X-STREAM SCIENCE

LEADERS MANUAL

Battle River Watershed Alliance

Enbridge

X-STREAM SCIENCE IS BROUGHT TO YOU BY…

We are the landowners, business people, researchers, and decision makers. We are the people that live, work, and play in the Battle River Watershed. We are the people that will ensure a stable economy, healthy natural areas, and resilient communities in this place that we love.

We provide relevant science, social science, policies, and education for a diverse community of people to create solutions to our watersheds challenges. Visit us at www.battleriverwatershed.ca to learn how we connect people to place for action.

Our Program Sponsor:

Over the past 65 years, Enbridge has become a leader in the safe and reliable delivery of energy in North America and is proud to be recognized as one of the Global 100 Most Sustainable Corporations in the World. Visit www.enbridge.com to learn more.

Our Program Partners:

The Battle River Watershed Alliance is one of 11 Watershed Planning and Advisory Councils (WPACs) in Alberta. We work with other WPACs to host X-Stream Science across the province. WPACs lead watershed planning, develop best management practices, foster stewardship activities, report on the state of the watershed, and educate users on the importance of water resources in our watersheds. Visit www.albertawpacs.ca to find out more about Alberta's WPACs.

Special recognition to the following organizations that supported the development of X-Stream Science:

- Alberta Lake Management Society (ALMS) www.alms.ca
- South Central Eco Institute (SCEI) River-watch, Manitoba. www.scecoinstitute.com

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INTRODUCTION

X-Stream science is an inquiry-based opportunity lead by local experts to connect students to their watershed through real world science.

It's Experiential:

Students will go outside to participate in hands-on, scientific inquiry by collecting biological, chemical, and physical data on the water and surrounding land. Content is curriculum-connected and place based.

It's Stewardship:

Water quality, quantity and land use data are collected, analyzed, and stored. This data will be monitored and compared over time. This data provides students and decision makers with the tools to make informed decisions in order to maintain a healthy watershed for future generations.

It's hands-on, it's real life… it's X-Stream Science!

It's lead by the questions:

- What is the health of our local stream environment?
- How do land use decisions affect water quality?
- How do habitat variables impact aquatic ecosystems?
- What changes can we see over time?

X-Stream Science has 3 parts:

In-class preparation presentation

Watershed experts will provide an overview of the watershed, reasons for monitoring the parameters we will study, and the scientific protocols students are expected to follow.

Stream-side field study

Students collect benthic macroinvertebrate samples as well as physical and chemical water data. All of the equipment, materials and guidance will be provided for this half-day outdoor experience.

In-class data analysis and debrief

What is impacting the stream? How does this affect our environment and community? Students will analyze and reflect on the data, and upload it to the BRWA website. This is a starting point for additional activities.

How to use this Leaders Manual

Field sheet cut-outs look like this!

This leaders manual has been developed for teachers and stewardship groups who are going to be hosting an X-Stream Science program. It contains background information on the data we are going to collect as well as the protocols for collecting it. This manual provides more details than what is covered in the field sheets. Field sheet cut outs show what participants will be filling in during the field study. Please review this manual before the field study day and bring it along so you can help your participants.

The leader's manual only covers the stream-side field study portion of the program, not the pre-presentation or the data analysis. For more on these, talk to your local coordinator or visit the website at www.battleriverwatershed.ca/x-stream-science.

Why Collect Water Quality Data?

Water quality allows us to assess whether our watershed is healthy and if the life that relies on that water is also healthy. When the water quality is poor, this indicates that something important is occurring upstream. For example, land use changes upstream can impact the water quality downstream! It is important that we take actions to ensure our watershed remains healthy.

X-Stream Science will allow participants a hands-on opportunity to research, investigate, collect, and interpret data and form conclusions on the condition of the water-body that they are monitoring.

The water quality data will be collected from streams across the watershed each year and will then be used by the WPACs and schools to build an ongoing monitoring program which evaluates the health of our local streams and the greater watersheds. To allow the data to be comparable, we must follow a standardized set of protocols. If a group does not follow the set protocols the educational focus of the program remains, but the data will not be used in the monitoring of the watershed. *If you notice that this has happened, please notify the leader so they can react appropriately.*

X-STREAM SCIENCE FIELD STUDY, AT A GLANCE

Site Information Field sheet page 1	*Upon arrival at the site, first gather this information:* **Site Information** • Record the names of the stream and watershed. Record the GPS location and the weather conditions. **Sample Reach** • Mark your 40-meter section and transects with flagging tape. Split your class into groups and assign each to a transect. **Site Sketch** • Draw the stream, noting features that could help future groups find the location.
Benthic Macroinvertebrate Sampling Field sheet pages 2-3	*Time to collect invertebrates:* **Collect Benthic Macroinvertebrates (BMI)** • Starting at the most downstream transect, team 1 collects BMI using a kick-and-sweep method. • Contents of the net are sieved to remove unwanted material. • Team 2 will start their collection as soon as team 1 is out of the water (continue pattern). • Invertebrates will be collected for a total of ten minutes. Time per transect is determined by number of transects. • BMI are sorted, identified, and tallied on field sheet.
Habitat and Land Use Data Field sheet page 4	*Teams waiting to collect their BMI should complete the following:* **Dominant Riparian Area Vegetation** • Complete the chart for both sides of the river. **Surrounding Land Use** • Check-off the land use present, circle the dominant vegetation present. • List sources of pollutants based on land use.

Water Quality

Field sheet page 4

When all BMI have been sorted and tallied, the team can move on to:

Water Quality

- Teams can use the turbidity tube to measure the turbidity.
- As a group, use the YSI probe to collect the temperature, dissolved oxygen, pH, total dissolved solids, and conductivity.

PREPARING FOR YOUR FIELD STUDY

X-Stream Science Worksheet

Have students complete the provided worksheet (appendix) either individually or in groups to prepare for the presentation and field study. It includes questions on watersheds and riparian ecosystems as well as indicators of water quality. This worksheet can be completed either before or during the in-class presentation.

In-Class Preparatory Presentation

Contact your local XSS coordinator to arrange the field study as well as a short presentation. Students will learn about the watershed, including water usage and health. An explanation and demonstration of the protocols we will be following for our data collection will help the field trip run more quickly and smoothly.

When and Where to Sample:

The best time to collect benthic macroinvertebrates (BMI) is in the spring and fall, before the larvae and nymphs have reached adulthood. Try to sample in May-June or September-October.

The BRWA has identified sites in each of the Battle River sub-watersheds for sampling. If you would like to create a new monitoring location, here are a few things to consider:

- Public access
- Washroom facilities nearby
- Stream-side access to water (not on a steep bank)
- Water depth and flow

As the BRWA would like to have long-term monitoring at each of the XSS sites, we hope you will take on a stretch of your local stream to monitor yearly.

Safety Considerations:

- Do not trespass (obtain permission from land owners prior to monitoring)
- Sampling sites (water quality concerns, stinging nettle, hazardous material)
- Access to area (short distance to road in case of emergency)
- Weather (exit water as soon as thunder heard)
- Fast flowing and deep water
- First Aid training and supplies. Know your location in case you need to call for help

EQUIPMENT

Personal Equipment

- Clothing suitable for changing weather and stream conditions
- First Aid kit and bear spray (if in area frequented by bears)
- Drinking water
- Waders (if you own waders)

Habitat Study

- GPS with topographic map
- Camera
- Sharpener, pencils, and erasers
- Large reel measuring tape: 60-meter
- Survey/flagging tape
- Wooden stakes (for marking out area)
- Clipboards
- Optional: binoculars/spotting scope

If you're sampling with the BRWA, we bring all of the equipment needed!

Physical Monitoring

- Thermometer for measuring air temperature
- Turbidity tube

Chemical Monitoring

- YSI monitoring device with probes
- Dry soft cloths for cleaning equipment

Benthic Macroinvertebrate Monitoring

- Rinse bottles
- Separators (i.e. ice cube tray)
- Kick nets
- Tweezers
- Buckets
- Turkey basters
- Sorting trays and white tubs
- Eye droppers
- Sieve with 350mm mesh
- Magnifiers
- Laminated ID sheets
- Waders (4 provided)

SITE INFORMATION

Field Sheet
Page 1

Your Stream and Watershed

Record the stream’s name on the field sheet. This is important since X-Stream Science data will be collected at many locations. It is also important to note the name of the watershed; this can provide additional data on the stream such as the type, upstream effects and land use in the area.

GPS Coordinates

Use GPS to find your longitude and latitude coordinates for the sampling site, this unique location specifies exactly where you are on earth, and no two addresses are alike! This is important to include on the field sheet, allowing the exact site to be sampled in the future.

Weather

Briefly describe the current weather conditions. Include temperature, cloudiness and wind conditions. Weather can affect what is happening in the water, such as temperature or turbidity.

SITE INFORMATION

Stream Name: ___________________________________

Coordinates: N __ __° __ __.__ __ __’ **W** __ __ __° __ __.__ __ __’

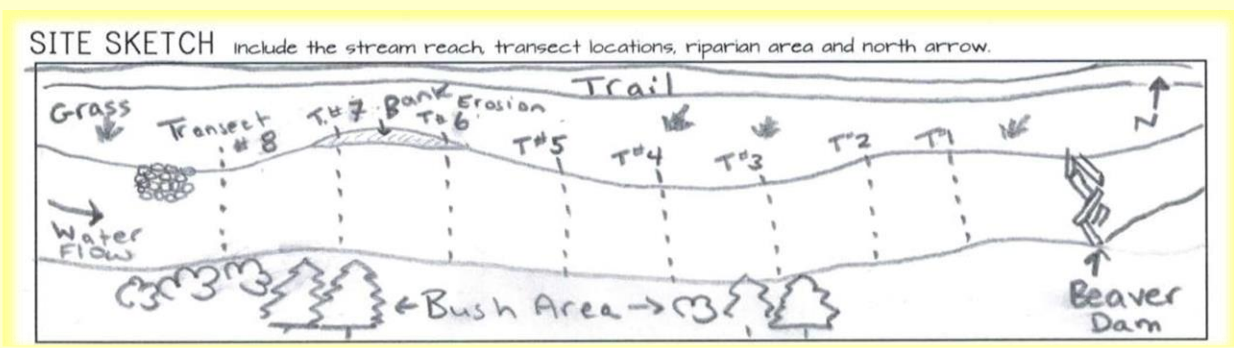
Watershed:_________________________ **Start Time:** _____ **End Time:**______

Weather: _________________________________ **Air Temperature:**______°C

Site Sketch:

Draw a sketch of the site that would help a future team to find the exact location you sampled. Your site sketch can include:

- Site access
- Habitat features
- Transect locations
- Major landscape and stream features
- North arrow
- Human features



Sample Reach

The sample reach is a 40-meter long portion of the stream which has aquatic habitat and riparian vegetation that is representative of the larger stream site. The reach marks the upstream and downstream points of our focus area, and the stream samples will be taken within the stream reach. The reach is determined using a long measuring tape and is made visible by marking the boundaries with flagging tape.

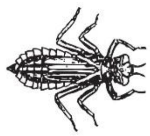
Site Set-up

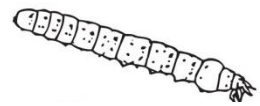
1. Mark the start and end of the 40-meter length along the stream using flagging tape (this is the sample reach).
2. Split your class into groups of 3-5 students. Each group will be responsible for 1 or 2 transects, depending on how many groups there are. A transect is the straight line across the stream where we collect data.

# of Transects/Teams	Time Sampling per Transect	Space Between Transects
10	1 min	4.5m
9	1 min, 6 seconds	5m
8	1 min, 15 seconds	6m
7	1 min, 25 seconds	6.5m
6	1 min, 40 seconds	8m
5	2 min	10m

3. Use the chart to determine the number of transects, the time you will sample at each transect, and the spacing between transects. Mark each transect along the reach with flagging tape. Every XSS site will collect benthic macroinvertebrates for a total of 10 minutes, so the time at each transect differs between each site based on the total number of transects.

BENTHIC MACROINVERTEBRATES (BMI)






BMI are invertebrates (animals that lack backbones) that can be seen by the naked eye (macro). They live part or all of their lives in or on the bottom (benthos) of a body of water and act as good **bio-indicators** because of the high level of biodiversity within this group of aquatic organisms. This lends a high variance in their ability to tolerate water quality issues. **Therefore, the presence or absence of certain species can be an indicator of compromised health in the river or stream.** From our collection and sorting of the BMI we can rate the stream as being in one of three pollution tolerance ratings: Fair (impaired), Good (possibly impaired), and Excellent (unimpaired).

Why do we collect Benthic Macroinvertebrates?

X-Stream Science collects BMI because they are:

- Easily collected as they are abundant and easily identified.
- Relatively immobile, spending a large part of their lifecycle in the same part of the stream, often clinging to objects preventing them from being swept away.
- Continuous indicators of the quality of the environment giving a time frame not seen in physical and chemical monitoring.
- A critical part of the stream food web. Their loss can impact organisms from other trophic levels.

Pollution Tolerance Index (PTI):

The PTI that we will use is made up of four categories of organisms:

1. **Intolerant**: these BMI are highly sensitive and cannot tolerate pollution before they start to die or move on to another area.
2. **Moderately Tolerant**: can handle a moderate range of stress related to water quality.
3. **Fairly Tolerant**: can handle a fairly wide range of stresses related to water quality.
4. **Very Tolerant**: can tolerate most pollution and usually are present in large numbers when water quality is poor.

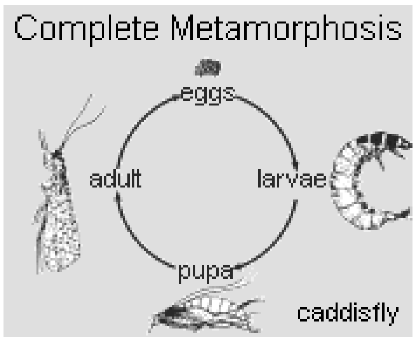
Each of these categories has been assigned an index value. The intolerant category has the highest value of four. In good water quality conditions, we should see representation from all four categories. If we are finding few to none of the intolerant category in our sample, this indicates there is some level of pollution present in the stream. The pollution scale shifts as numbers of the very tolerant species increase and other category numbers decrease.

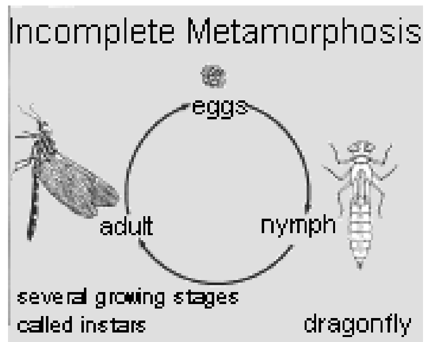
Life and Times of Benthic Macroinvertebrates

BMI have complex life cycles and must undergo metamorphosis

Complete Metamorphosis: these insects go through egg, larva, pupa and adult stages. Examples include true flies, beetles and caddisflies.

Incomplete Metamorphosis: have only three phases: egg, nymph and adult. Examples include mayflies, dragonflies, stoneflies and true bugs.





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BMI also have four main methods of eating and catching their food

Shredders: break down clumps of organic matter and detritus (e.g. cranefly larvae, case-building caddisfly larvae, scuds, aquatic sowbugs, and some of the smaller stonefly nymphs).

Collectors: feed on fine organic matter. This may include the organic matter produced by the shredders.

- **Filtering collectors:** filter the fine particles from the flowing current (e.g. blackfly larvae and net-building caddisfly larvae).
- **Gathering collectors:** gather organic matter while crawling along the substrate (e.g. mayfly nymphs, adult beetles, and midge larvae).

Grazers and scrapers: feed on algae growing on the rocks and vegetation (e.g. snails, flathead mayfly nymphs, and some case-building caddisfly larvae).

Predators: feed on other aquatic animals (e.g. dragonfly nymphs, giant water bugs, most beetle larvae and some adults, damselfly nymphs, water striders, dobsonfly nymphs, fishfly nymphs, and some stonefly nymphs).

Collecting Benthic Macroinvertebrates:

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Page 2

Time to Get Down to Business!

Each team should be assigned at least one transect. Have the team members determine their roles and fill in the chart.

Team #1 will start sampling at transect #1, **the furthest downstream**. Only one group will sample at a time to prevent extra BMI from being swept away and landing in downstream nets!

First, decide who is going to do what:

Role	Duties	Team Member(s)
Collectors	2 people. One person holds the net, one person kicks up the stream bottom (the substrate).	
Timer & Recorder	1 person. Keeps time for the collectors. Helps the net cleaners.	
Net Cleaners	1 or more people. Takes the net from the collectors and transfers BMI into the bucket. Passes the clean net to the next group.	

Fun Facts! Did you know…?

- Stoneflies can live in ephemeral streams which often dry out. The stonefly nymph slows down its metabolism and suspends growth until water returns.
- Caddisfly females return to the water to lay their eggs, diving down to attach them to submerged rocks and vegetation. They can stay under water for up to 30 minutes.
- Mayfly nymphs act like scorpions when threatened, raising their tail and lower abdomen up over their head mimicking a predator.
- Dragonflies can breathe or respire through both their gills and their wing pads.

Collection:

1. Collectors: starting at the edge of the stream bank, the kicker, standing upstream in front of the net, moves along the transect kicking into the substrate. The net holder, standing downstream of the kicker, moves along with the kicker ensuring that everything kicked up enters the net.

2. Timer: start recording the time as soon as the kicker starts. Announce the ½ point, ¾ point, and completion. If the kicker takes a break, pause the timer.

3. When the time is up, the collectors pass the net over to the net cleaners, being careful not to dump anything out of the net.

4. Net cleaners transfer BMI from the net into the sieve. Use a water bottle to rinse the net and sieve. Make sure you don't lose any of the BMI! Use forceps to remove any clingers that may be on the net. Once all soil, stones or plant material is inspected for insects and removed, transfer the BMI into the bucket.

5. As soon as Team #1 have collected their BMI and exited the water, the group sampling transect #2 (just upstream from transect #1) can begin, following the same steps.

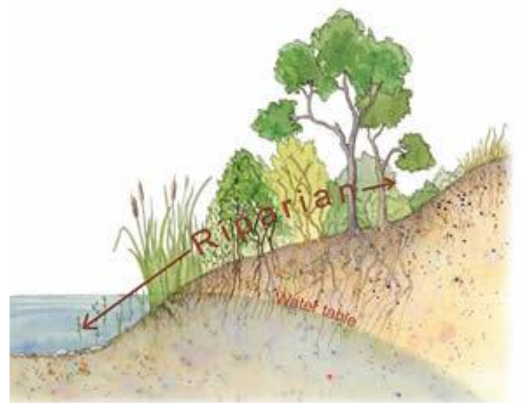
Sorting your BMI

Have your team members work together to find ALL of the BMI in their tray. BMIs are sorted by taxa groups into the ice-cube trays using the identification keys provided. For example, place all of the mayflies together. Sorted BMI should be counted and the tally written on the field sheet.

After the BMI have been counted and approved by a leader, release the BMI back into the stream that it was collected from.

HABITAT & LAND USE

What is a riparian area?



©Cows and Fish

The area of land next to any water body is a special transition zone between aquatic (water) life and terrestrial (land) life. The plants and animals that live in the soil of this riparian area are land based, but need the wet zone to thrive.

It is common to see cattails, willows, sedges, and sometimes trees such as birch in a riparian area. Animals including deer, moose, coyotes, amphibians, reptiles, and many species of birds rely on riparian areas for food, shelter, and access to water. Riparian areas support such an abundance of life that they are often referred to as a 'ribbon of green'.

Riparian areas also help keep the water clean by filtering out pollution and protecting the banks from erosion.

How vegetation and land use impact the stream

The riparian vegetation (or lack thereof) can have major implications on the water body. If humans heavily impact the surrounding land, riparian vegetation will help mitigate the effects on the water. Besides mitigating human activity, vegetation provides positive influences such as:

- **Nutrients:** Numerous deciduous trees and shrubs (that lose their leaves every year) close to the water will increase the amount of organic material entering the stream, which serves as food for aquatic organisms.
- **Filter and buffer the water:** Help remove unwanted pollutants and improve the water quality.
- **Reduce flood or drought impacts:** Tremendously important for water storage.
- Maintain banks/prevent erosion: Roots help stabilize the soil.
- **Shade:** Overhanging trees or shrubs shade the water, keeping it cool. Cooler water holds more oxygen than warmer water. Overhanging vegetation can also offer protection, creating great habitat for fish and invertebrates.
- **Maintain biodiversity:** Not only do the riparian areas provide shade, but they also provide a significant amount of habitats for wildlife.

Riparian Vegetation

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Page 4

What plant communities are most commonly found at each transect? Team members should visit each transect to determine the dominant vegetation on the right side and left side of the stream (looking upstream).

By reading the vegetation descriptions on the field sheet, fill in the chart with your observations.

Vegetation (Plant) Types:

None: The surface is bare soil, all rock, or pavement.
Cultivated: The vegetation is human planted, such as crops or mowed grass.
Grassland: Natural grasses and forbs which are tall and unkept.
Bush: some trees mixed with shrubs and grasses.
Forest: mature trees with a lot of canopy cover and dense ground cover.

Transect	Left Side	Right Side
1	Forest	Grassland
2	Cultivated	None
3		
4		
5		
6		
7		
8		
9		
10		

Surrounding Land Use

After examining the area around the sample reach, thinking about where they are and perhaps even looking at maps, teams should check off all the land uses which are common in the area and circle the dominant, most common land use.

√Check the land uses present, circle the most common

√Forest/Bush　√ Field/Pasture　√ Agriculture/Cropland

☐ Residential/Urban　√Park　☐ Commercial/Industrial

☐ Mining　☐ Other:

For example, the Battle River at Riverdale Park has field/pasture, agriculture, and park surrounding it, but the most common land use is forest.

WATER QUALITY

X-Stream Science includes physical and chemical water quality parameters. You will conduct some or all of the following tests:

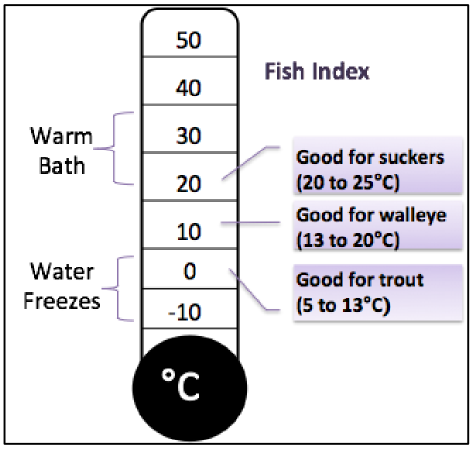
Physical Tests: Temperature, Turbidity, Conductivity, Total Dissolved Solids
Chemical Tests: pH, Dissolved Oxygen (DO)

Physical Parameters

Temperature:

What it means: Just like air temperature, the temperature of water is the measure of how warm or cool it is.

Why it matters: Temperature impacts the biological, chemical, and physical processes in water. Higher temperatures lead to a higher rate of chemical reactions. The colder the water, the more dissolved oxygen (DO) the water can hold, making it available to aquatic flora and fauna. The temperature influences the types of biodiversity found in the ecosystem.



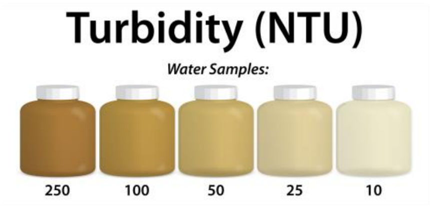
How it can change: A number of factors influence the temperature of the water.

- Location of stream (elevation, latitude)
- Depth of water
- Weather (cloud cover, time of day, season, and air circulation)
- Natural factors (plant shade from riparian area)
- Human factors (thermal discharge from power-plants, industry, or sewage)

How to measure: The temperature of the water can be determined by holding a thermometer under the water until it stabilizes. For X-Stream Science, the YSI temperature probe will measure the temperature for us.

How to interpret: The optimum range for all aquatic and terrestrial life to function without stress is 5°C to 25°C. Each species has a threshold somewhere within this.

Turbidity:



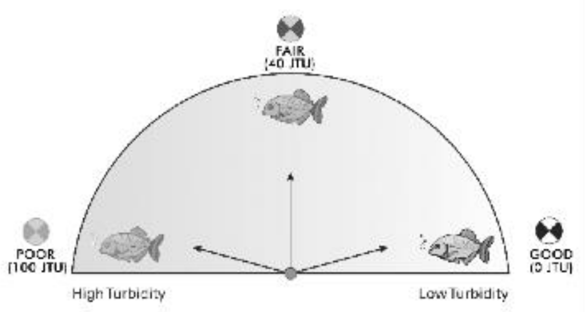
Source: 1 studyblue.com

What it means: Turbidity is the measurement of the clarity of the water. It measures the amount of suspended particles in the water column, such as soil, algae, plankton, microbes, and other substances. The higher the turbidity, the more suspended solids and therefore, the harder it would be to see through the water.

Why it matters: Higher turbidity will generally lead to a decrease in water quality, and a decrease in the amount of life the stream can support.

Higher turbidity can cause:

- An increase in water temperature. Darker water will absorb more heat.
- A decrease in dissolved oxygen due to increased heat.
- A decrease in photosynthesis by aquatic plants due to the reduced light available.
- Decrease in aquatic plants, but a potential increase for algal blooms.
- Aquatic biota; such as invertebrates or fish, suffer because of clogged gills. They could have a lowered resistance to disease, a decrease in growth rate, and egg and larval development problems.
- Smothering of fish and amphibian eggs and BMIs by the settling particles in slower moving water.
- Decrease in habitat for BMIs.



How it can change: Some streams are naturally more turbid than others. Humans can increase or decrease the amount of turbidity in the water by land-use decisions.

Turbidity increases in the stream where there is:

- Stream bank erosion
- Wastewater discharge
- Urban runoff, including storm water
- Stirring of bottom sediments
- Excessive algal and cyanobacteria growth

How to measure: Turbidity is measured in JTU (Jackson Turbidity Units) or NTU (Nephelometer Turbidity Units), depending on your sampling device. The units are interchangeable and both are based on the amount of suspended solids in the water. Turbidity is usually measured using a Secchi disc lowered into the lake. The depth measurement is taken when you can no longer see the disc and is then converted to JTU or NTU.

X-Stream Science uses a turbidity tube, another very common method used to measure the NTU of flowing water. Turbidity tubes have a Secchi disc at the bottom of a long clear tube. The tube is filled with water which is slowly released from the bottom of the tube until the Secchi disc at the bottom is visible.

Step by Step:

- Fill the turbidity tube with water from the stream reach you are testing, make sure it is flowing water, not water from the bottom of the stream.
- Have a team member look into the top of the tube while another releases the water from the bottom.
- When the black and white Secchi disc is distinguishable, the depth of the water is recorded to the nearest centimetre.
- Multiple team members can try the test and the results should be averaged.

How to interpret: Turbidity units can be determined through the use of predetermined tables that were formulated through the use of a conversion equation.

Distance from bottom of Tube (cm)	NTU's	Distance from bottom of Tube (cm)	NTU's
<6.25	>240	28.75 to 31.25	24
6.25 to 7	240	31.25 to 33.75	21
7 to 8	185	33.75 to 36.25	19
8 to 9.5	150	36.25 to 38.75	17
9.5 to 10.5	120	38.75 to 41.25	15
10.5 to 12	100	41.25 to 43.75	14
12 to 13.75	90	43.75 to 46.25	13
13.75 to 16.25	65	46.25 to 48.75	12
16.25 to 18.75	50	48.75 to 51.25	11
18.75 to 21.25	40	51.25 to 53.75	10
21.25 to 23.75	35	53.75 to 57.5	9
23.75 to 26.25	30	57.5 to 60	8
26.25 to 28.75	27	Over 60	<8

The larger the NTU unit the less clear the water is and the more suspended particles. If the NTU is greater than 240, most gilled organisms will have disappeared.

Conductivity:

What it means: Conductivity is a measure of the water's ability to conduct an electric current (dissolved solids and ions in the water transmit electricity). The more dissolved solids in the water, the higher the conductivity. The specific conductivity of natural surface waters ranges from 50-100µ*S*/cm.

Why it matters: Higher conductivity means there are more ions (salts and other substances). Aquatic biota have a range of tolerance to ionic composition. It also can be an indication of contaminated ground and surface water entering the stream.

How it can change: An increase in dissolved solids, ions, and temperature will change the conductivity. These changes can happen by:

- Thermal pollution or removal of riparian vegetation
- Geology of stream (what minerals the bedrock contains)
- Changes in pH

How to measure: Conductivity is measured using the YSI probe in microsiemens per centimeter (µS/cm).

How to interpret: Conductivity in natural surface waters ranges from 50 to 150 µS/cm. During spring runoff, the conductivity is usually at its lowest as the extra runoff dilutes the water. Industrial wastes can increase surface water conductivity up to 10,000 µS/cm.

Total Dissolved Solids (TDS):

What it means: TDS is the measure of all of the solids, organic or inorganic, that are completely dissolved in the water.

Why it matters: These substances can easily go undetected unless they are in high enough concentrations to become saturated or change the physical characteristics of the water body.

How it can change: TDS can increase when the water comes into contact with other substances (water is a universal solvent).

How to measure: TDS can be calculated from the electrical conductivity reading.

Equation: **Total dissolved solids = 0.65 (constant) x specific conductance**
The YSI probe does this conversion and gives you a reading for the TDS.

How to interpret: If the TDS reading is high, this indicates a large amount of dissolved solids in the stream. It may be in the best interest to take a complete water sample and send it to a laboratory for a comprehensive water quality test looking at parameters not tested on site. Typical values for irrigation water are 500-3000 mg/L and drinking water is <500 mg/L.

Chemical Parameters

pH:

What it means: pH is the measure of acidity or alkalinity of the water.

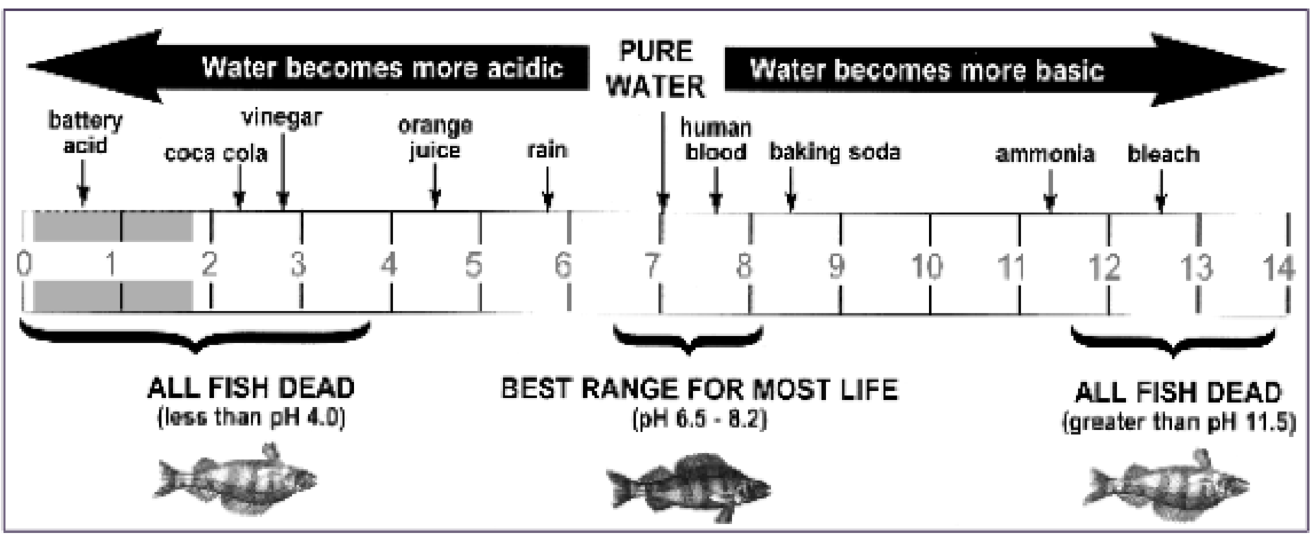
Why it matters: The optimal pH for aquatic organisms in freshwater is between 6.5 and 8.2. Changes in the pH will stress the life in the water. Outside of this range the *intolerant* species will disappear. Changes in the pH can also influence the amount of nutrients and heavy metals in the water. For example, if the pH falls below 5.5, heavy metals trapped in sediment will be released in forms toxic to aquatic organisms.

How it can change: A number of things both natural and anthropogenic (human caused) can influence pH.

- The rocks and minerals (geology) in the immediate area and upstream
- The riparian area (water draining through leaf litter has lower pH)
- Urban runoff (surface water runoff may bring pollution)
- Acid precipitation
- Photosynthesis (decrease in carbon dioxide results in higher pH)

How to measure: pH is measured by the concentration of the hydrogen ion (H^+) in the water. It is expressed on a scale of 0 (acid) to 14 (alkaline/basic). Pure water has a neutral pH of 7.

How to interpret: If the pH is outside the range of 6.5-8.2 you will not see benthic macroinvertebrates from all four of the categories, most will be from the very *tolerant* category.



Dissolved Oxygen:

What it means: Dissolved Oxygen (DO) is the amount of oxygen freely attached to water molecules, available to the aquatic plants and animals.

Why it matters: Oxygen is essential for life in our streams and is one of the most important measurements of water quality when looking at the health of an aquatic ecosystem. The amount of DO needed varies with each species; mayfly and stonefly nymphs, caddisfly larvae and beetle larvae need a high DO, while more tolerant species such as worms and fly larvae need less.

How it can change:

- Temperature (cold water holds more DO than warmer water). The amount of available DO can fluctuate greatly over short periods of time since the water temperature also fluctuates.
- Turbidity
- Altitude/atmospheric pressure
- Salinity
- Winter ice cover
- Abundance of plants and algae
- Flow and depth of water
- Discharges and effluents entering the river or stream
- Amount of decaying organic material
- Seasonality

How to measure: The amount of dissolved oxygen is measured in % saturation. A stream that is moving very quickly could have 100% saturation, whereas a stream with high organic material would have less. In X-Stream Science DO is measured in parts per million (ppm) and the YSI Probe will automatically calculate the DO.

How to interpret:
(1) 8 mg/L: there are no impairments to the BMI;
(2) 5 mg/L: there is some production impairment especially to sensitive species;
(3) 4 mg/L: there will be limited taxa present and acute levels of mortality.

Most organisms (including fish) cannot survive below certain DO levels – less than 4 mg/L has detrimental effects on most aquatic organisms. The recommended minimum DO is 5 mg/L (1 day) and 6.5 mg/L (7 day mean) [ESRD, 2014].

Alternatively:

(1) <60%: the water quality is poor;
(2) 60-79% it is acceptable to most aquatic organisms;
(3) 80-125% is excellent;
(4) Supersaturation, above 125%, becomes dangerous for organisms. This may cause gas bubble disease in the organisms similar to how "the bends" affects scuba divers.

To Calculate Percent Saturation:

Equation: $$\% \, \boldsymbol{Saturation} = \frac{\boldsymbol{DO}\left(\frac{mg}{L}\right)(\boldsymbol{your\ sample})}{\boldsymbol{Max\ DO}\left(\frac{mg}{L}\right)(\boldsymbol{from\ chart\ below})} \boldsymbol{x}\ \mathbf{100}\%$$

Example at 16°C and a sample of 8.0 mg/L:

$$\frac{\mathbf{8.0}\left(\frac{mg}{L}\right)}{\mathbf{9.9}\left(\frac{mg}{l}\right)} \boldsymbol{x}\mathbf{100}\% = \mathbf{81}\%$$

Dissolved Oxygen Saturation Table

Temperature °C	DO mg/L	Temperature °C	DO mg/L	Temperature °C	DO mg/L
0	14.6	11	11.0	22	8.7
1	14.2	12	10.8	23	8.6
2	13.8	13	10.5	24	8.4
3	13.5	14	10.3	25	8.3
4	13.1	15	10.1	26	8.1
5	12.8	16	9.9	27	8.0
6	12.5	17	9.7	28	7.8
7	12.1	18	9.5	29	7.7
8	11.8	19	9.3	30	7.5
9	11.6	20	9.1	31	7.4
10	11.3	21	8.9	32	7.3

Thank you for participating in XSS!

This is the end of the field study, but there is an additional data analysis activity in "Calculating River Health with Benthic Macroinvertebrate Indices – Student Lab Manual" (appendix) where students can reflect on the experience and calculate more precise indicators of stream health.

GLOSSARY

Bank- The area immediately adjacent to and slopes toward the bed of a watercourse. The bank is necessary to maintain the integrity of a watercourse.

Bankfull Channel - The high water mark left by annual peak water events.

Bankfull Wetted Width - The distance from the water's surface to the height of the measuring tape at bankfull width.

Bioindicators - A living organism that its presence or absence gives us an idea of the health of an ecosystem.

BMI (Benthic Macroinvertebrates) - Organisms without backbones that inhabit the bottom substrates (sediments, debris, logs) of their habitats for at least part of their life cycle. Macroinvertebrates are visible to the naked eye and are retained by mesh sizes greater than or equal to 200 to 500 micrometers.

Cultivated – Land where the vegetation is human planted, such as with crops or mowed grass.

Discharge - The volume of water transported through a given area.

Dissolved Oxygen (DO) - The amount of oxygen freely attached to water molecules, available to the aquatic plants and animals.

Ecological Pyramids - A graphical representation designed to show the biomass or bio productivity at each trophic level in a given ecosystem.

Electro Conductivity - The ability of water to carry an electrical current. The level of conductivity is related to the amount of inorganic dissolved solids.

Elevation – The height above a given level, typically above sea level.

Food web – The feeding relationships among specific members of the community. There can be multiple connections between members.

Metamorphosis - The process of transformation from an immature form to an adult form in two or more distinct stages.

Minimum Wetted Width – The minimum distance where the water meets land on both sides of the stream.

Mitigate - The elimination or reduction of the frequency, magnitude, or severity of exposure to risks.

Parameter – A characteristic or factor.

pH – A numeric scale used to specify the acidity or alkalinity of an aqueous solution.

Primary Production – an important process where new organic matter is created through photosynthesis.

Primary Productivity – the rate of primary production (Production x time^{-1}).

Protocol - A system of rules that explain the correct conduct and procedures to be followed.

Riparian - The lands adjacent to streams, rivers, lakes and wetlands, where the vegetation and soils are strongly influenced by the presence of water.

Sample Reach - A 40-meter-long portion of the stream that is representative of the larger stream site, where all sampling takes place.

Substrate – The sediment at the bottom of the streams in which organisms live and grow on.

Tolerate - Capable of continued subjection to a condition without adverse reaction.

Total dissolved solids (TDS) - The total amount of solids, organic or inorganic, that are completely dissolved in the water. TDS include common salts such as sodium, chloride, calcium, magnesium, potassium, sulphates and bicarbonates.

Transect - A straight line across the river (perpendicular to streamflow) along which BMI sampling will take place.

Trophic levels – The position an organism occupies in the food chain.

Turbidity – A measure of water clarity; how much the material suspended in water decreases the passage of light through the water.

UTM Coordinates - A system of coordinates that describes position on a map.

Velocity – The speed at which water is flowing.

Watershed - A watershed is the area of land where all of the water that is under it or drains off of it goes into the same place.

Wetted channel- Where the water meets land on both sides of the stream.

REFERENCES

Alberta Environment & Sustainable Resource Development (ESRD). 2014. Environmental Quality Guidelines for Alberta Surface Waters. Water Policy Branch, Policy Division. Edmonton. 48 pp.

Kemker, Christine. “Dissolved Oxygen.” *Fundamentals of Environmental Measurements*. Fondriest Environmental, Inc. 19 Nov. 2013. Web. < http://www.fondriest.com/environmental-measurements/parameters/water-quality/dissolved-oxygen/ >.

X-STREAM SCIENCE

PREPARATION WORKSHEET

Complete before the X-Stream Science Field Day

1. What is a watershed?

____

____

____

2. What watershed do you live in?

____

3. What water body do you get your drinking water from? Where does your wastewater go?

____

____

4. Where are you going to be sampling during X-Stream Science? What do you know about what is upstream and what is downstream from your site? How could these affect the river?

____

____

____

5. Why should people study and care about water quality?

____

____

____

6. What are benthic macroinvertebrates and why do we use them to monitor water quality?

____

____

____

7. What is a riparian area?

____

____

____

Briefly define the following and explain why they are important when analyzing water quality:

1. Temperature:

2. Turbidity:

3. pH:

4. Dissolved Oxygen:

5. Phosphorus:

6. Nitrogen:

Team:______ Transect:_________

Team Members: _______________

____

____

Date: _________________________

X-STREAM SCIENCE

FIELD SHEET

SITE INFORMATION

Stream Name: _________________________________

Coordinates: N __ __º__ __.__ __ __' W __ __ __º__ __.__ __ __'

Watershed:________________________ Start Time: _____ End Time:______

Weather: ________________________________ Air Temperature:______°C

SAMPLE REACH *Our 40-meter length should represent the whole stream*

1. As a class, mark the start and end of a 40-meter length with flagging tape.
2. Divide into teams of 3-5 people. Each team will be responsible for at least 1 transect. A transect is the straight line across the stream where we collect data. Mark off each transect with flagging tape.

# of Transects/Teams	Time Sampling per Transect	Space Between Transects
10	1 min	4.5m
9	1 min, 6 seconds	5m
8	1 min, 15 seconds	6m
7	1 min, 25 seconds	6.5m
6	1 min, 40 seconds	8m
5	2 min	10m

SITE SKETCH

Include the stream reach, transect locations, riparian area, and north arrow.

BENTHIC MACRO-INVERTEBRATES (BMI)

First, decide who is going to do what:

Role	Duties	Team Member(s)
Collectors	2 people. One person holds the net, one person kicks up the stream bottom (the substrate).	
Timer & Recorder	1 person. Keeps time for the collectors. Helps the net cleaners.	
Net Cleaners	1 or more people. Takes the net from the collectors and transfers BMI into the bucket. Passes the clean net to the next group.	

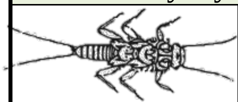
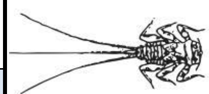
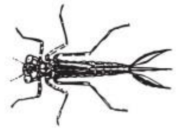
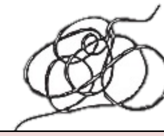
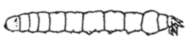
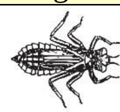
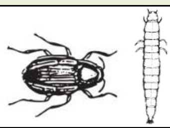
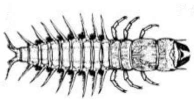
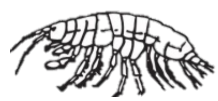
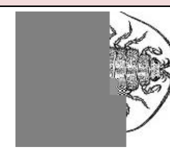
*Start BMI sampling at your transect when groups downstream of you are done.

1. Collectors: starting at the edge of stream bank, the kicker (standing upstream in front of the net) moves along the transect kicking into the substrate. The net holder moves along downstream ensuring everything kicked up enters the net.
2. Timer: start recording the time as soon as the collectors start to kick. Announce the ½ point, ¾ time, and completion. If the kicker takes a break, pause the timer.
3. When the time is up, collectors pass the net over to the net cleaners. Collectors take off chest waders; pass them to next group, then help with BMI sorting.
4. Net cleaners transfer BMI from the net into the sieve. Use forceps to remove any clingers that may be on the net. Use a water bottle to rinse the net into the sieve. Make sure you don't lose any of the BMI! Once all the soil is sieved, transfer the BMI into the bucket with clean water.
5. Identify BMI using the key. Sort BMI that are the same into one cube of the ice cube tray. Make sure you get every BMI grouped, even the smallest creatures. Use the tally sheet to record numbers as you go. Every BMI in your sample must be counted.
6. Once your sample has been counted and approved by your leader, release the BMI back into stream.

Transcect Tally
Class Tally

BENTHIC MACRO-INVERTEBRATES TALLY

Tally the number of invertebrates you find in their individual boxes.

Intolerant (1-4)	Moderately Tolerant (5)	Fairly Tolerant (6-7)	Very Tolerant (8)
Stonefly Nymph	Mayfly Nymph	Damselfly Nymph	Aquatic Worm
			
Cranefly Larva	Dragonfly Nymph	Midge Larva	Leech
			
Caddisfly Larva	Mosquito Larva	Blood Midge Larva	Gilled Snail
			
Riffle Beetle and Larva	True Bug Adult	Black Fly Larva	Left-Handed/ Pouch Snail
			
Dobsonfly	Clam/Mussel	Scud	Sowbug
			
Watersnipe Larva	Predaceous Diving Beetle/Water Tiger	Mite	
			
# of individuals: # of types: Weighting Factor: 4	# of individuals: # of types: Weighting Factor: 3	# of individuals: # of types: Weighting Factor: 2	# of individuals: # of types: Weighting Factor: 1
Find final values for each tolerance category: Final Value = # of types x Weighting Factor			
Number of types __ x 4 Final Value = ___	Number of types __ x 3 Final Value = ___	Number of types __ x 2 Final Value = ___	Number of types __ x 1 Final Value = ___

Add all 4 Final Values to find the ratings.

Transect Pollution Tolerance Index Rating: _______

Class Pollution Tolerance Index Rating: _______

Pollution Tolerance Ratings:

23 or more:	Excellent
17-22:	Good
11-16:	Fair

WATER QUALITY DATA

These measurements will be done as a group with the YSI probe and turbidity tube.

Water Temperature: ______ºC Dissolved Oxygen (DO): ______mg/L

pH: ______ Conductivity (SPC): ______µS/cm

Turbidity: ______cm Total Dissolved Solids: ______mg/L

DOMINANT RIPARIAN AREA VEGETATION:

The plants that live beside the water's edge

Vegetation (Plant) Types:

None: The surface is bare soil, sand, rock, or pavement.

Cultivated: The vegetation is human planted, such as crops or mowed grass.

Grassland: Natural grasses and forbs which are tall and unkempt.

Bush: some trees mixed with shrubs and grasses.

Forest: mature trees with a lot of canopy cover and dense ground cover.

Choose a vegetation type for each side of the stream at each

Transect	Left Side	Right Side
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

SURROUNDING LAND USE:

What is happening around the river?

√Check the land uses present, circle the most common

□Forest/Bush □Field/Pasture □Agriculture/Cropland

□Residential/Urban □Park □Commercial/Industrial

□Mining □Other:___________

Based on the surrounding land use, what are sources of pollutants?

____

____

X-STREAM SCIENCE

Calculating River Health with Benthic Macroinvertebrate Indices

Student Lab Manual

Group member names: ____

____

Date:___________

Brought to you by:

Battle River Watershed Alliance

Enbridge

What are indices?

Benthic Macro Invertebrate (BMI) indices are calculations to determine the health of a stream. BMI help us understand stream water quality because of their specific habitat needs.

To complete your X-Stream Science project, you will calculate 4 BMI indices using this manual. The Battle River Watershed Alliance will record and store your data to understand the health of our rivers now and over time.

To complete this worksheet, you will need your class BMI tally sheet from the field experience.

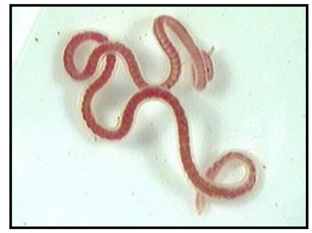
You will complete 4 indices:

1. Percent Worm
2. Percent Midge
3. Percent EPT
4. HBI

For all of these indices, you will need to know the total amount of BMI your class collected.

Total number of BMI we found: ___________ = N.

1. Percent Worm



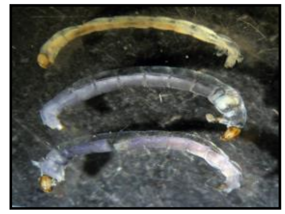
This index measures how many worms are present in a stream compared to other species.

A lot of worms in a stream generally mean there is a lot of organic pollution. Streams with a lot of organic pollution (such as soil erosion and animal manure) can have lots of algae (which feed on organic nutrients). Algae results in low oxygen levels which make it difficult for other organisms to survive in the stream. All of these things make for an unhealthy system.

The most common type of worm we will find is known simply as the aquatic worm.

Equation	Score
$= \frac{100x\,(\#\ of\ worms)}{N}$ N = total number of BMI in your sample	More than 30% = Unhealthy 10-30% = Possibly Unhealthy Less than 10% = Healthy
Worm Calculation	**Example**
Total BMI (N) = _____ Add up the total amount of worms you found: **Worm Count = _____** Divide the total number of worms by the total number of BMI (N): **Worm Ratio = _____ ÷ _____ = ______** Multiply the resulting number by 100: **_____ x 100 = _____% Worm** **Score = __________**	Sample (N) = 120 BMI Worm Count = 45 Worm Ratio = 45 ÷ 120 = 0.375 0.375 X 100 = 37.5% Worm Score= Unhealthy (Greater than 30%)

2. <u>Percent Midge</u>



This index measures how many midges are present in a stream compared to other species.

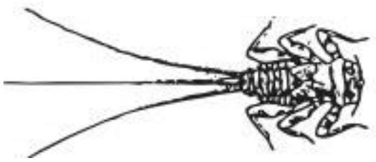
Midges are fairly common in stream habitats, but a high number indicates high pollution content in the river as they are able to handle it better than some other organisms. They are also strong competitors with other organisms due to fast reproduction, so they will generally push more sensitive species out of environments with more polluted conditions.

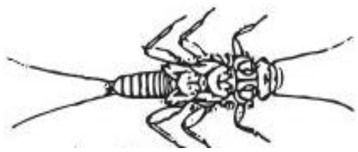
Equation	Score
$= 100\ x\ \frac{\#\ of\ all\ midges}{N}$ N= Total number of BMI in sample	Greater than 40% = Unhealthy 10-40% = Possibly Unhealthy Less than 10% = Healthy

Midge Calculation	Example
Total BMI (N) = _____	Sample= 70 BMI
Add up the total amount of midges you found: **Midge Count = _____**	Midge Count = 19
Divide the total number of midges by the total number of BMI (N): **Midge Ratio = _____ ÷ _____ = ______**	Midge Ratio = <u>19</u> ÷ <u>70</u> = <u>0.271</u>
Multiply the resulting number by 100: **_____ x 100 = _____% Midge**	<u>0.271</u> x <u>100</u> = <u>27.1%</u> Worm
Score = __________	Score= Possibly Unhealthy

3. Percent EPT

This index tells us what percentage of the sample are made of
Mayflies (Ephemeroptera), Stoneflies (Plecoptera), and Caddisflies (Trichoptera)





These three fly species only live in very clean streams, so the numbers they appear in can help us determine how healthy each stream is. They cannot tolerate streams with high levels of suspended solids, (such as garbage or un-dissolvable chemicals).

Equation	Score
$= 100\ x \frac{\#S+\#C+\#M}{N}$ #S = number of Stoneflies found #C = number of Caddisflies found #M = number of Mayflies found N = number of total BMI in sample (including all flies)	Less than 5%= Unhealthy 5-10%= Possibly Unhealthy Greater than 10%= Healthy

EPT Calculation	**Example**
Sample (N) = _____	Sample = 60 BMI
Stonefly Count = _____	Stonefly Count = 3
Caddisfly Count = _____	Caddisfly Count = 8
Mayfly Count = _____	Mayfly Count = 7
Add the total number of all Stoneflies, Caddisflies, and Mayflies together: **# EPT = _____ + _____ + _____ = _____**	# EPT = 3 + 8 + 7 = 18
Divide this number by the total number of BMI (N): **EPT Ratio = _____ ÷ _____ = _____**	EPT Ratio = 18 ÷ 60 = 0.3
Multiply the resulting number by 100: **_____ x 100 = _____ %EPT**	0.3 x 100 = 30%EPT
Score=	Score: Healthy

Hilsenhoff Biotic Index (HBI)

The HBI is the most in-depth of all indices as it accounts for all species found in a sample.

The Hilsenhoff Biotic Index (HBI) assigns each different species collected a "tolerance value" to explain how good it is at surviving in unclean water.

HBI will use the numbers of all species and their specific tolerance values together to determine the nutrient levels of a stream. This value will give us the best idea of how healthy the stream is overall.

TOLERANCE VALUE CHART

Common Name	Tolerance	Common Name	Tolerance
Aquatic Worm	8	Mayfly Nymph	5
Black Fly Larva	6	Midge and Blood Midge Larva	7
Caddisfly Larva	4	Mite	6
Clam/Mussel	5	Mosquito Larva	5
Cranefly Larva	3	Predacious Diving Beetle/Water Tiger	6
Damselfly Nymph	7	Riffle Beetle and Larva	4
Dobsonfly	0	Scud	6
Dragonfly Nymph	5	Sowbug	8
Gilled Snail	3	Stonefly Nymph	1
Leech	8	True Bug	5
Left-handed/Pouch Snail	8	Watersnipe	2

HBI Calculation	Example
Equation: $HBI = \sum \frac{ni \ x \ ti}{N}$ n_i= total # of BMI found of of **ONE** species t_i= tolerance value of that **SAME** species N= number of total BMI in sample	Sample= 140 BMI
Sample (N)=_____ Find the tolerance value and number of one of your BMI. Write the data in the proper fields in the chart on the next page. Then, multiply the number of that BMI by its tolerance value.	BMI: Water Mite # of Water Mite = 8 Tolerance Value = 6 8 x 6 = 48
Divide this resulting number by the total sample number (N) and record this number as the HBI index value. Repeat these steps for every species found in the sample. Add all of these numbers together to get your total HBI index score.	48 ÷ 140 = 0.343

BMI	# of BMI found	Tolerance Value	# of BMI x Tolerance=	Total Sample N = _____	HBI Index Value
EXAMPLE Water mite	**8**	**6**	**48**	**140**	**0.343**
	8 x 6 = 48		**48 / 140 = 0.343**		
Add all of the HBI Index Values for a total HBI Score here:					

HBI Score	Hilsenoff's Categories	HBI Score	Hilsenoff's Categories
0.00-4.25	Very Good	4.26-5.00	Good
5.01-5.75	Fair	5.76-6.50	Fairly Poor
6.51-7.25	Poor	7.26-10.00	Very Poor

Our Score is:__________

Understanding the Results

Write your final scores (healthy, possibly unhealthy or unhealthy) for each indices here:

% WORM INDEX VALUE: __________

Healthy	Possibly Healthy	Unhealthy
A system with a healthy percent worm score would likely indicate that some worms are present, but not in large numbers. This would suggest that there are low amounts of organic pollution and high oxygen levels.	Possibly healthy systems usually indicate that there are some problems but the situation has the potential to get better or worse. In the case of worms, it would suggest that there is some organic pollution coming from somewhere, but not at serious levels yet.	Unhealthy systems are generally highly polluted with organic contaminants and contain low oxygen. This makes it difficult for a variety of BMI to live there (except worms) and is therefore an issue.

% MIDGE INDEX VALUE: __________

Healthy	Possibly Healthy	Unhealthy
Midges are key parts of healthy ecosystems, but only in small numbers. A system with a healthy percent midge score would indicate a system with high amounts of nutrients and oxygen. This type of system would also have a large variety of species types as there is enough resources for all species to compete with the midges.	In the case of midges, it would suggest that there is some oxygen and nutrients available for other species to compete with the midges, but not enough to create a flourishing ecosystem.	In the case of midges, an unhealthy system would suggest that there is not enough oxygen or nutrients available for other species to compete with the midges. Without the nutrients, other species have difficulty surviving, and the stream will continue to deteriorate.

% EPT INDEX VALUE: ___________

Healthy	Possibly Healthy	Unhealthy
A healthy EPT score would suggest high amounts of Caddis, May, and Stoneflies. These species only live in the cleanest environments, and therefore would reflect well upon that stream. This type of stream would contain high nutrients, oxygen, and low levels of any pollutants. *EPT is likely most effective when used first to determine whether a stream has an issue or not*	In the case of EPT, a possibly healthy score would suggest there is some of these fly species present, but not enough to deem it healthy quite yet. Remember, flies can get swept in by strong winds or floods, so they can appear by chance and distort results. It could also indicate a stream that was once healthy, but is slowly worsening. These flies would be likely be leaving soon.	An unhealthy EPT score would suggest that there is nearly none of these flies present, and therefore the stream has an issue of some kind. It is a great start to finding what the problem is when we know from this that there is a problem! EPT on its own cannot tell us what the problem is, just that one exists. Usually, this problem is low oxygen levels or high amounts of harmful chemicals in the water that hurts these sensitive flies.

HBI INDEX VALUE: _______________

Healthy (0-5.0 HBI Score)	Possibly Healthy (5.01-6.5 HBI Score)	Unhealthy (6.51-10 HBI Score)
A healthy HBI score indicates that the whole stream is overall very healthy. This would include low levels of harmful chemicals, high oxygen/nutrient levels, and low human disturbance. This type of system can support a large variety of life.	A possibly healthy HBI score suggests that the stream system is having some issues in one area, but is doing alright overall. The issues will be fairly obvious if you notice a high amount of one species in the sample. This species can help give better insight into what exactly is wrong. This type of stream can get better or worse depending if the problem is addressed.	An unhealthy HBI scores means that the whole stream system isn't doing well. It has multiple problems that cover a variety of areas and would take a long time to fix. These areas could include pollution, human disturbance, or invasive species.

Interpreting your results

What is the overall health of the section of stream you sampled?

____

____

____

What sources of pollution may this stream be exposed to?

____

____

____

What are 3 things we could do to help improve the water quality?

____

____

____

THANK YOU FOR TAKING PART IN X-STREAM SCIENCE!

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Scientific Method

Students could use the scientific method to lead their X-Stream Science investigations. Using the scientific methods allows students to ask and answer questions, make observations, and complete field study data collection in a real life setting.

Steps of the Scientific Method

1. Ask or pose a question (include the treatment and the biological pattern you are examining):

Is the water quality in the Medicine River healthy?

2. Do Background Research

Where is the Medicine River? What human impacts can be found on the land adjacent to the river? What is happening upstream of our proposed site?

3. Construct a Hypothesis (the treatment will affect the mechanism(s) that create the biological pattern):

If we carry out water quality monitoring on the Medicine River we will find that the testing area is falling below the acceptable guidelines for a healthy aquatic ecosystem.

4. Test your Hypothesis (Experiential Learning)

X-Stream Science Protocol carried out at the site.

5. Analyze Data and Draw a Conclusion

Example: As there was no BMIs collected that fall in the intolerant category this indicates that there may be something impacting the water quality. This supports our hypothesis that acceptable guidelines have been exceeded.

6. Communicate your Results

Create a report, presentation, video or other method that shares your scientific method and findings.

X-STREAM SCIENCE

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Keep in Touch!

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