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.

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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.

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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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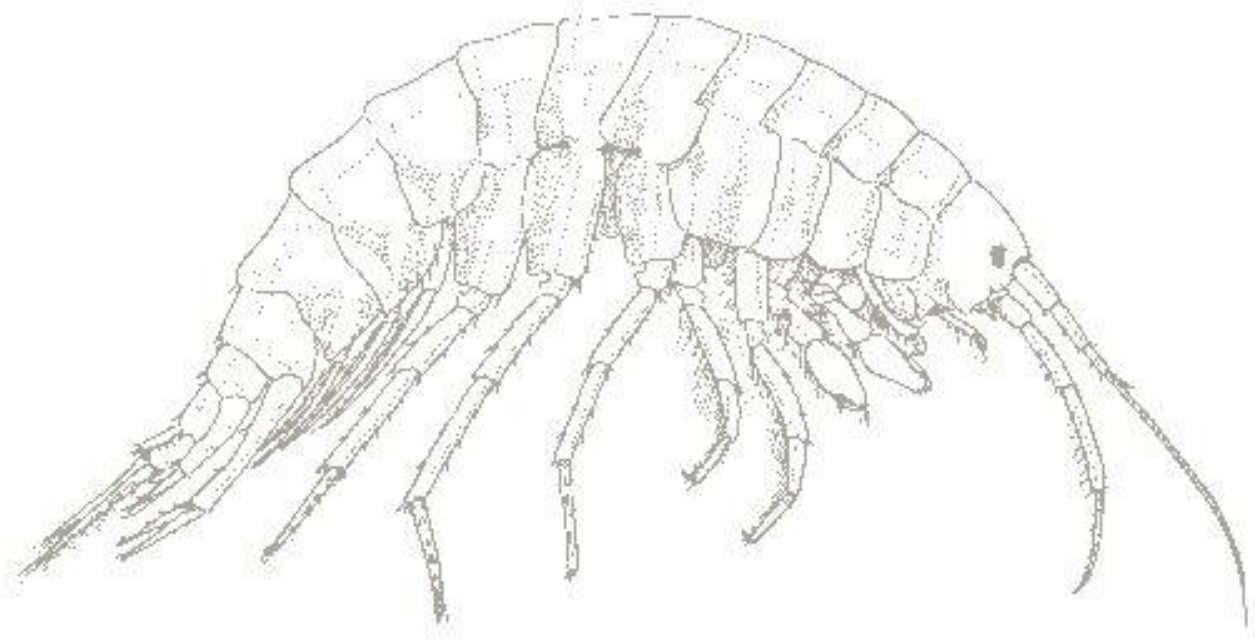


Introduction

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.

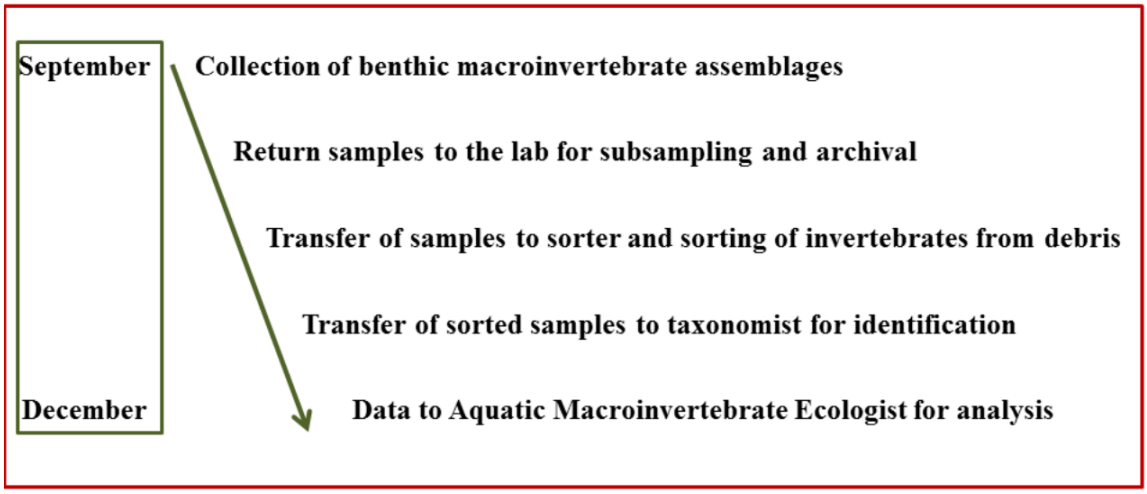


Figure 1. Flowchart of processes and coarse timeline for the collection and preparation of benthic macroinvertebrate samples as part of an ecosystem health assessment.

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.

Benthic macroinvertebrate collection for isotopic analysis

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:

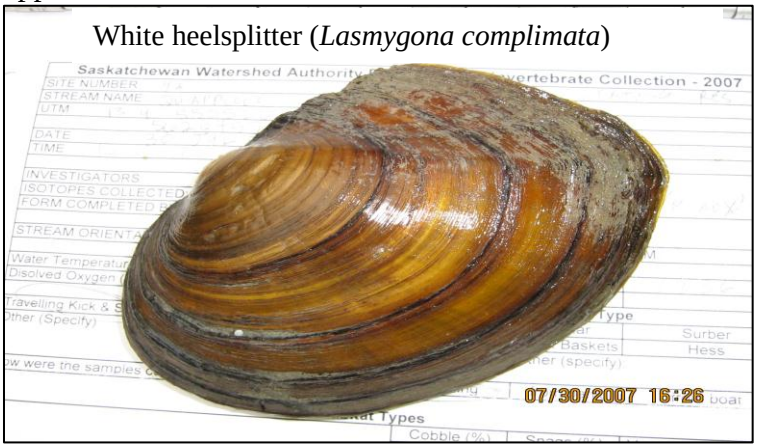
1. Collect snails by overturning rocks and searching macrophytes along the submerged banks of the river and dive for mussels in the benthic regions.

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^{o}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

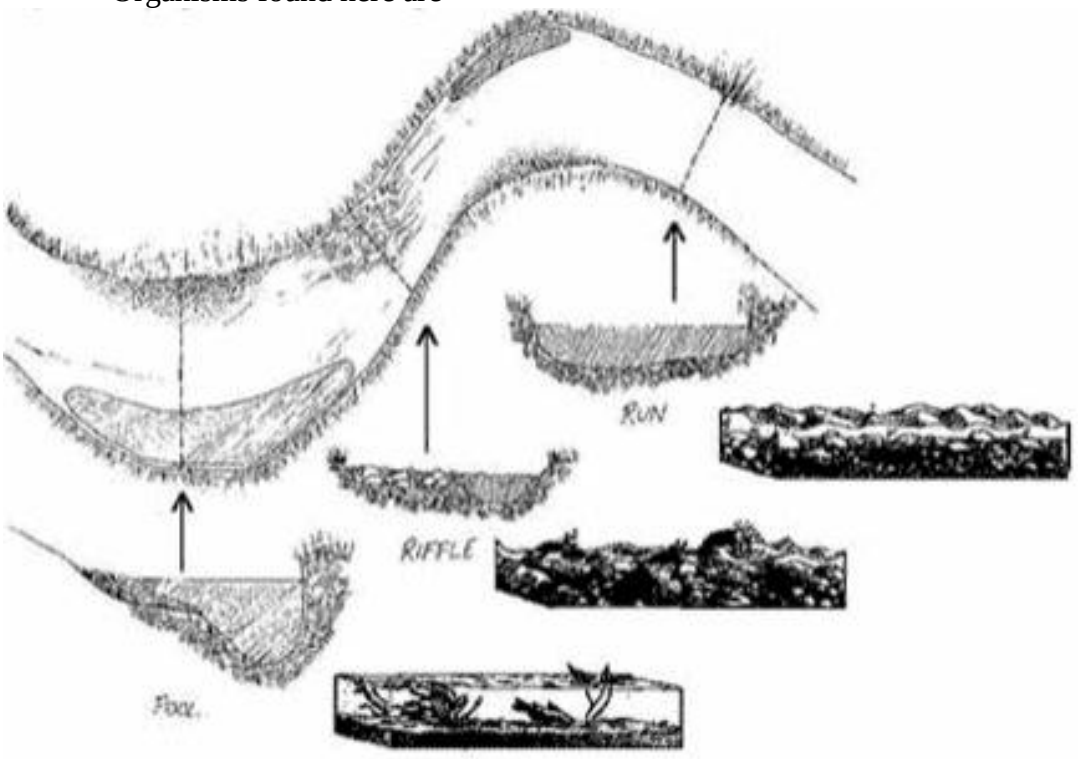


Figure 2: Diagram of components of the stream including a riffle, run and pool. A pool is deep and slow moving water whereas a riffle and run are shallow and fast moving. A riffle has cobble and a run has no obstructions. Image credit: http://www.lakesuperiorstreams.org/understanding/riffle_run_pool.htm

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).

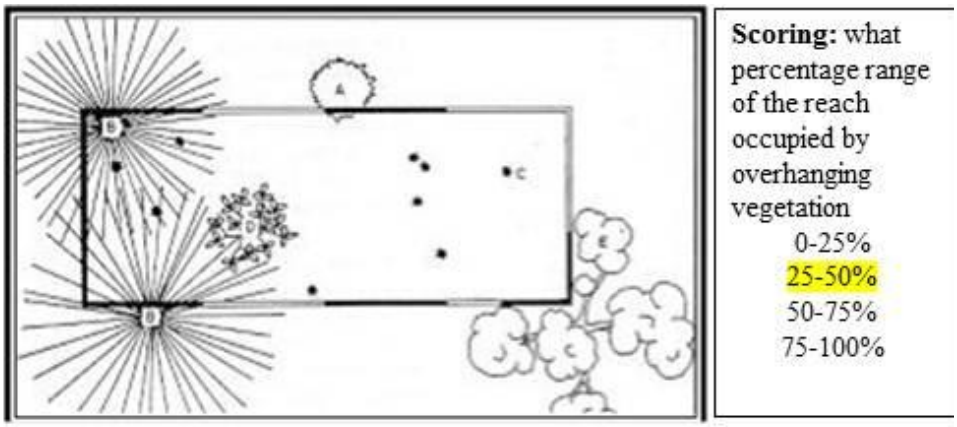


Figure 7: Estimation of vegetative canopy cover. This inner rectangle represents the area considered canopy cover in habitat assessment. This would be scored in the range of 25-50% canopy cover. Photo credit: PCAP riparian health assessment.

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

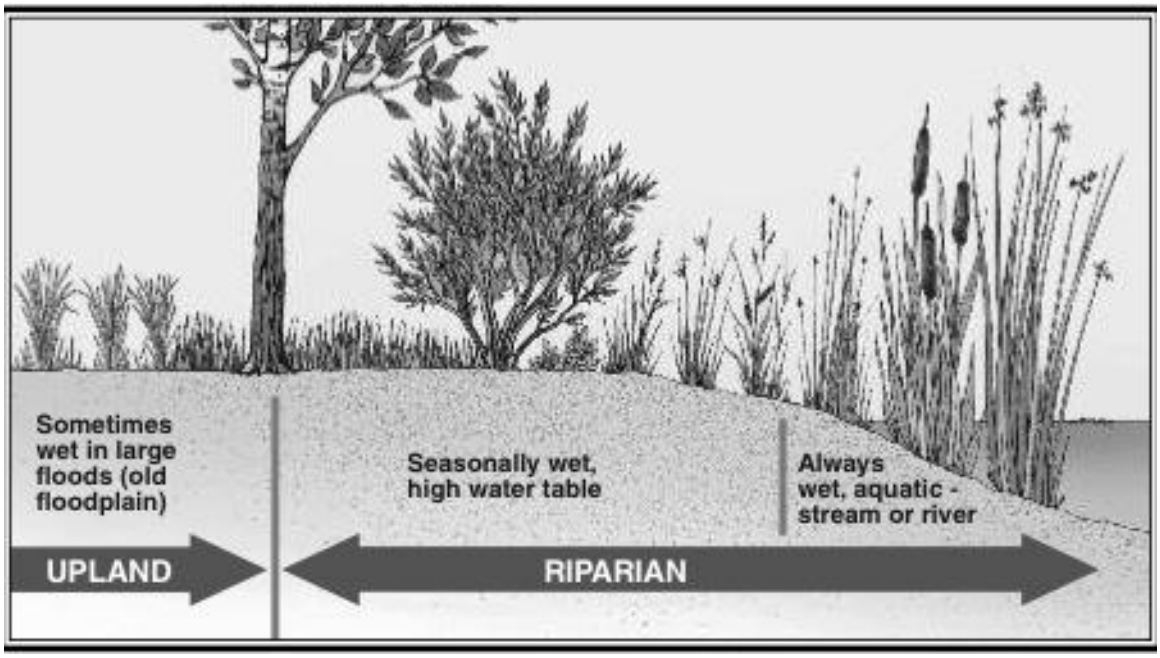


Figure 8: Illustration of riparian and upland area Photo credit: Prairie Conservation Action Plan, 2008.

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.

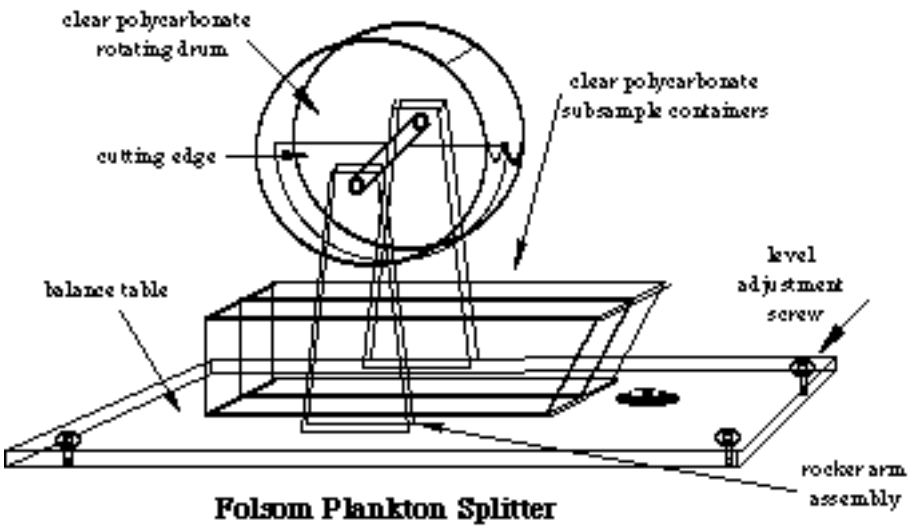


Figure 11: Folsom Plankton Splitter and its Components. Photo Credit: http://www.aquaticresearch.com/folsom_plankton_splitter.htm

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

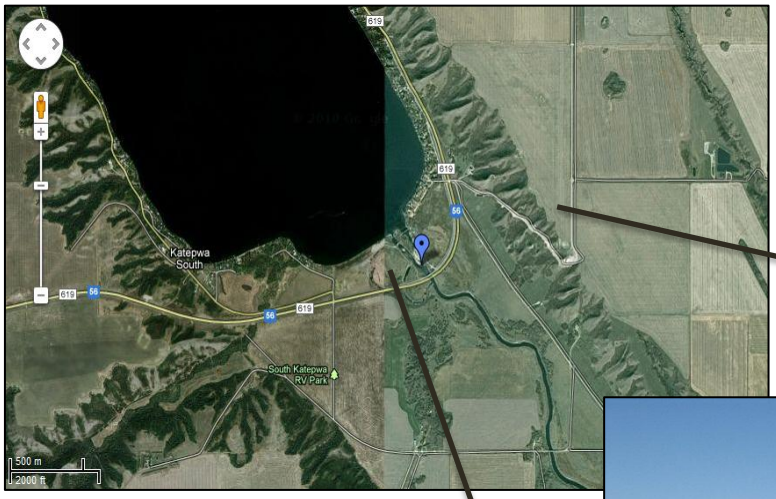
1. Qu'Appelle River: at Highway 56

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

Site Notes:

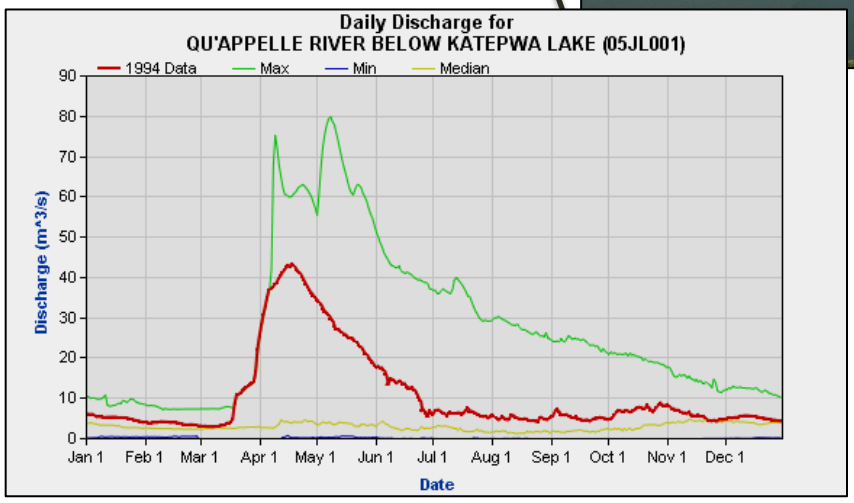
- To access the site follow Highway 56 from Fort Qu'Appelle along Katepwa lakes and sample ~100 downstream of the bridge on Highway 56 to avoid influences of the water control structure.
- The site has shallow banks and is easily accessible from the bridge.

Location:



Site Image:

Hydrometric Data:

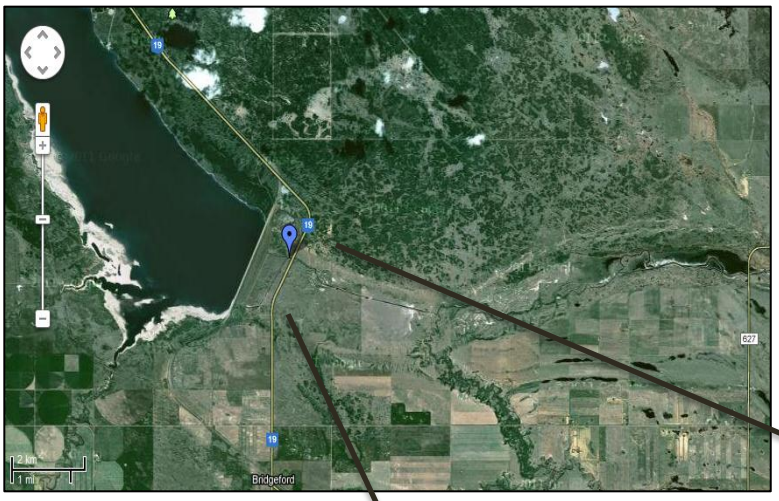


Historical daily discharge from Qu'Appelle River below Katepwa Lake hydrometric station. Statistics corresponding to 31 years of data recorded from 1955 to 1994. http://www.wsc.ec.gc.ca/applications/H2O/graph-eng.cfm?station=05JL001&report=daily&data=fl

2. Qu'Appelle: Highway 19

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

Location:

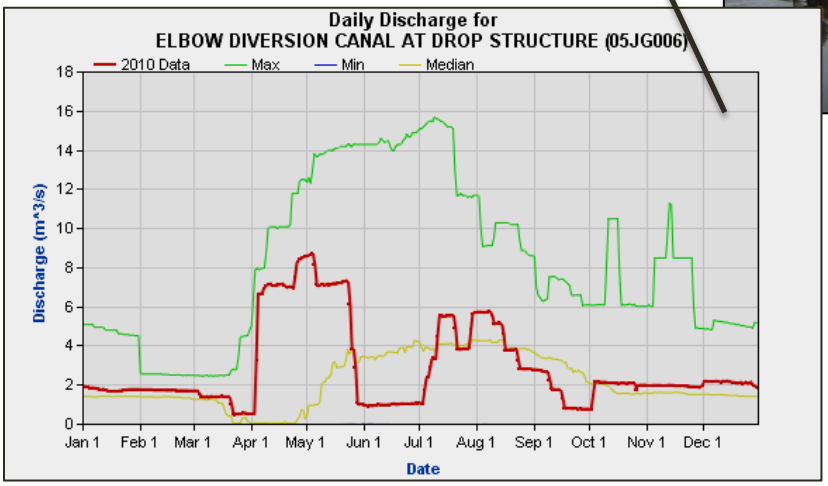


Site Notes:

- 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

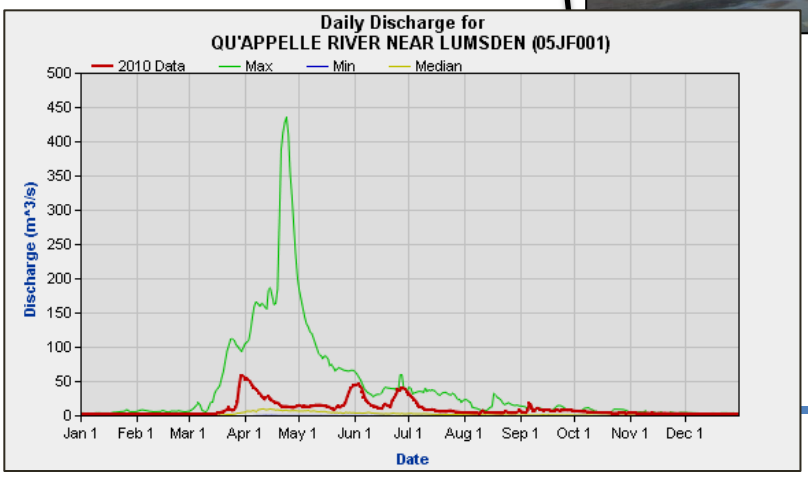
Site Notes:

- 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.

Location:

Site Image:

Hydrometric Data:

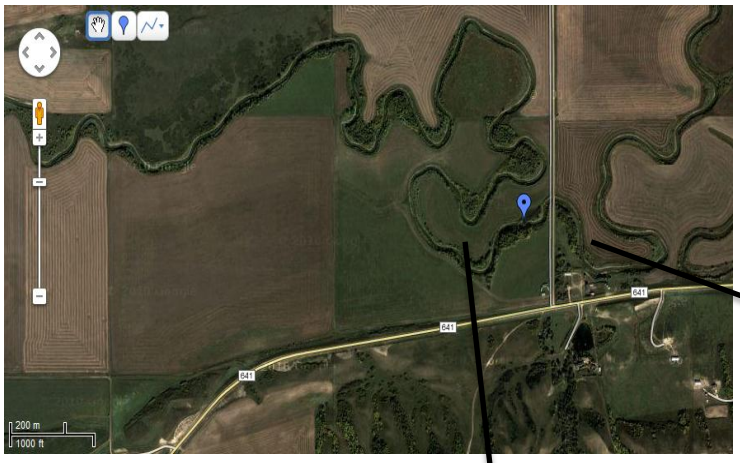


Historical data from Qu'Appelle River near Lumsden hydrometric station. Statistics corresponding to 84 years of data recorded from 1911 to 2010. http://www.wsc.ec.gc.ca/applications/H2O/graph-eng.cfm?station=05JF001&report=daily&data=flow&year=2010

4. Qu'Appelle River: Above Wascana

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

Location:

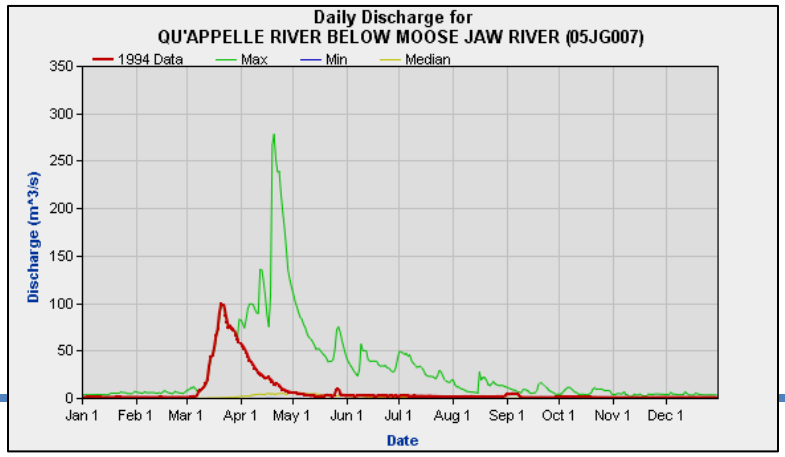


Site notes:

- 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

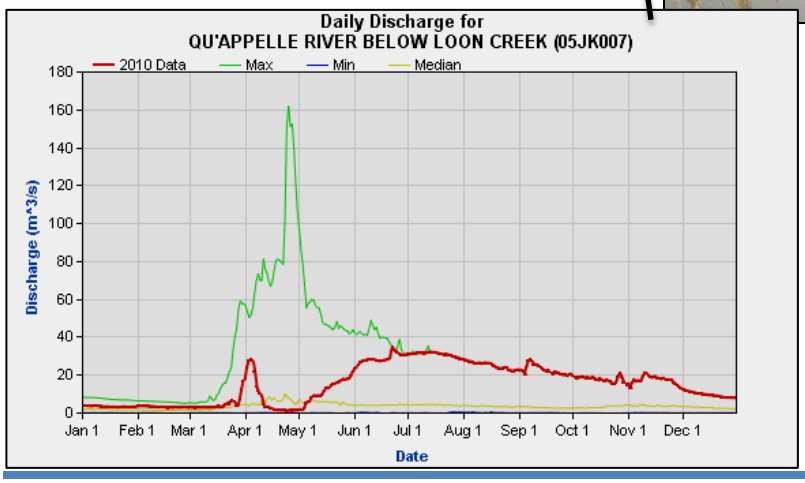
Location:

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

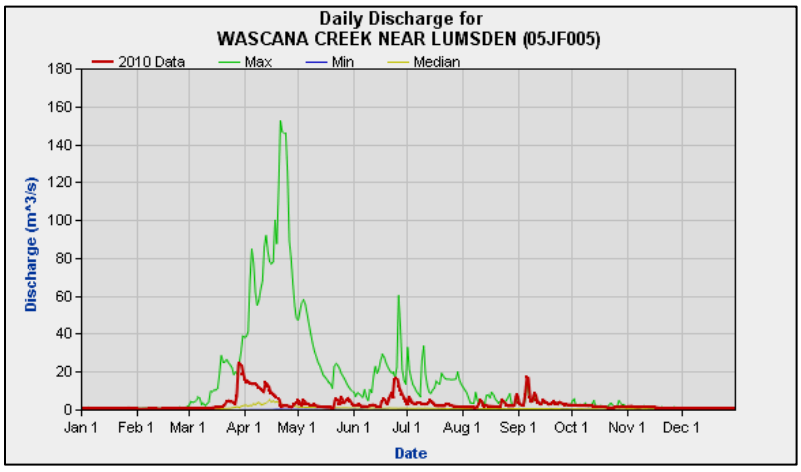
Site Notes:

- 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

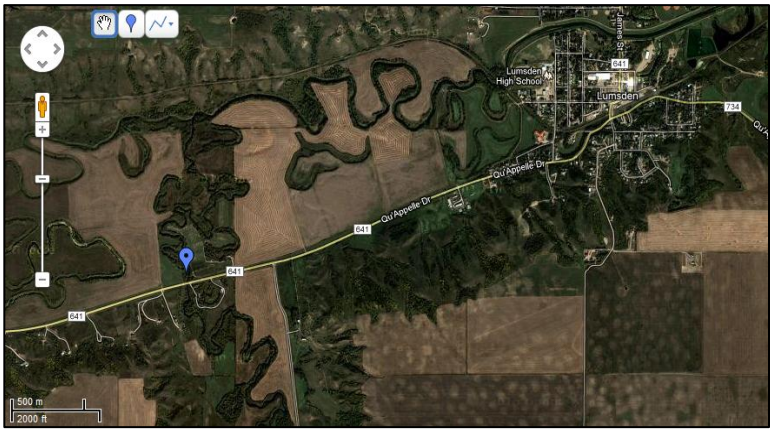
Hydrometric Data:



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:

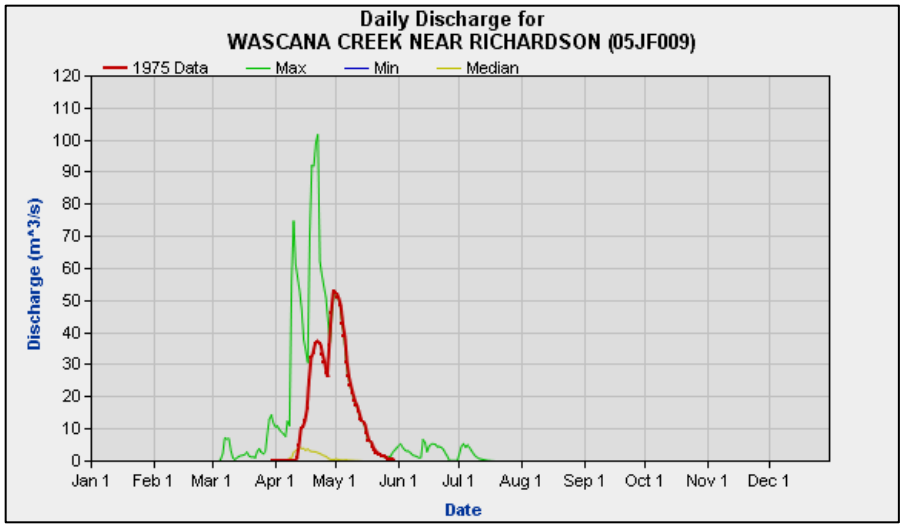


*Historical site picture unavailable

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.**

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

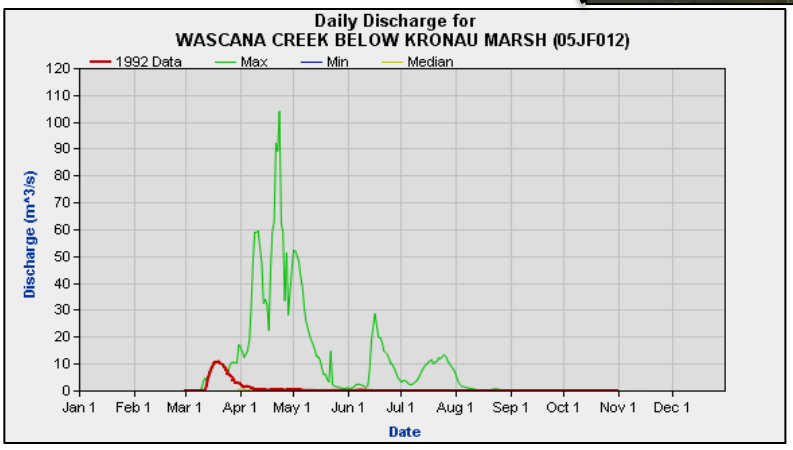
Lat/Lon= 50.30917N, 104.36527W
UTM= 5565716.5n 450127.8e
Location:

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:



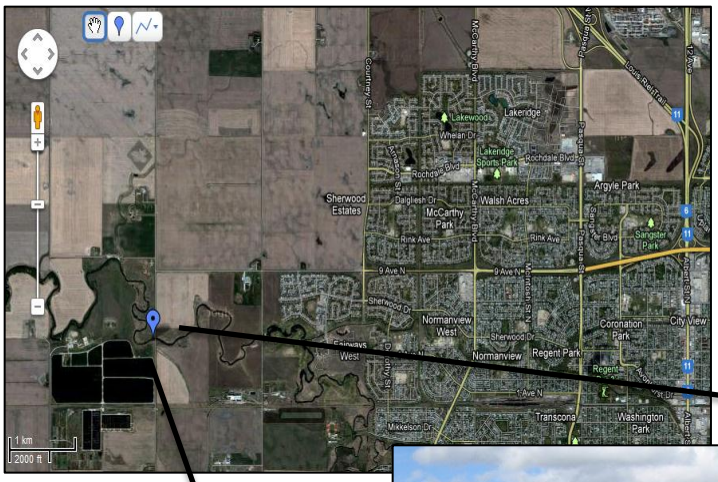
Historical daily discharges from Wascana Creek below Kronau Marsh hydrometric station. Statistics corresponding to 19 years of data recorded from 1974 to 1992. http://www.wsc.ec.gc.ca/applications/H2O/graph-eng.cfm?station=05JF012&report=daily&year=1992

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

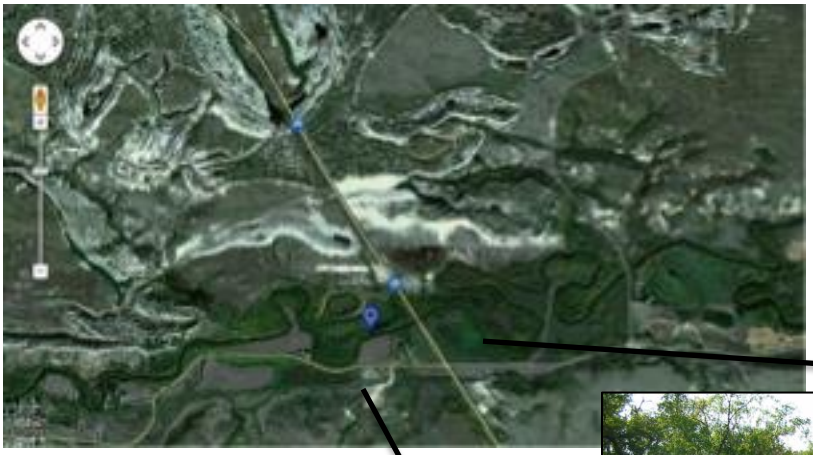
12. Souris River: Highway 39 at Roche Percee

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.

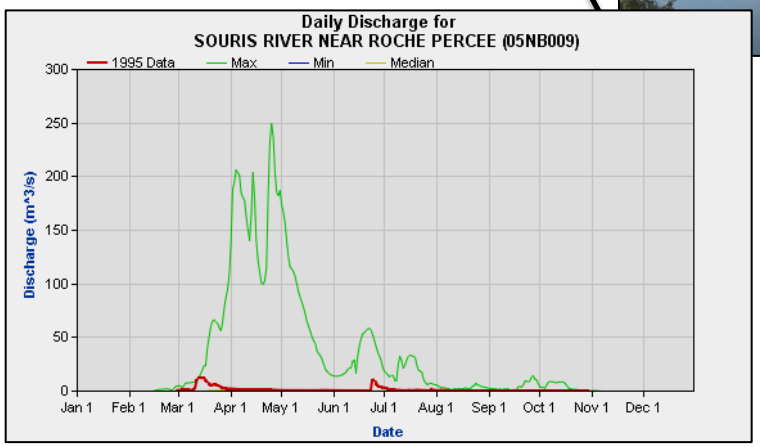
Location:



:

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

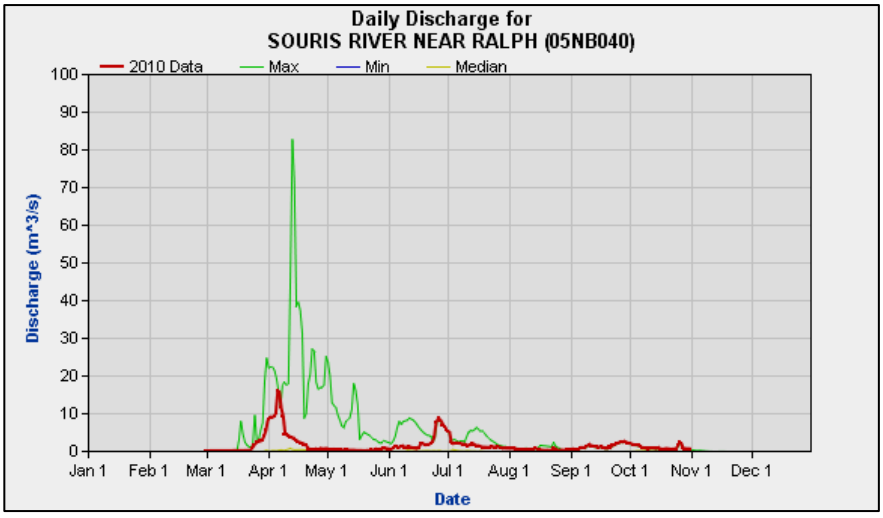
Site Notes:

- 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

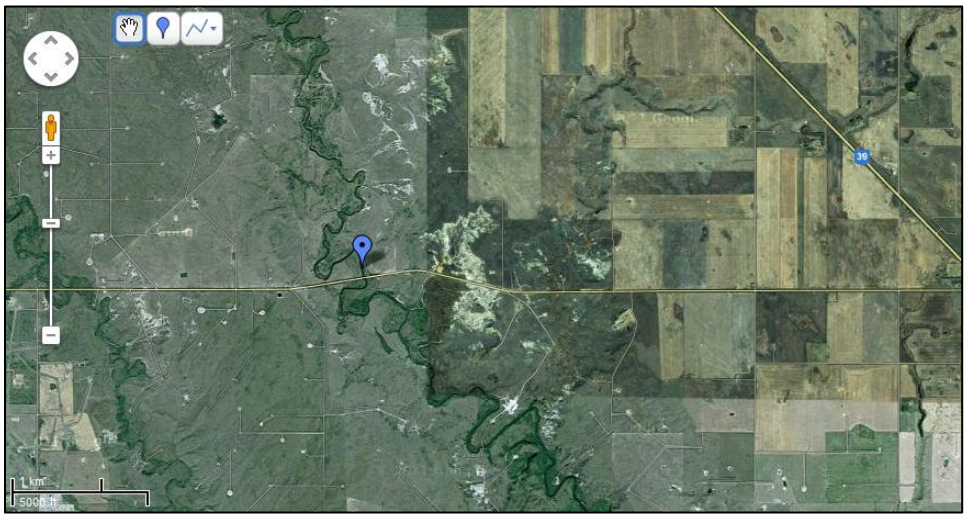
14. Souris River: West of Halbrite

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

Site Notes:

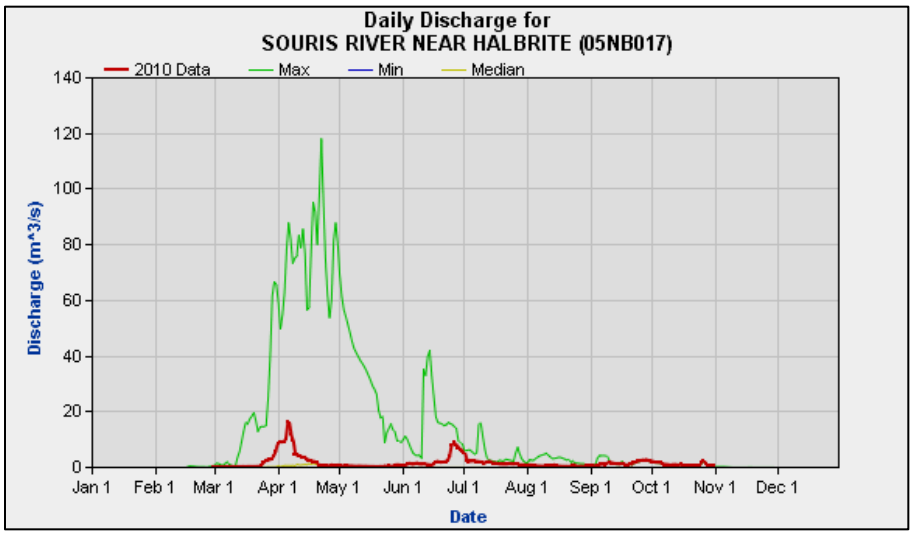
- Directly west of Halbrite on Grid 705
- Annual discharge in 2010 is 29 878 dam^3 According to Environment Canada, Water Survey of Canada Service the median peak and minimum flow are very low, less than $5m^3/s$.

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

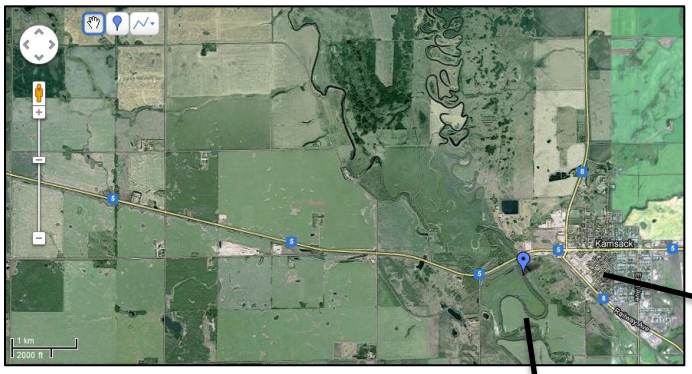
15. Assiniboine River: Kamsack (PPWB site)

UTM=721784.0n 5707536.0e

Site Notes:

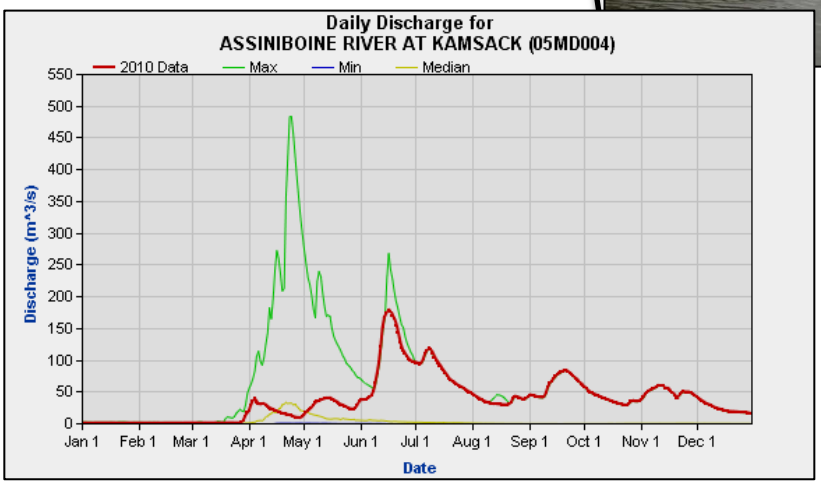
- Site is located immediate west of Kamsack off Highway 5.
- Bottom substrate is predominantly mud with some cobble. Boreal transition ecozone so coniferous vegetation is present.
- Median annual discharge is 139104.5184 dam^3, median peak flow 55.3m^3 and median minimum flow 0.054m^3/s.

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:

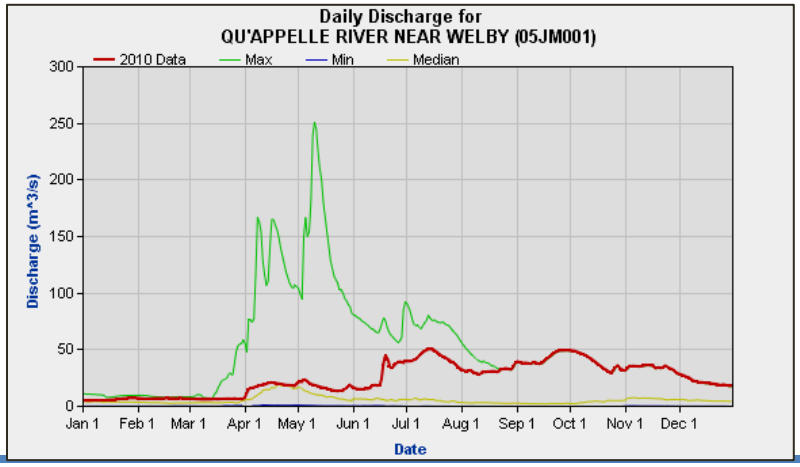
- Site is located south of Welby and east on a Grid off Highway 8.
- The site is a shallow area with mud substrate.
- Median annual flow is 173239.6896 dam^3, median peak flow 39.75m^3/s and median

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)

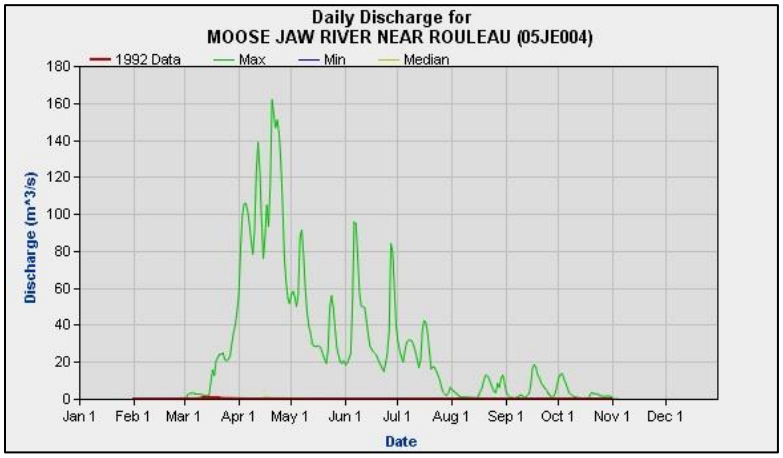
Lat/Long= 50.191598970872235N, 104.9859628187386W
UTM=5559934.0n 501002.0e

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?	

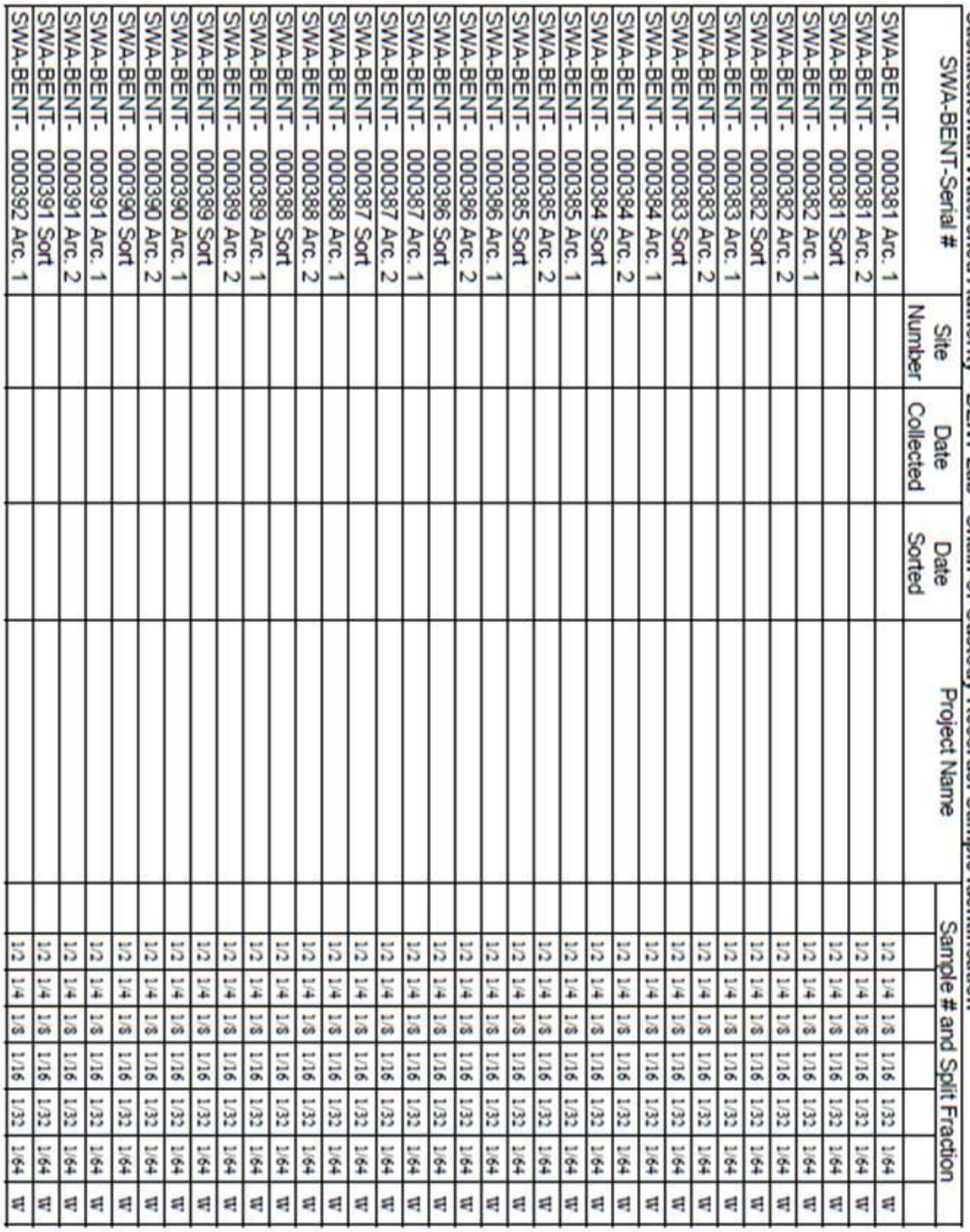
MoE Isotope Collection Label		MoE Isotope Collection Label	
Location		Location	
Date		Date	
Collector		Collector	
Waterbody		Waterbody	
Project		Project	
Sample id?		Sample id?	

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					
SWA BENT					
SWA BENT					
SWA BENT					
SWA BENT					
SWA BENT					
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