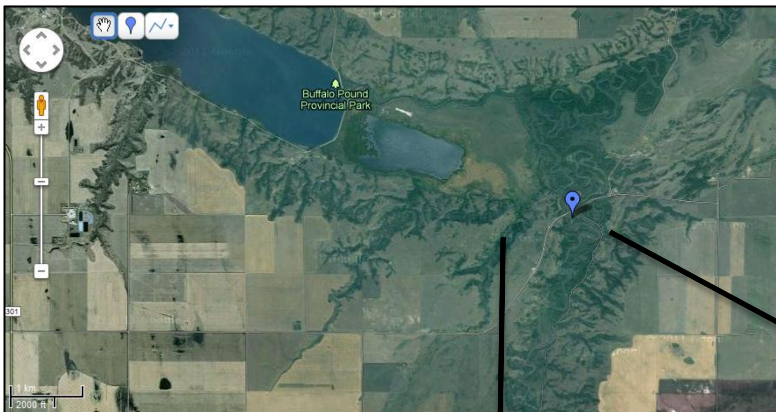
11. Moose Jaw River: Above QR, South of BPWTP

Site Notes:

- South of Buffalo Pound Provincial Park and is best accessed following Grid 642 following the map shown below.
- This site is typically very shallow with steep banks and has sandy substrate.
- **Collect isotopic data at this site following Section 4.**

Lat/Lon= 50.3228N, 105.1715W
UTM= 5574536.2n 512208.4e

Location:



Site Image:

*Hydrometric graph unavailable

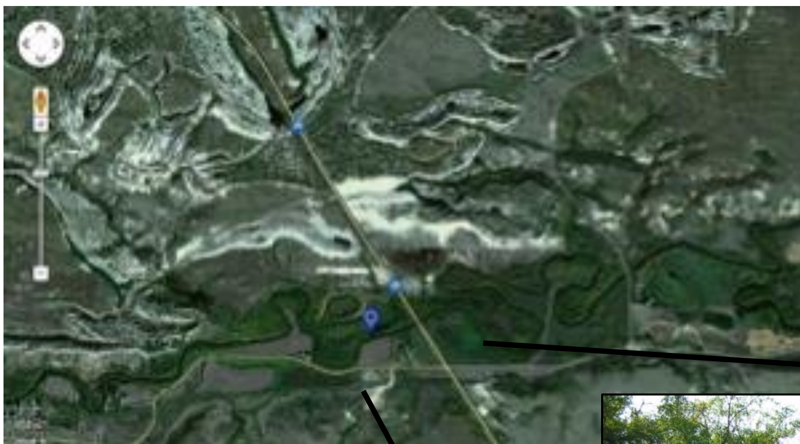
12. Souris River: Highway 39 at Roche Percee

Lat/Lon=49.07061N, 102.8087W
UTM= 5437619.0n 339955.0e

Site Notes:

- This site is easily accessible off Highway 39 West of Roche Percee
- Vegetated banks and a high percentage canopy cover with a mud substrate.
- Median annual flow is 18610.0416 dam^3, median peak discharge 9.03m^3/s and median minimum discharge 0m^3/s.

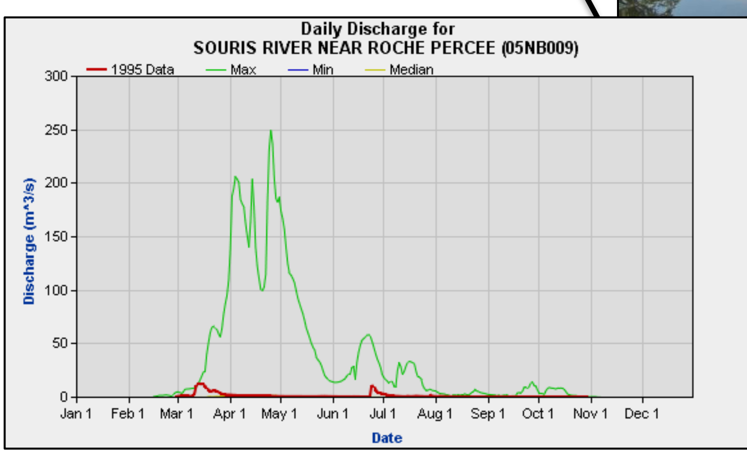
Location:



:

Site Image:

Hydrometric Data:



Historical daily discharges for Souris River near Roche Percee hydrometric station. Statistics corresponding to 36 years of data recorded from 1956 to 1995. http://www.wsc.ec.gc.ca/applications/H2O/graph-eng.cfm?station=05NB009&report=daily&data=flow&ye

13. Souris River: Nickle Lake Discharge

Lat/Lon= 49.57861N, 103.77500W
UTM= 5466867.8n 388358.9e

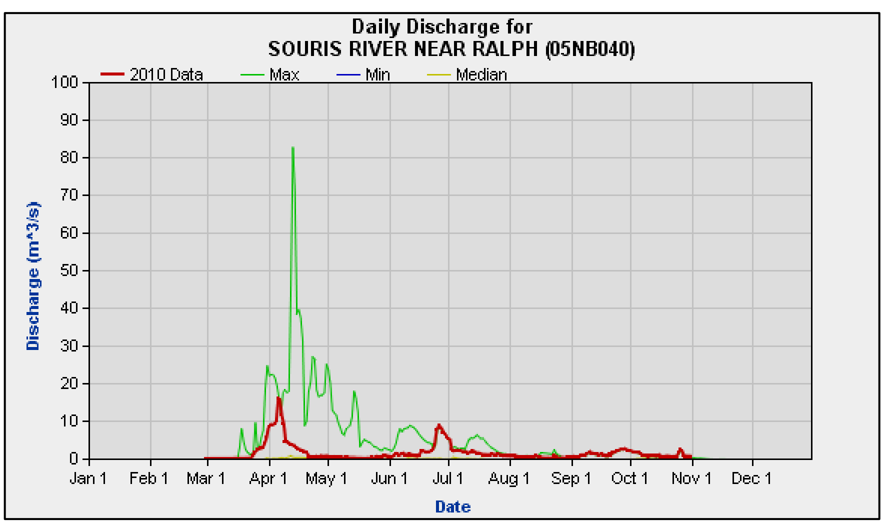
Site Notes:

- Site southwest of Ralph, SK off Highway 39. Site is downstream of Nickle Lake Discharge and upstream of the bridge.
- Area of very low flow with median peak and minimum flows less than 5 m^3/s.

Location:

*Historical site image unavailable

Hydrometric Data:



Historical daily discharges for Souris River near Ralph hydrometric Station. Statistics corresponding to 14 years of data recorded from 1997 to 2010. http://www.wsc.ec.gc.ca/applications/H2O/graph-eng.cfm?station=05NB040&report=daily&data=flow&year=2010

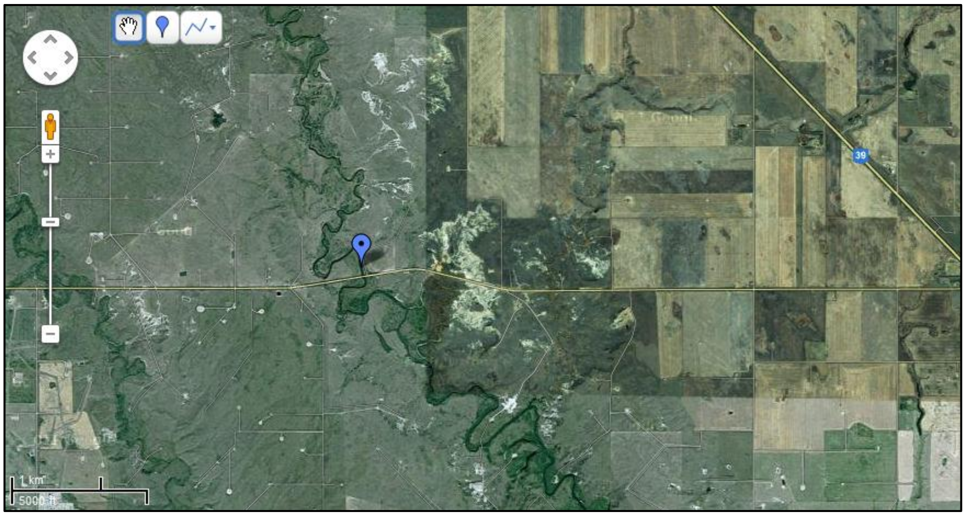
14. Souris River: West of Halbrite

Lat/Lon=49.49306N, 103.66250W
UTM=5461324.2n 383263.5e

Site Notes:

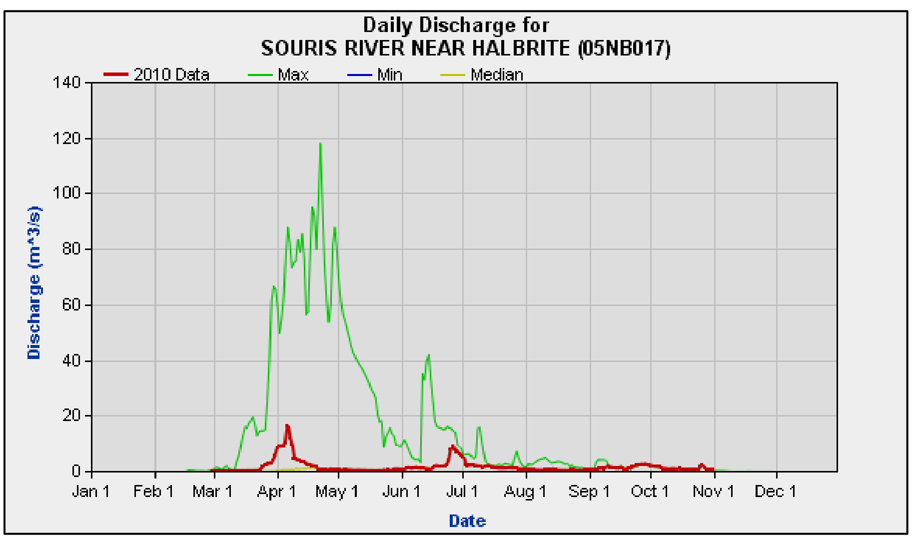
- Directly west of Halbrite on Grid 705
- Annual discharge in 2010 is 29 878 dam^3 According to Environment Canada, Water Survey of Canada Service the median peak and minimum flow are very low, less than $5m^3/s$.

Location:



*Historical site image unavailable

Hydrometric Data:



Historic daily discharges for Souris River near Halbrite Hydrometic station. Statistics corresponding to 49 years of data recorded from 1959 to 2010. http://www.wsc.ec.gc.ca/applications/H2O/graph-eng.cfm?yearb=&yeare=&station=05NB017&report=daily&year=2010

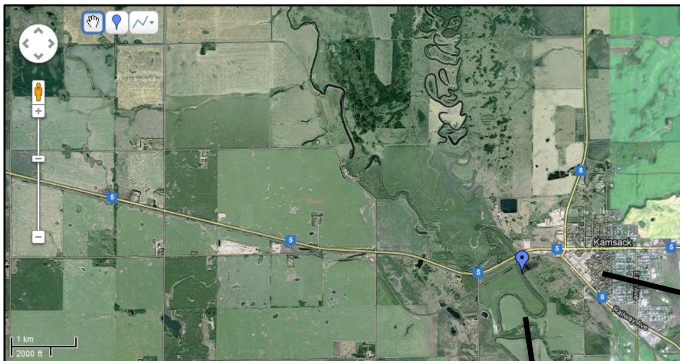
15. Assiniboine River: Kamsack (PPWB site)

UTM=721784.0n   5707536.0e

Site Notes:

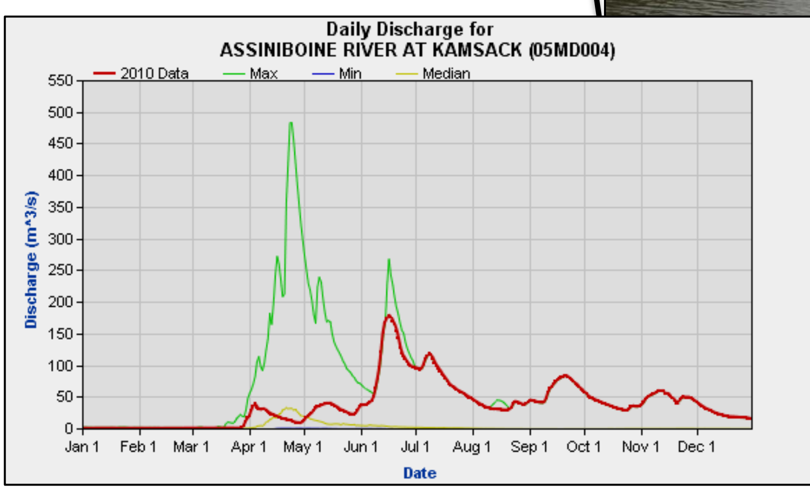
- Site is located immediate west of Kamsack off Highway 5.
- Bottom substrate is predominantly mud with some cobble. Boreal transition ecozone so coniferous vegetation is present.
- Median annual discharge is 139104.5184 dam^3, median peak flow 55.3m^3 and median minimum flow 0.054m^3/s.

Location:



Site Image:

Hydrometric Data:



Historical daily discharge from Assiniboine River near Kamsack hydrometric station. Statistics corresponding to 67 years of data recorded from 1944 to 2010. http://www.wsc.ec.gc.ca/applications/H2O/graph-eng.cfm?station=05MD004&report=daily&data=flow&ye

16. Qu'Appelle River: Welby (PPWB Site)

Site Notes:

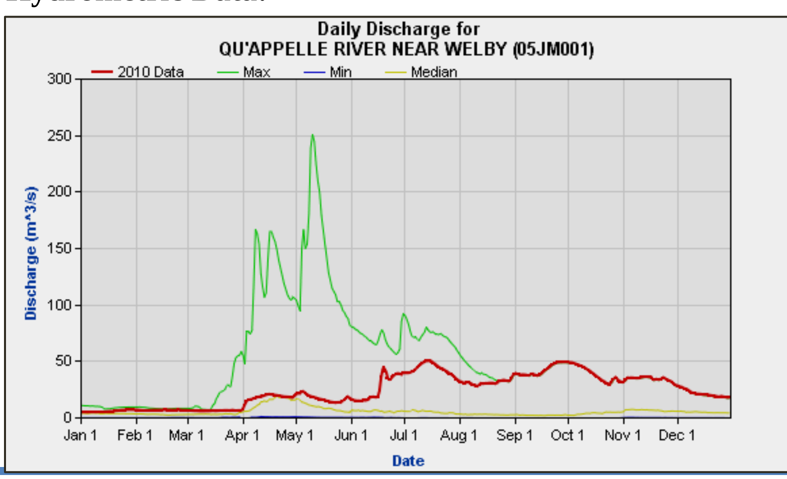
- Site is located south of Welby and east on a Grid off Highway 8.
- The site is a shallow area with mud substrate.
- Median annual flow is 173239.6896 dam^3, median peak flow 39.75m^3/s and median

Lat/Lon= 50.5120404W, 102.35762N
UTM=5598899.2n 687340.0e

Location:

Site Image:

Hydrometric Data:



Historical daily discharges for Qu'Appelle River near Welby hydrometric station. Statistics corresponding to 51 years of data recorded from 1915 to 2010. http://www.wsc.ec.gc.ca/applications/H2O/graph-eng.cfm?station=05JM001&report=daily&year=2010

17. Moose Jaw River: Roleau (MoA ref Site)

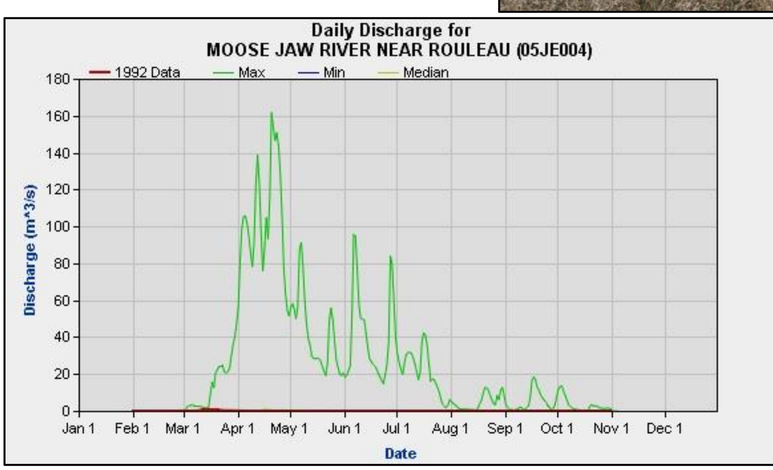
Lat/Long= 50.191598970872235N,
104.9859628187386W
UTM=5559934.0n 501002.0e

Site Notes:

- Located directly east of Roleau, it is accessible easily by following the grid road shown in the map below.
- Current hydrometric data is unavailable, however median annual discharge from 1944 to 1992 at this site is 752.3 dam^3.
- This is an area with low flow and the median peak flow and minimum flow are both near 0

Location:

Site Image:



Historic daily discharges for Moose Jaw River near Rouleau Hydrometric Station. Statistics corresponding to 49 years of data recorded from 1944 to 1992. http://www.wsc.ec.gc.ca/applications/H2O/graph-eng.cfm?station=05JE004&report=daily&data=flow&year=1992

Appendix B) Benthic macroinvertebrate sample collection sheets

Benthic macroinvertebrate collection sheet (from SWA)

Minitstry of Environment Benthic Macroinvertebrate Collection - 2012

SITE NUMBER:	LOCATION
STREAM NAME:	INVESTIGATORS:
UTM	DATE
	TIME
PROJECT	BMI SAMPLE#'S

Water Quality

Water Temperature (C):	Salinity (ppt):	Conductivity (uS/cm):
Dissolved Oxygen (mg/L):		Turbdity (NTU's):

Benthos Collection

Sample #	Habitat	Method	Replicates	Time	Area	Transect Depth (m):
Example	**Run/Riffle/Pool**	**TK&S**	**5**	**10s**	**~30cmX30cm**	**Depth at 1/4,1/2,3/4 of transect**
1						
2						
3						
4						
Habitat Type	**Mud (%)**	**Sand (%)**	**Gravel (%)**	**Cobble (%)**	**Boulder (%)**	**Vegetated banks (%)**
1						
2						
3						
4						

Physical Characteristics

Velocity: Time (s): Distance (m):

Substrate: *Enter dominant substrate class and second dominant class for each sample (X/x)*

	Sample 1	Sample 2	Sample 3	Sample 4
Sample:				

Embeddedness:

Substrate Notes:

Channel Flow Status:

Sediment Deposition Score:

Class	Description
1	Clay (hard pan)
2	Silt (gritty, < 0.06 mm particle)
3	Sand (grainy, 0.06 - 2mm)
4	Gravel (2-65 mm)
5	Cobble (65 - 250 mm)
6	Boulder (> 250 mm)
7	Bed Rock

Bank Stability

Other	Left	Right

% Canopy Cover (circle)		Zone	Left Bank	Right Bank	Riparian Vegetative Community
0-24	25-49	1.5-10 m			1 (None), 2 (cultivated), 3 (pasture), 4 (scrubland),
50-74	75-100	10-30 m			5 (forest, coniferous), 6 (forest, deciduous)
		30-100 m			

Aquatic Vegetation

Type: Emergent (E), Rooted Floating (RF), Submergent (S), Free Floating (FF)

Macrophyte Type

	Sample 1	Sample 2	Sample 3	Sample 4
Sample:				

Algae Type

	Sample 1	Sample 2	Sample 3	Sample 4
Sample:				

Use 1: Abundant, 2: Present, 3: Absent

	Sample 1	Sample 2	Sample 3	Sample 4
Wood Deb.				
Macrophyte:				

	Sample 1	Sample 2	Sample 3	Sample 4
Detritus:				
Algae:				

River Characterization Perennial Intermittent Unknown

General Comments:

Riparian Health Assessment Field Sheet (1 of 2)

RIPARIAN HEALTH ASSESSMENT - FIELD SHEET

Landowner/lessee:________________ Date:________ Reach No:_____

Stream/River: ________________________________

Site Description:______________________________

____

						Scores or N/A *Actual*	*Possible*
1. Vegetative Cover of Floodplain and Streambanks							
	6	*4*	*2*	*0*		___	___
2. Invasive Plant Species							
	3	*2*	*1*	*0*	(cover)	___	___
	3	*2*	*1*	*0*	(density)	___	___
3. Disturbance-increaser Undesirable Herbaceous Species							
	3	*2*	*1*	*0*		___	___
4. Preferred Tree and Shrub Establishment and Regeneration							
	6	*4*	*2*	*0*		___	___
5. Utilization of Preferred Trees and Shrubs							
	3	*2*	*1*	*0*		___	___
6. Standing Decadent and Dead Woody Material							
	3	*2*	*1*	*0*		___	___
7. Streambank Root Mass Protection							
	6	*4*	*2*	*0*		___	___
8. Human-Caused Bare Ground							
	6	*4*	*2*	*0*		___	___
9. Streambank Structurally Altered by Human Activity							
	6	*4*	*2*	*0*		___	___
10. Streambank Subject to Active Lateral Cutting							
	6	*4*	*2*	*0*		___	___
11. Reach Structurally Altered by Human Activity (excl. banks)							
	3	*2*	*1*	*0*		___	___
12. Stream Channel Incisement (vertical stability)							
	9	*6*	*3*	*0*		___	___
					TOTAL	___	___

Health Score = Total actual score / Total possible score = _________

%	0-59	60-79	80-100
	← Unhealthy →	← Healthy With Problems →	← Healthy →

Riparian Health Assessment Field Sheet (2 of 2)

RIPARIAN HEALTH ASSESSMENT - FIELD SHEET

Comments

1. Vegetative Cover of Floodplain and Streambanks
2. Invasive Plant Species
3. Disturbance-Increaser Undesirable Herbaceous Species
4. Preferred Tree and Shrub Establishment and Regeneration
5. Utilization of Preferred Trees and Shrubs
6. Standing Decadent and Dead Woody Material
7. Streambank Root Mass Protection
8. Human-Caused Bare Ground
9. Streambank Structurally Altered by Human Activity
10. Streambank Subject to Active Lateral Cutting
11. Pugging, Hummocking and/or Rutting
12. Stream Channel Incisement (vertical stability)

Sketch stream reach here	*Show photo locations*

Benthic macroinvertebrate sample collection labels

MoE BMI Collection Label

Site Code	MoE_2012_
Waterbody	
Location	
Sample #	1

MoE BMI Collection Label

Site Code	MoE_2012_
Waterbody	
Location	
Sample #	2

MoE BMI Collection Label

Site Code	MoE_2012_
Waterbody	
Location	
Sample #	3

MoE BMI Collection Label

Site Code	MoE_2012_
Waterbody	
Location	
Sample #	4

MoE BMI Collection Label

Site Code	MoE_2012_
Waterbody	
Location	
Sample #	1

MoE BMI Collection Label

Site Code	MoE_2012_
Waterbody	
Location	
Sample #	2

MoE BMI Collection Label

Site Code	MoE_2012_
Waterbody	
Location	
Sample #	3

MoE BMI Collection Label

Site Code	MoE_2012_
Waterbody	
Location	
Sample #	4

MoE BMI Collection Label

Site Code	MoE_2012_
Waterbody	
Location	
Sample #	1

MoE BMI Collection Label

Site Code	MoE_2012_
Waterbody	
Location	
Sample #	2

MoE BMI Collection Label

Site Code	MoE_2012_
Waterbody	
Location	
Sample #	3

MoE BMI Collection Label

Site Code	MoE_2012_
Waterbody	
Location	
Sample #	4

MoE BMI Collection Label

Site Code	MoE_2012_
Waterbody	
Location	
Sample #	1

MoE BMI Collection Label

Site Code	MoE_2012_
Waterbody	
Location	
Sample #	2

MoE BMI Collection Label

Site Code	MoE_2012_
Waterbody	
Location	
Sample #	3

MoE BMI Collection Label

Site Code	MoE_2012_
Waterbody	
Location	
Sample #	4

MoE BMI Collection Label

Site Code	MoE_2012_
Waterbody	
Location	
Sample #	1

MoE BMI Collection Label

Site Code	MoE_2012_
Waterbody	
Location	
Sample #	2

MoE BMI Collection Label

Site Code	MoE_2012_
Waterbody	
Location	
Sample #	3

MoE BMI Collection Label

Site Code	MoE_2012_
Waterbody	
Location	
Sample #	4

SWA BMI Sorting Label | **SWA BMI Sorting Label**

Site# & WB		Site# & WB	
Date		Date	
Method		Method	
Sample #		Sample #	
Sort Fraction		Sort Fraction	

SWA BMI Sorting Label | **SWA BMI Sorting Label**

Site# & WB		Site# & WB	
Date		Date	
Method		Method	
Sample #		Sample #	
Sort Fraction		Sort Fraction	

SWA BMI Sorting Label | **SWA BMI Sorting Label**

Site# & WB		Site# & WB	
Date		Date	
Method		Method	
Sample #		Sample #	
Sort Fraction		Sort Fraction	

SWA BMI Sorting Label | **SWA BMI Sorting Label**

Site# & WB		Site# & WB	
Date		Date	
Method		Method	
Sample #		Sample #	
Sort Fraction		Sort Fraction	

SWA BMI Sorting Label | **SWA BMI Sorting Label**

Site# & WB		Site# & WB	
Date		Date	
Method		Method	
Sample #		Sample #	
Sort Fraction		Sort Fraction	

SWA BMI Sorting Label | **SWA BMI Sorting Label**

Site# & WB		Site# & WB	
Date		Date	
Method		Method	
Sample #		Sample #	
Sort Fraction		Sort Fraction	

SWA BMI Sorting Label | **SWA BMI Sorting Label**

Site# & WB		Site# & WB	
Date		Date	
Method		Method	
Sample #		Sample #	
Sort Fraction		Sort Fraction	

SWA BMI Sorting Label | **SWA BMI Sorting Label**

Site# & WB		Site# & WB	
Date		Date	
Method		Method	
Sample #		Sample #	
Sort Fraction		Sort Fraction	

SWA BMI Sorting Label | **SWA BMI Sorting Label**

Site# & WB		Site# & WB	
Date		Date	
Method		Method	
Sample #		Sample #	
Sort Fraction		Sort Fraction	

Benthic macroinvertebrate sample log in sheet

SWA Benthic Macroinvertebrate Sample Log-in Sheet					
Site Code	Stream Name	Date Collected	Collected by	# of Samples	Date Received by SWA Lab

Isotope sample collection labels

MoE Isotope Collection Label		MoE Isotope Collection Label	
Location		Location	
Date		Date	
Collector		Collector	
Waterbody		Waterbody	
Project		Project	
Sample id?		Sample id?	

MoE Isotope Collection Label		MoE Isotope Collection Label	
Location		Location	
Date		Date	
Collector		Collector	
Waterbody		Waterbody	
Project		Project	
Sample id?		Sample id?	

MoE Isotope Collection Label		MoE Isotope Collection Label	
Location		Location	
Date		Date	
Collector		Collector	
Waterbody		Waterbody	
Project		Project	
Sample id?		Sample id?	

MoE Isotope Collection Label		MoE Isotope Collection Label	
Location		Location	
Date		Date	
Collector		Collector	
Waterbody		Waterbody	
Project		Project	
Sample id?		Sample id?	

MoE Isotope Collection Label		MoE Isotope Collection Label	
Location		Location	
Date		Date	
Collector		Collector	
Waterbody		Waterbody	
Project		Project	
Sample id?		Sample id?	

MoE Isotope Collection Label		MoE Isotope Collection Label	
Location		Location	
Date		Date	
Collector		Collector	
Waterbody		Waterbody	
Project		Project	
Sample id?		Sample id?	

MoE Isotope Collection Label		MoE Isotope Collection Label	
Location		Location	
Date		Date	
Collector		Collector	
Waterbody		Waterbody	
Project		Project	
Sample id?		Sample id?	

MoE Isotope Collection Label		MoE Isotope Collection Label	
Location		Location	
Date		Date	
Collector		Collector	
Waterbody		Waterbody	
Project		Project	
Sample id?		Sample id?	

Isotope sample log-in sheet

SWA Isotope Sample Log-in Sheet					
Site Code	Stream Name	Sample Type	Date Collected	Collected by:	# of Samples

Example Chain of Custody and serial number assignment sheet

Saskatchewan Watershed Authority - BENT Lab - Chain-of-Custody Records: Sample Identification

SWA-BENT-Serial #	Site Number	Date Collected	Date Sorted	Project Name	Sample # and Split Fraction							
SWA-BENT- 000381 Arc. 1						1/2	1/4	1/8	1/16	1/32	1/64	W
SWA-BENT- 000381 Arc. 2						1/2	1/4	1/8	1/16	1/32	1/64	W
SWA-BENT- 000381 Sort						1/2	1/4	1/8	1/16	1/32	1/64	W
SWA-BENT- 000382 Arc. 1						1/2	1/4	1/8	1/16	1/32	1/64	W
SWA-BENT- 000382 Arc. 2						1/2	1/4	1/8	1/16	1/32	1/64	W
SWA-BENT- 000382 Sort						1/2	1/4	1/8	1/16	1/32	1/64	W
SWA-BENT- 000383 Arc. 1						1/2	1/4	1/8	1/16	1/32	1/64	W
SWA-BENT- 000383 Arc. 2						1/2	1/4	1/8	1/16	1/32	1/64	W
SWA-BENT- 000383 Sort						1/2	1/4	1/8	1/16	1/32	1/64	W
SWA-BENT- 000384 Arc. 1						1/2	1/4	1/8	1/16	1/32	1/64	W
SWA-BENT- 000384 Arc. 2						1/2	1/4	1/8	1/16	1/32	1/64	W
SWA-BENT- 000384 Sort						1/2	1/4	1/8	1/16	1/32	1/64	W
SWA-BENT- 000385 Arc. 1						1/2	1/4	1/8	1/16	1/32	1/64	W
SWA-BENT- 000385 Arc. 2						1/2	1/4	1/8	1/16	1/32	1/64	W
SWA-BENT- 000385 Sort						1/2	1/4	1/8	1/16	1/32	1/64	W
SWA-BENT- 000386 Arc. 1						1/2	1/4	1/8	1/16	1/32	1/64	W
SWA-BENT- 000386 Arc. 2						1/2	1/4	1/8	1/16	1/32	1/64	W
SWA-BENT- 000386 Sort						1/2	1/4	1/8	1/16	1/32	1/64	W
SWA-BENT- 000387 Arc. 1						1/2	1/4	1/8	1/16	1/32	1/64	W
SWA-BENT- 000387 Arc. 2						1/2	1/4	1/8	1/16	1/32	1/64	W
SWA-BENT- 000387 Sort						1/2	1/4	1/8	1/16	1/32	1/64	W
SWA-BENT- 000388 Arc. 1						1/2	1/4	1/8	1/16	1/32	1/64	W
SWA-BENT- 000388 Arc. 2						1/2	1/4	1/8	1/16	1/32	1/64	W
SWA-BENT- 000388 Sort						1/2	1/4	1/8	1/16	1/32	1/64	W
SWA-BENT- 000389 Arc. 1						1/2	1/4	1/8	1/16	1/32	1/64	W
SWA-BENT- 000389 Arc. 2						1/2	1/4	1/8	1/16	1/32	1/64	W
SWA-BENT- 000389 Sort						1/2	1/4	1/8	1/16	1/32	1/64	W
SWA-BENT- 000390 Arc. 1						1/2	1/4	1/8	1/16	1/32	1/64	W
SWA-BENT- 000390 Arc. 2						1/2	1/4	1/8	1/16	1/32	1/64	W
SWA-BENT- 000390 Sort						1/2	1/4	1/8	1/16	1/32	1/64	W
SWA-BENT- 000391 Arc. 1						1/2	1/4	1/8	1/16	1/32	1/64	W
SWA-BENT- 000391 Arc. 2						1/2	1/4	1/8	1/16	1/32	1/64	W
SWA-BENT- 000391 Sort						1/2	1/4	1/8	1/16	1/32	1/64	W
SWA-BENT- 000392 Arc. 1						1/2	1/4	1/8	1/16	1/32	1/64	W

Chain of custody sheet for samples leaving the lab to consultants

Saskatchewan Watershed Authority - BENT Lab - Chain of Custody Records

Date Sent to Sorter:
Date Sent to Identifyer:

Sample Serial #	Site #	Waterbody	Sample Date	Fraction	Project Name
SWA BENT					
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1) D-70; Overall condition is Healthy, with a TSA D value of 2.5 and the site is within the 95% confidence interval of reference sites in its biological grouping (p = 0.97). The only metric that is showing any stress is the number of species present, but even it is not impaired.

2) H-60; Overall condition is Stressed, with a TSA D value of 2.7 and the site is outside the 95% confidence interval of reference sites in its biological grouping (p = 0.91). In this site it is the Simpson's diversity and the number of species which are driving the impairment. However, it is important to note that this site is just barely stressed relative to reference condition, and certainly is not impaired.

I can compare D-70 to the historical collections made in 2007, with the caveat that there were slight differences in collection method. However, D-70 in 2007 is healthy as well, with an overall D value of 2.2, and is well within the 95% confidence interval of reference sites in its biological grouping (p = 0.99). No metrics were showing any stress at that time.

To reference how these values are calculated, please see State of the Watershed Report from 2010:
https://www.wsask.ca/Global/About%20WSA/Publications/State%20of%20the%20Watershed/d_AppendixA-ConditionIndicators.PDF