Finger Lakes Regional Stream Monitoring Network MANUAL

FingerLakes Community College

Finger Lakes Institute

Finger Lakes PRISM
Partnership for Regional Invasive Species Management

Hobart and William Smith Colleges

HOBART AND WILLIAM SMITH COLLEGES

FINGER LAKES INSTITUTE

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TABLE OF CONTENTS

INTRODUCTION

WHY CONDUCT STREAM MONITORING?

Stream monitoring is an important component of understanding the general health of a watershed. Historically, stream monitoring incorporated only water quality analyses, however the inclusion of biological monitoring and assessment of physical habitat has become critical to our understanding of stream and watershed health. Monitoring at this level gives insight to the community of organisms that live in the stream as well as the environmental perturbations that occur in this environment.

By providing monitoring protocols for the Finger Lakes Regional Stream Monitoring Network (FLRSMN) we hope that participating schools and citizen science volunteers will be able to share their data with one another and follow-up with interesting and dynamic investigations of their local stream as well as provide comparative studies of the streams throughout the Finger Lakes region.

Monitoring local stream sites with students and volunteers is a rewarding experience! We hope that this manual provides you with enough information to get started. Once stream monitoring is completed, you will be able to upload data into the FLRSMN database through the FLI website (http://www.hws.edu/fli/stream_monitoring.aspx) enabling everyone involved in the network direct access to regional data. Over the long-term this data will provide valuable insights into the health of local streams that feed into the Finger Lakes and Lake Ontario, and an overall assessment of Finger Lakes water quality.

PROTOCOL OVERVIEW

The Finger Lakes Regional Stream Monitoring Network program involves three protocols that together assess environmental conditions and overall stream health. The protocols include benthic macroinvertebrate sampling, a physical assessment of the stream banks, bottom substrate, and surrounding terrestrial conditions (riparian zone and land use) and chemical analysis of the stream water. The combination of these three protocols provides an excellent survey of the potential impacts to the stream ecosystem and allow students and teachers to learn more about the abiotic and biotic aspects of this complex environment. There are two levels or tiers of protocols available to choose from depending on time available and appropriateness for students. Tier One provides an overall look at the health of the stream site, while Tier Two provides a more thorough examination and quantification, and requires more time. New to the FLRSMN Protocols, we've added a section on invasive species (see page 19).

BEFORE YOU BEGIN

First and foremost, student safety must be considered when selecting the sampling site, including safe access to the stream from the streambank and safe water depth in the stream, especially during spring conditions when water levels and velocity are typically much higher than other times of year. It is recommended that you visit your selected stream monitoring location prior to bringing student to the site to assess for safe access and water levels.

Additionally, if you are performing the Benthic Macroinvertebrate Biomonitoring portion of the FLRSMN protocol you will need to obtain a **NYS DEC License to Collect (no fee)**. Please visit the DEC website www.dec.ny.gov for more details. This license is required for both Tier 1 and Tier 2 macroinvertabrate sampling. Please note that the application will require approximately 45 days to process and review.

If you have questions about terminology, please refer to Glossary on page 22.

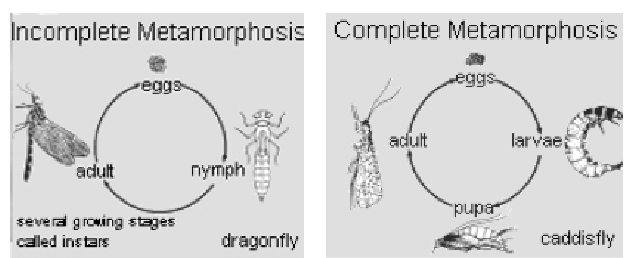
Benthic Macroinvertebrate Biomonitoring

Biomonitoring is an important method of determining changes in biological communities over time. It is commonly used in stream ecology to help determine the health of the organisms that live below the water's surface and is also an indicator of relative water quality. Specifically, stream ecologists assess the macroinvertebrate community using a relatively easy sampling technique to identify and verify if potential water quality problems or habitat degradation issues are evident. Keeping track of any changes that occur in these communities can help pinpoint environmental impacts on both the physical and chemical components of the stream ecosystem. These specific descriptive characteristics of a community are known as bioindicators.

Students identifying macroinvertebrates.

By analyzing benthic macroinvertebrate communities one can gain a substantial understanding of the overall stream health. The use of macroinvertebrates as a key source for biomonitoring is the result of their abundance in New York State streams as well as their species-specific sensitivity to environmental impacts. Furthermore, macroinvertebrates offer a more comprehensive indicator of water quality or non-chemical environmental factors than most analyses measuring one single chemical or physical parameter because of the length of time it takes for an insect to develop and grow in their environment and the conditions they face. Many insects spend more than a year in a stream before maturing to the terrestrial adult form we are typically more familiar with. As a result, the presence/absence of specific insect species integrates environmental conditions. Finally, in terms of this particular program, macroinvertebrate surveys provide hands-on evaluation of the stream community for students. Benthic macroinvertebrate biomonitoring is ultimately one of the more accessible means for students to fully appreciate stream and watershed ecology.

Macroinvertebrates are organisms that do not have a backbone (invertebrate) and are generally visible to the naked eye but can be caught in a 500 μm (0.5 mm) net or sieve. This term often refers to aquatic macroinvertebrates which include snails, clams, crayfish, worms, and insects, as well as others. In streams, macroinvertebrates are generally found on and amongst the bottom substrate, which is why they are considered benthic. All non-insect macroinvertebrates are completely aquatic organisms, however most insects are considered semi-aquatic, meaning that they spend part of their life underwater and part of their life as a terrestrial organism.



Figures 1 and 2. The life cycle of an aquatic insect. Complete and incomplete metamorphosis differs by the number of stages as well as the appearance of the immature form. (Source: http://www.epa.gov/bioiweb1/html/lifecycle.html)

An aquatic insect begins its life as an egg deposited under water. Whether aquatic insects go through complete or incomplete metamorphosis determines whether they develop into a nymph or larvae. Complete metamorphosis involves four stages, while incomplete metamorphosis involves three stages (Figure 1). For complete metamorphosis, the larval and pupae stages are aquatic, while the adult is terrestrial (Figure 2).

Often macroinvertebrates that experience complete metamorphosis have a grub-like appearance when in the larval or pupae stage. In comparison, insects that undergo incomplete metamorphosis are aquatic in the nymph stage and tend to look very similar to the terrestrial adult (except for the developing wings; USEPA, 2011). Some insects, such as those in the group Coleoptera (beetles), spend their entire life underwater even though they go through incomplete metamorphosis.

Sampling Methods: The Finger Lakes Regional Stream Monitoring Protocol involves two levels or tiers of protocols for use depending on the time available for sampling and appropriateness for students. Both protocols use the same equipment and collection methods, but differ with regard to the level of detail to which the sample is analyzed.

TIER 1 • *Recommended for younger students and/or classes with less than one hour of sampling time*

Tier 1 protocols use the presence/absence of major groups of macroinvertebrates to monitor water quality and stream health with the understanding that certain groups are more susceptible to environmental impacts. For example, the three major groups used as a standard for excellent water quality are the Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). These species of insects exist in the water during the juvenile stage and are susceptible to mortality from factors such as low dissolved oxygen, high water temperatures, low pH levels, and siltation. Conversely, under these adverse conditions species such as the Oligochaeta (worms) and Chironomidae (midges) thrive and therefore may be found in high quantities when streams are significantly polluted.

TIER 2 • *Recommended for older students and/or classes with more than one hour of sampling time*

Tier 2 protocols take the analysis a step further toward quantifying whether a site is impacted or not. During this protocol, students collect and identify 100 organisms and characterize the percent composition of the sample to be compared to a “model” New York State stream community. It also provides a biotic index that gives macroinvertebrate groups a numerical value scale between 0-10, representing the extent to which they show sensitivity to environmental impacts. (Bode et al., 2002; Hudson River Watch 2004).

Benthic Macroinvertebrate Sampling Protocol

Materials needed for each group:

- D-net
- 1-2 sample pans to temporarily store macroinvertebrates
- 1 ice cube tray for sorting specimens
- Magnifying glass or field microscope
- Forceps or plastic spoons
- Field guides or laminated dichotomous keys

Methods:

1. Collect stream water in a large sample pan and place it on the shore. This will provide temporary storage of macroinvertebrates.
2. In a stream riffle, place a D-net approximately 1 foot downstream from your feet along the stream bottom. The position of the net is important so that the water flow will deliver organisms hiding under and between rocks on the bottom of the stream into the net.
3. Conduct the "riffle dance" for 5 minutes moving along a diagonal line (transect) across the stream channel:

   – With the net directly downstream of your feet, disturb the sediment rigorously by twisting and dragging your feet on the stream bottom.

   – If you encounter any large boulders or cobbles that cannot be disturbed with your feet, you can brush them off with your hands to allow anything attached to it to flow into the net.
4. If you have collected large rocks or sticks in your sample, inspect them carefully and wash any specimens off in the water within your net.
5. Carefully place the debris you've collected into pan by inverting your net into the water and rinsing off anything clinging to the net.
6. Add additional water to the pan as necessary in order to semi-submerge the debris allowing any macroinvertebrates to be suspended in liquid.
7. Begin counting the macroinvertebrates by transferring them with forceps or spoons to ice cube trays filled with stream water and record the necessary information on your data sheet. Group like organisms a designated section of the tray.
8. Finally, place all debris and macroinvertebrates collected back into the stream as alive and undamaged as possible.

Physical Stream Habitat Assessment

A 50-meter length of stream will be used to conduct the physical assessment of the stream.

Weather and Land Use

Recording the **weather** can put into context the stream characteristics the day of monitoring. It is important to record the current weather conditions as well as conditions during the past 24 hours to assess stream characteristics such as high or low water level, turbidity, appearance of the stream, and velocity. For example, if there was a heavy rainfall the day before sampling, the stream may be carrying woody debris or sediment from the watershed, and the stream may have higher than normal water levels. High water levels may also cause the stream to appear as if there are no pools, just fast running riffles.

Land use activities next to or adjacent to the stream may also impact stream characteristics such as bank erosion, woody debris found in the stream channel, and the presence or absence of certain substrates such as silt and mud. One would expect to find more woody debris in a stream site next to woodlands versus cropland or pasture, unless it was carried from a source upstream. A lot of silt, clay or mud may indicate that the stream is carrying sediment from nearby land use activities such as farming, forestry, or industrial/residential construction.

Method:

1. Measure out a 50-meter stream reach using the provided meter tape.
2. Record the current temperature and weather conditions as well as the past 24 hour's weather conditions.
3. Before entering the stream, perform a visual assessment of the nearby land uses on either side of the stream.
4. Record observed land uses by checking off listed land uses. If "other" is selected, include a brief description or explanation.

Channel Characteristics

Background: Studying channel characteristics such as bank stability and in-stream habitat provide information about factors such as food and shelter that promote healthy aquatic communities. Eroded banks (Figure 3) are the result of high flow and the degradation of streamside vegetation associated by a variety of human activities. Streams that are channelized to prevent flooding, they are supported or secured with rip-rap (manmade bank protection in the form of large boulders or concrete) to reduce erosion, and many times the woody vegetation along streams are removed to accommodate adjacent land use activities such as parkland, residential settings, and commercial or industrial construction. The loss of shrubs and trees along the stream bank can alter stream temperature, due to loss of shading and can also facilitate erosion of the stream bank without strong woody roots to hold the soil in place. Furthermore trees and shrubs provide food to the aquatic macroinvertebates and bacteria in the stream that depend on leaf litter for food, as well as habitat during high storm flows.

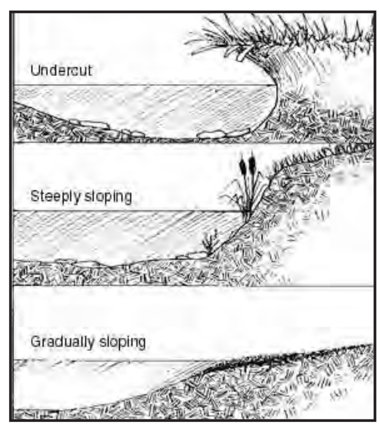


Figure 3. Diagram illustrating three types of bank formations. (Source: U.S. EPA, 2007)

Undercut banks are cave-like overhangs along the banks. Undercut banks have a positive impact on stream health, providing micro-habitats for many fish in the form of shade, and shelter. Studies have found that undercut banks also have more abundance of macroinvetebrates than other habitats in streams (Rhodes et. al. 1991). However, if seriously undercut, the bank could be vulnerable to collapse (U.S. EPA 1997).

Methods: When examining the channel characteristics note the presence and length of eroded banks exposed from lack of vegetation, rip-rap occurrences, and undercut banks. To determine whether it is an undercut bank place a meter stick under the bank. If part of the meter stick disappears it can be recorded as an undercut bank.

Stream Habitat

Background: Rootwads can be found along streams that have trees and shrubs along the banks in the form of tree roots spread out like a fan along the water's edge. Like the undercut banks, the rootwads provide a micro-habitat for aquatic organisms, trap organic debris and provide food and shelter. Rootwads also play an important role in protecting the bank from erosion.

Example of rootwads along a stream bank.

Large woody debris (larger than 10 cm in diameter) plays an important ecological function in a stream and should be counted along the 50 m stretch. Woody debris provides structural support for aquatic organisms to hide and rest from predators. Large woody debris can enter a stream from the adjacent trees and shrubs along the banks. Once in the stream channel the debris can form log jams, which slow the water and form pools. The debris collects leaf litter providing a natural colonization site for macroinvertebrates to feed. The decay of large woody debris also provides food for bacteria, fungi, and other aquatic organisms.

Methods: Record the total number of rootwads and large woody debris observed along the 50 meter stretch of stream.

Pools and Riffles

Using a riffle area for macroinvertebrate sampling.

Background: Pools and riffles provide different habitat characteristics defined mostly by depth and flow of water. Pools are deeper (>0.5 m) areas where velocities of water are slower. Riffles are faster running, shallow areas (< 0.5 m). Each provides unique habitats for fish and aquatic organisms. Pools are areas where fish may stop and rest (U.S. EPA 1997).

Methods: Tally up the total number of each of the two habitat types. Riffles are shallow areas where the surface of the water appears textured and are audible as the water flows over the substrate. Pools however, appear still and calm and may gently swirl. Both habitat types may be present on opposite sides of a stream channel with each abutting an opposing bank.

Channel Dimensions and Discharge Measurements

Background: Discharge from a stream is defined as the "volume of water in a stream passing a given point at a given moment in time, expressed as a measure of volume per unit of time, i.e. cubic meter per second" (USGS 2010). Scientists use discharge estimates with other data to assess the transport of sediments and chemical pollutants to the watershed. For example, a scientist may use discharge data to calculate the volume of water available for dilution of pollutants; if discharge is low the stream does not have the same capacity to dilute chemical pollutants as it would during periods of high flow and volume. By comparison, streams with a high discharge rate will transport more sediment downstream than one with low discharge rates.

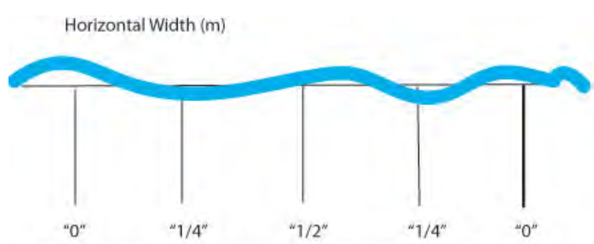
The formula for calculating discharge of a stream is Q=WDV

Where: Q= average stream discharge (cubic meters/second)
W= average stream width (m)
D= average stream depth (m)
V=average stream velocity (m/s)

Methods: The average stream width, depth and velocity must first be measured in order to calculate the discharge of a stream.

Step 1: Measure the stream width at a select section of stream. Record measurement on data sheet.

Step 2. Measure the stream depth at four equal intervals across the same section of stream as shown in the diagram below. Record depth measurements.



Step 3. Calculate the average stream depth

Step 4. To calculate velocity, measure out a 5-meter length of stream and drop a tennis ball at mid-channel. Record the time it takes for the tennis ball to travel the 5-meter distance and calculate the velocity in m/s. Conduct three velocity trials in total and calculate the average stream velocity.

Step 5. Calculate the average stream discharge using the formula Q=WDV.

Substrate

A stream channel with various sizes of substrate.

Background: Determining the size and type of substrate or stream bottom material is also important for habitat assessment because many aquatic organisms, particularly benthic macroinvertebrates and many fish species, rely on larger substrate (gravel, cobbles, and boulders) for protection and reproduction (Figure 4). The presence and commonality of these substrates will determine whether a stream can support aquatic macroinvertebrates and the fish that feed on them. Cobbles and gravel provide an ideal habitat for many aquatic macroinvertebrates, while aquatic worms prefer silt and sand to burrow (Hudson River Watch 2004). High amounts of silt and mud on a cobble substrate may cause problems for fish spawning, as it can smother fish eggs which deplete them of oxygen.

Methods: Conduct an assessment of the 50-meter stream length and rank the substrate based on how much or often it is found. For Tier 2 habitat monitoring, record the width of the longest axis (length) for 10 random pebble samples. Then calculate and record the average size of these 10 samples.

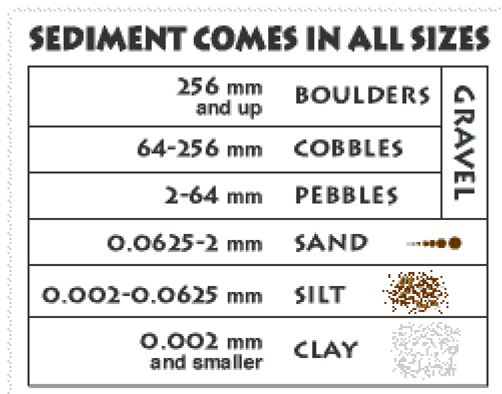


Figure 4. Relative particle sizes of substrate (USGS 2014).

TIER 1 • *Recommended for younger students and/or classes with less than one hour of sampling time*

Tier 1 protocols uses visual observations to assess stream channel characteristics and presence of habitat features, such as rootwads, woody debris, pools and riffles, that are beneficial to may aquatic organisms including insects and fish. Presence of eroded or undercut banks can provide insight into the volume and velocity of stream flow.

TIER 2 • *Recommended for all students and classes with more than one hour of sampling time*

Tier 2 protocols include the Tier 1 visual observations as well as measurements of stream depth and velocity used to calculate average stream discharge, and an assessment of the stream substrate. Stream discharge is an important value used in determining dilution rates for potential chemical pollutants. Stream substrate assessment is a valuable habitat assessment tool for determining what types of aquatic insects could be present in the aquatic ecosystem.

Water Quality Assessment

Although chemical analysis of stream water represents only a snapshot of water quality it is still important in determining stream health. The following protocol includes measurement of water appearance/odor, temperature, dissolved oxygen, pH, alkalinity and chloride.

Water Appearance and Odor

Background: The appearance of stream water can give a good indication of water quality if one knows what to look for. Generally clear water is a good sign. Murky or brown-colored water often means siltation is occurring as a result of eroding banks. Tea-brown colored water is often due to the tannins found in vegetation leaching. This is similar to the way tea leaves colors tea brown. Algal blooms will be clearly visible as clouds of green and are often the result of nutrient in the stream. If the water appears oily, it may be from runoff from surrounding roads and other impervious surfaces.

Methods: Note and record the water appearance and odor of the stream by checking all characteristics that apply and recording any additional observations.

Temperature and Aquatic Life

Temperature is important to measure in a stream environment because temperature regulates a number of other parameters such as dissolved oxygen content (see below) and the rates of metabolic activity of aquatic organisms and bacteria. As temperature rises, so does metabolic activity including the rates of growth, respiration, and decomposition. Most aquatic organisms have a preferred temperature range, for example, trout need water temperatures at ~20° C or less to survive and reproduce. Temperatures in streams can increase due to human-induced activities that impact the habitat in the stream watershed. For example, development and subsequent loss of trees and other woody shrubs will reduce the amount of shade and filtration of water along the streambanks and increase the amount of hard surfaces that absorb heat. Removal of trees and shrubs from streambanks may impact stream temperatures by direct warming of water in the stream as well. Other factors that can cause "thermal" pollution are effluents from industrial and wastewater treatment plants (WOW 2004).

Methods: The temperature of streamwater is collected using the Vernier Labquest2 interface with Vernier probe. Once the Labquest2 and probe are connected, and the probe is placed in the water, hit the collect button. When the value stabilizes record the temperature in degrees Celsius.

Dissolved Oxygen and Aquatic Life

Dissolved oxygen (DO) is essential to all aquatic life. In a stream environment, aquatic organisms such as trout and their food sources (mayflies, stoneflies) require DO levels at or above 6 mg/l (equivalent to ppm). While humans and terrestrial animals breathe oxygen from the air, aquatic animals use oxygen that is dissolved in water.

Background: An aquatic animal breathes by absorbing free oxygen into its blood through its gills or directly through its body surface. Oxygen (O_2) is consumed in surface waters by all aquatic organisms: fish, plants, algae, bacteria, and invertebrates. The oxygen molecule in dissolved oxygen is free (O_2) which differs from the oxygen atom bound to hydrogen in a water molecule (H_2O). Oxygen gets into water three ways: 1) diffusion from the surrounding air; 2) aeration (rapid movement); and 3) when released as a by-product of photosynthesis by algae and aquatic plants. There are a number of physical and biological factors that can impact the DO levels in a water body such as a lake (WOW 2004).

Factor 1 - DO and Photosynthesis

Photosynthesis by aquatic plants and algae may contribute significant amounts of O_2 to a water body. During the day when light is present, aquatic plants and algae release O_2 as a by-product of photosynthesis. On the other hand, the process by which aquatic life uses O_2 is called respiration. Below are the formulas for photosynthesis and respiration.

Photosynthesis

$H_2O + CO_2$ + light energy ---> carbohydrate + O_2

Respiration

carbohydrate + O_2 ---> $CO_2 + H_2O$ + energy for respiration

During the day DO levels in a water body will remain constant as the cycle of O_2 consumption by respiration is replenished by photosynthesis, aeration and diffusion. At night, however, photosynthesis ceases, but the rate of respiration remains the same, subsequently DO levels drop (Figure 5). Normally, this diurnal DO cycle will not harm aquatic life. However, in bodies of water that have large populations of plants and algae one would expect to see dramatic variations in the cycle of DO concentrations from day to night which may stress aquatic organisms. Figure 5 shows a typical diurnal cycle of DO levels (measured in mg/l).

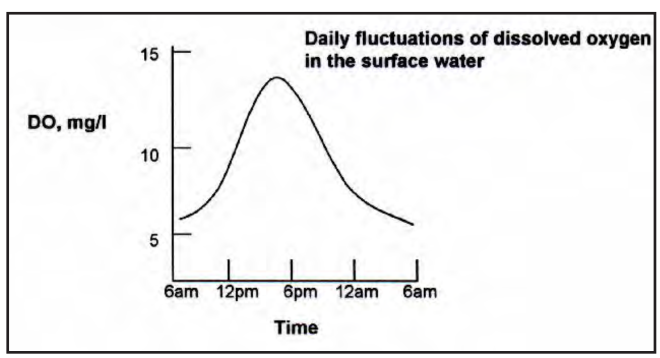


Figure 5. Typical dissolved oxygen levels in surface water during the summer months (NCSU 2014).

The typical concentration of dissolved oxygen (DO) over the course of one day naturally rises during the day and falls at night in the summertime.

Factor 2 - DO and Decomposition
Decomposition of plant and animal/human wastes also affects DO levels in a water body. A stream with large inputs of nutrients or organic wastes may show low DO concentrations because O_2 is used by bacteria and fungi during the process of decomposition. Although aquatic plants and algae are important for releasing O_2 during photosynthesis, too much of a good thing can cause problems; streams with excessive plant life can actually become nutrient rich as plants die off, decompose and release nutrients. Finally, organic matter build-up in a stream also accelerates the rate of decomposition and DO uptake. Organic matter comes from wastewater treatment plants that discharge into a stream, farmland runoff, and sediments from streams. Excess nutrient concentrations can also stimulate a similar chain reaction that increases algal production, decomposition, and DO uptake.

Factor 3 - DO and Temperature
Another factor that plays a role in DO levels in streams is temperature: the colder the water, the more O_2 it can hold. Think about drinking a glass of cold water versus a glass of lukewarm water. The warmer water tastes "flat" because the O_2 has been removed through heating. When graphing DO and temperature one would expect to find an inverse relationship between the two variables, that is, as temperature increases, DO decreases (Figure 6).

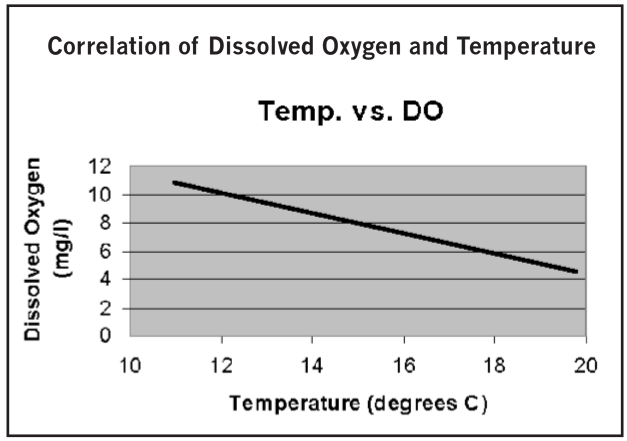


Figure 6. Relationship between water temperature and dissolved oxygen (SLUH 2014).

Increased temperatures also impact the level of biological activity in a stream. Warmer temperatures in the summer increase biological activity and the use of O_2 by aquatic organisms, whereas in the winter, biological activity drops off with decreasing temperatures. Similar to the diurnal cycles of DO there are seasonal cycles of DO in streams.

Methods: DO is measured in two ways: with a Vernier Optical DO probe and a LaMotte Test Kit #7414. The Vernier Optical DO Probe is recommended for Tier 1 protocols and the LaMotte DO test kit, which is a titration method, is recommended for Tier 2 protocols. Classes performing the Tier 2 protocols can also use the Vernier Optical DO probe for comparison purposes. Specific instructions for both DO testing methods are included in each FLRSMN monitoring kit. Students performing the DO titration using the LaMotte Test Kit should wear appropriate lab safety protection, including safety goggles and gloves.

****Waste Handling and Clean-up Procedures**:** Put the contents of the titration tube into the provided waste container. The waste container is meant to hold only the portion of the stream water that has been treated with chemicals for analysis. Rinse the titration tube with distilled water and place it back in the chloride ion kit. Discard any leftover chemicals in the titration tube in waste receptacle and handle with care until you are back at school. If your school has a chemical waste disposal process, waste can be handled through your own school. If not, waste can be returned to FLI with the FLRSMN monitoring kits to be disposed of properly.

pH and Aquatic Life

pH in the aquatic environment is driven by many factors including acidic rainfall, photosynthesis by plants, and the "buffering capacity" of the stream watershed soils and bedrock. pH is a measure of hydrogen concentration, with a range of 0-14 (no units). The pH scale is used to quantify acidity, with 0 being the most acidic and 14 the most alkaline. A value of 7 is neutral. Solutions with a pH of less than 7 are acids, while those with a pH greater than 7 are bases. A decrease in pH represents an increase in acidity, and an increase in pH represents a decrease in acidity. The scale is also logarithmic, meaning that a one-unit change actually represents a tenfold change.

The pH of water is considered another indicator of water quality and a number of factors can cause variation in pH. The sensitivity of aquatic organisms to the pH of their environment varies, but there are some that can withstand low (acidic) pH values, while others can't. Small changes in pH can endanger many kinds of plants and animals. Table 1 shows the effects to aquatic organisms when pH is too low or too high.

Table 1. – Effects of pH on Aquatic Organisms
Source: Center for Earth and Environmental Science at Indiana University - Purdue University Indianapolis

pH	Effect
3.0-3.5	Unlikely that fish can survive for more than a few hours in this range. Some plants and invertebrates can be found at pH levels this low.
3.5-4.0	Know to be lethal to salmonids.
4.0-4.5	All fish, most frogs, and insects are absent.
4.5-5.0	Mayfly and many other insects absent. Most fish eggs will not hatch.
5.0-5.5	Bottom dwelling bacteria (decomposers) begin to die. Leaf litter and detritus begin to accumulate, locking up essential nutrients and interrupting chemical cycling. Plankton begin to disappear. Snails and clams absent.
6.0-6.5	Freshwater shrimp absent. Unlikely to be directly harmful to fish.
6.5-8.2	Optimal range for most organisms.
8.2-9.0	Unlikely to be directly harmful to fish. Indirect effects could occur due to chemical changes of the water.
9.0-10.5	Likely to be harmful to salmonids and perch if level persists.
10.5-11.0	Rapidly lethal to salmonids. Prolonged exposure is lethal to species such as carp and perch.
11.0-11.5	Lethal to all species of fish.

Factor 1 – Photosynthesis and pH: During respiration, aquatic plants and primary producers give out CO_2, which dissolves in water as carbonic acid (H_2CO_3), a weak acid, thereby lowering the pH. During photosynthesis aquatic plants and primary producers use up dissolved carbon dioxide this in turn reduces the acidity of the water and so pH increases. For this reason, pH may be higher during daylight hours and during the growing season, when photosynthesis is at a maximum.

Factor 2 – Acid rain and pH: Rainfall is somewhat acidic by nature, due to atmospheric carbon dioxide (gas) reacting with precipitation (rain drops) to make carbonic acid (H_2CO_3). The acidity of rainfall is critical for the weathering of rocks and formation of soils on land. Without it many of the necessary minerals and nutrients to grow plants would be absent. However, acid rain intensifies this weathering process and can have negative impacts on the landscape and surface waters where transported ions and sediments end up (Figure 7). While normal rainfall is slightly acidic

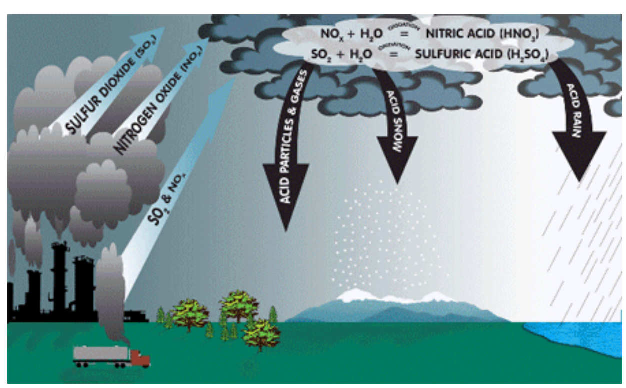


Figure 7. Above is a graph that illustrates the acid rain cycle (NYS DEC 2011).

(about 5.5) the average pH of rainfall in New York State ranges from 4.5 to 5-0 – 30 times more acidic than "normal."

Factor 3 – Buffering Capacity and pH: In the Finger Lakes region, calcareous soils and limestone outcrops, which contain $CaCO_3$ (calcium carbonate) are dominant in the landscape and provide a "buffer" against acid rain (Lajewski et. al. 2003). The buffering capacity of these soils reduces the acidity of acid rain as it filters through to the groundwater and stream channel. (See Alkalinity and Aquatic Life section)

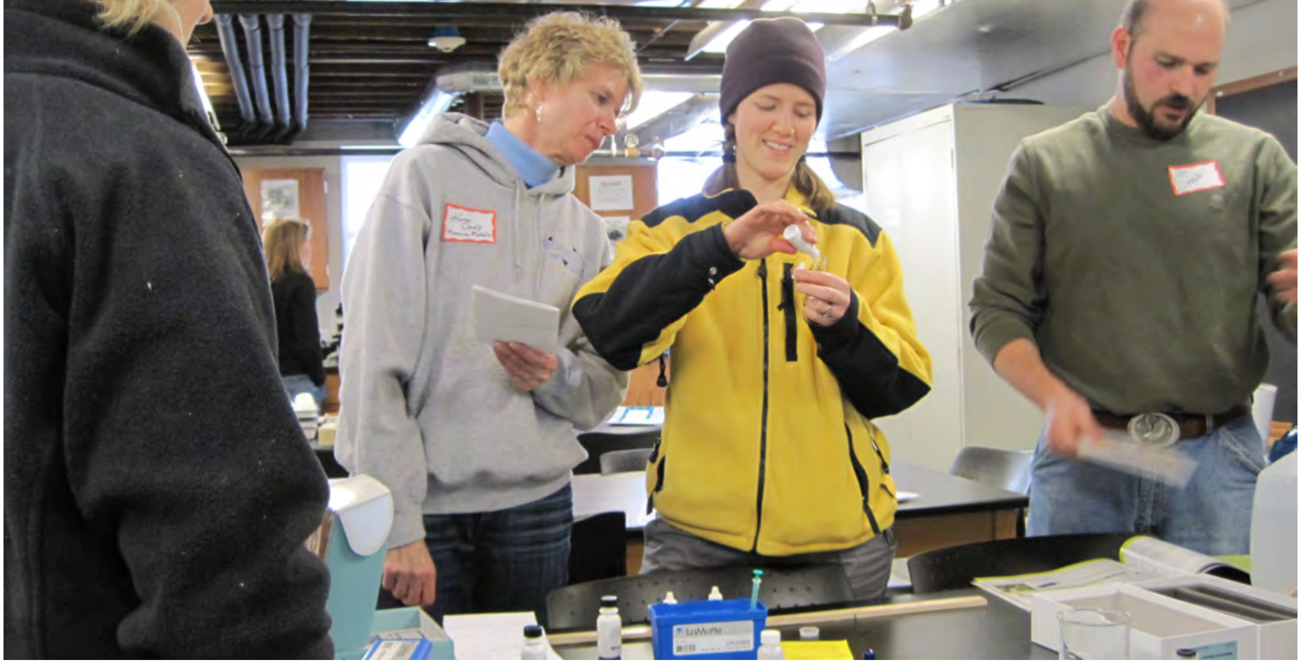
Methods: Measuring pH can be done in two ways: using the Oakton pH probe and/or the LaMotte pH #5858 test kit. Both methods are appropriate for Tier 1 or Tier 2 protocols. To measure the pH using the probe, calibrate the device using the calibration directions included in FLRSMN monitoring kit. Once it is calibrated, turn it on and place it in the middle of a riffle section of the stream. The numbers on the probe may vary over time, so wait until the values on the probe stablizes (wait one minute). Once the pH value does not fluctuate, record that reading. Students performing the pH test using the LaMotte pH Test Kit #5858 should wear appropriate lab safety protection, including safety goggles and gloves.

****Waste Handling and Clean-up Procedures**:** Put the contents of the sample test tube into the provided waste container. The waste container is meant to hold only the portion of the stream water that has been treated with chemicals for analysis. Rinse the test tube with distilled water and place it back in the pH test kit. If your school has a chemical waste disposal process, waste can be handled through your own school. If not, waste can be returned to FLI with the FLRSMN monitoring kits to be disposed of properly.

Using the Vernier Labquest2 probe to measure temperature.

Alkalinity and Aquatic Life

Alkalinity is the measurement of water's ability to neutralize or "buffer" acids (U.S. EPA 2014) and, as such, is linked to water pH levels. Effective buffering agents are bicarbonate and carbonate compounds found in the limestone bedrock and alkaline soils common in parts of the Finger Lakes region. Measuring alkalinity is important to help determine a stream's ability to neutralize acidic pollution from rainfall or wastewater (U.S. EPA 2014). Surface waters will typically have an alkalinity range between 20-200 ppm and in geographic locations with limestone bedrock or alkaline soil the range is 100-500 ppm.



Alkalinity is important to aquatic life because a higher alkalinity can protect against sudden changes in pH from a pollution event or moderate the impacts of ongoing acid rain. Many aquatic species are sensitive to acidic conditions. For more details, see Table 1. Effects of pH on Aquatic Organisms (previous section).

Methods: (**Optional for Tier One Protocol**) To measure alkalinity, use LaMotte Test Kit 4491-DR to collect a sample of water from the stream and measure alkalinity in ppm. Follow instructions that come with the kits. Students performing the alkalinity test should wear appropriate lab safety protection, including safety goggles and gloves.

****Waste Handling and Clean-up Procedures**:** Put the contents of the titration tube into the provided waste container. The waste container is meant to hold only the portion of the stream water that has been treated with chemicals for analysis. Rinse the titration tube with distilled water and place it back in the alkalinity test kit. Discard any leftover chemicals in the titration tube in waste receptacle and handle with care until you are back at school. If your school has a chemical waste disposal process, waste can be handled through your own school. If not, waste can be returned to FLI with the FLRSMN monitoring kits to be disposed of properly.

Chloride and Aquatic Life

In New York State, measuring chloride can be important to understand water quality as a result of possible contamination from road salts (either NaCl or $CaCl_2$). Other sources of chlorides include both ground and surface waters, specifically wastewater treatment plants that use chlorine to disinfect water before it is discharged, agricultural runoff (fertilizers and animal waste), water softeners, discharge from landfills and septic tanks.

Although not usually harmful to people, chloride drinking water standards are set a limit at 250 ppm. The same is true for most aquatic organisms in freshwater environments. Whereas low levels may not harm aquatic life, high levels over a long period of time may cause acute toxicity. Elevated chloride levels may inhibit plant growth, impair reproduction, and decrease diversity of stream biota. The NYS standard for safe levels of chlorides in stream environments is <250 ppm to ensure the health of aquatic organisms.

Methods: (**Optional for Tier One Protocol**) Use LaMotte Kit 4503 to collect a sample of water from the stream and measure chloride in ppm. Follow instructions that come with the kits, although skip step 2 because there is no need to adjust for pH if it is between 7 and 10 (the typical range for streams in the Finger Lakes region). Note that Reagent #2 can stain heavily if it gets on hands or clothing. Students performing the chloride test should wear appropriate lab safety protection, including safety goggles and gloves.

****Waste Handling and Clean-up Procedures**:** Put the contents of the titration tube into the provided waste container. The waste container is meant to hold only the portion of the stream water that has been treated with chemicals for analysis. Rinse the titration tube with distilled water and place it back in the chloride ion kit. Discard any leftover chemicals in the titration tube in waste receptacle and handle with care until you are back at school. If your school has a chemical waste disposal process, waste can be handled through your own school. If not, waste can be returned to FLI with the FLRSMN monitoring kits to be disposed of properly.

TIER 1 • *Recommended for younger students and/or classes with more than one hour of sampling time*

Tier 1 protocols include a visual assessment of the stream water appearance as well as recording any noticeable odors. Water quality tests to be performed are temperature, pH and dissolved oxygen. While chemical test kits are provided for measuring pH and dissolved oxygen, both parameters can also be measured using the Vernier Labquest2 for DO and the Oakton probe for pH. The LaMotte test kit for DO requires a titration. We recommend that teachers read through the steps for using the LaMotte DO test kit to determine whether that particular test is appropriate for your students.

TIER 2 • *Recommended for older students*

Tier 2 protocols include a visual assessment of the steam water appearance and presence of any odor as well as chemical testing for pH, dissolved oxygen, alkalinity and chloride, and measuring temperature. Measuring DO and alkalinity using the LaMotte test kits require titrations. If your student have not performed titrations before, additional instruction is recommended.

FOR ALL WATER QUALITY TESTING: To ensure safety of your students, be sure to provide lab safety goggles and gloves if needed. The LaMotte test kit for chloride uses Reagent #2 which can stain hands and clothing. Additionally, wastes from the chemical test kits need to be disposed of properly. Waste handling instructions are provided for each test in the methods section.

Invasive Species

Invasive species are non-native species with the potential to cause serious harm to the environment, economy and even human health. Invasives have characteristics that enable them to outcompete native organisms and also lack predators that would keep their population in check. Once introduced to an area, invasive species quickly take over and wreak havoc on the surrounding ecosystem. In fact, invasive species are one of the greatest threats to New York State's rich biodiversity.

Invasive species are introduced to aquatic, terrestrial and riparian ecosystems either intentionally or accidentally through recreational vehicles and gear, nursery stock, construction activities, exotic aquarium and pet trade, and even bilge water from large ships making transatlantic voyages. Invasive species can displace native fish, plant, tree, and wildlife species; degrade habitat leading to habitat loss; cause severe economic damage due to crop damage and disease in crops and livestock; and aid in the loss of recreational opportunities.

The most effective and economic way to combat invasive species is through Early Detection Rapid Response (EDRR) programs. The earlier an invasive species is detected, the more effective its management (Figure 8). Citizen scientists are vital to reducing the spread and impact of invasive species. Through the FLRSMN, teachers and students have the potential to find and report high priority invasive species.

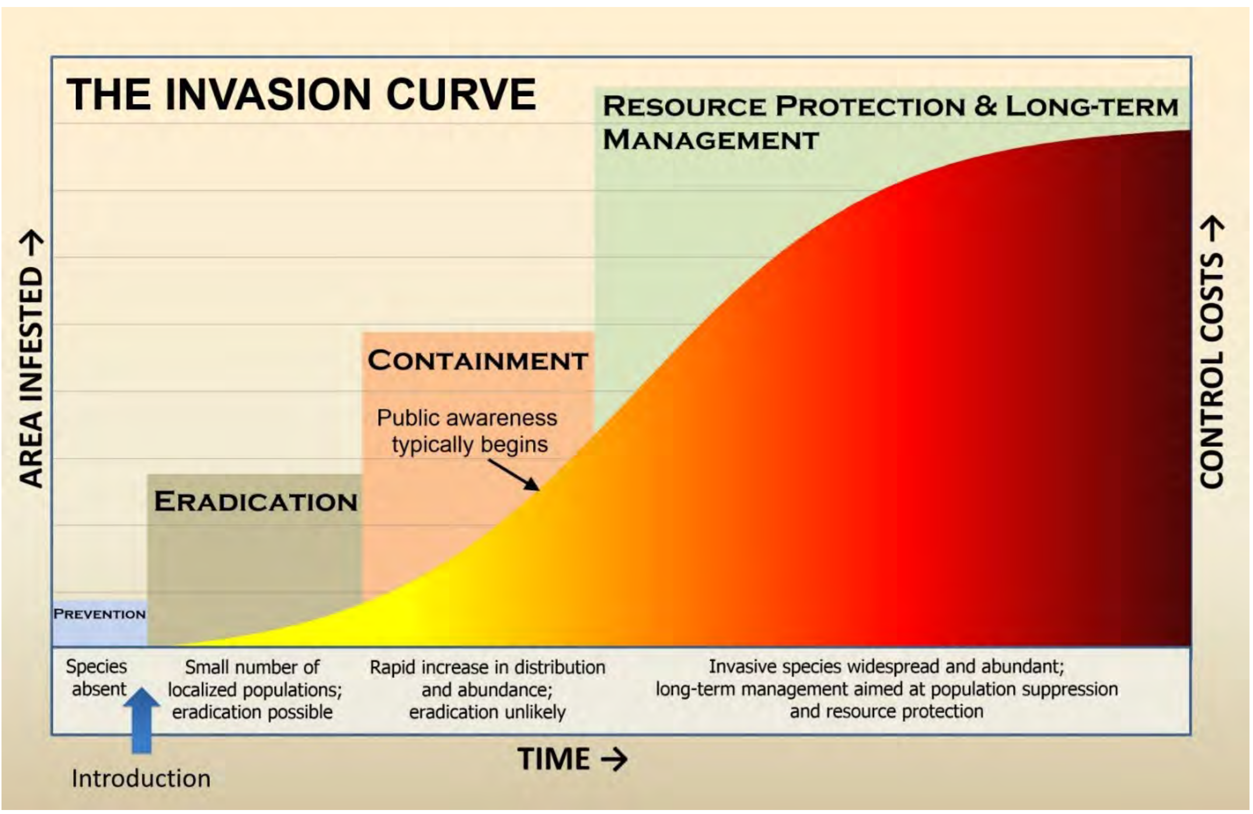


Figure 8. The invasive species invasion curve.

The Finger Lakes Partnership for Regional Invasive Species Management (PRISM) has identified several invasive species of concern that could be identified and reported through the FLRSMN (see below). To learn more about these stream and riparian invasive species, visit http://fingerlakesinvasives.org/

(see next page)

INVASIVE SPECIES OF CONCERN

Stream Invasives	Riparian/Terrestrial Invasives
Western Mosquitofish *(Gambusia affini)*	Flowering Rush (*Butomus umbellatus)*
Eastern Mosquitofish (*Gambusia holbrooki)*	Giant Hogweed *(Heracleum mantegazzianum)* DO NOT TOUCH!
Round Goby *(Neogobius melanostomus)*	Japanese Knotweed (*Fallopia japonica)*
Oriental Weatherfish *(Misgurnus anguillicaudatus)*	Purple Loosstrife (*Lythrum salicaria)*
Sea Lamprey *(Petromyzon marinus)*	Common Reed (*Phragmites australis)*
Faucet Snail *(Bithynia tentaculata)*	Lesser Celandine, Fig Buttercup (*Ranunculus ficaria)*
Chinese Mystery Snail *(Bellamya/ Cipangopaludina chinensis)*	Mile-A-Minute (*Persicaria perfoliata)*
New Zealand Mud Snail *(Potamopyrgus antipodarum)*	Pale Swallow-wort (*Vincetoxicum rossicum*)
Red Swamp Crayfish *(Procambarus clarkia)*	Yellow Flag Iris (*Iris pseudacorus*)
Rusty Crayfish *(Orconecte rusticus)*	Wild Parsnip (*Pastinaca sativa*) DO NOT TOUCH!
Brittleleaf Naiad (*Najas minor*)	
Starry Stonewort *(Nitellopsis obtuse)*	
Eurasian Watermilfoil *(Myriophyllum spicatum)*	
Hydrilla *(Hydrilla verticillata)*	
Water Chestnut *(Trapa natans)*	
Didymo aka “Rock Snot” (*Didymosphenia geminate)*	

METHODS:

1. Stream invasive species of concern can be collected and identified during benthic biomonitoring

2. Riparian and terrestrial invasive species of concerns should be identified through visual assessment of the stream corridor. <u>CAUTION! If you see something that looks like Giant Hogweed or Wild Parsnip, DO NOT TOUCH! Report immediately!</u> If skin contact occurs, wash immediately with soap and water, and cover to prevent sun exposure.

3. To confirm the identification of an invasive species, place the sample in a white sampling bin and take a photo. Tips: for aquatic plants, make sure enough water is in the bin for the plant material to float; for all samples, place an item in the sampling bin for scale. Send images to the FLI Education Program Manager or Invasive Species Outreach and Volunteer Coordinator for confirmation.

4. Record invasive species on data sheet and submit online using the FLRSMN database.

Finger Lakes Regional Stream Monitoring Network: Complete Materials List

Please do an inventory of the FLRSMN monitoring kit before and after sampling to ensure that nothing is lost or left behind at your stream site.

Contact FLI @ 315-781-4386 or 315-781-4390 if something is missing or needs refills/replacements.

Item	Check if in kit	Purpose
Boots or waders or water shoes	Students provide	
Meter reel	X	To measure the stream site sample length and width
Meter stick	X	To measure the stream depth
Tennis ball	X	To measure velocity
Stop watch	X – Vernier Labquest2 has a stopwatch	To measure velocity
4 D-Nets	X	To collect macroinvertebrates
5 Sample pans (1 per group)	X	To temporarily hold insects
5 Ice cube trays (1 per group)	X	To sort insects
Forceps	X	To separate macroinvertebrates
Hand magnifiers and box magnifiers	X	To examine and ID macroinvertebrates
Field guides	X	Teacher resource to ID invertebrates
Major groupings ID sheet	X	To ID the 5 major groups- Tier One
Laminated ID sheets- B&W + color		To ID invertebrates and invasives
Leaf-Pack Network Macroinvertebrate flash cards	X	To ID invertebrates
Vernier Labquest2	X	Interface with probes
Vernier temp probe	X	
Vernier Optical DO probe and guard	X	For Tier One and Two
Oakton pH probe and instructions	X	Optional for Tier One
Buffer solution 7 pH	X	To calibrate the pH probe
LaMotte DO #7414 test kit	X	Optional for Tier One
LaMotte Chloride #4503 test kit	X	Optional for Tier One
LaMotte pH #5858 test kit	X	Optional for Tier One
LaMotte Alkalinity #4491-DR test kit	X	Optional for Tier One
3 Waste receptacles	X	To dispose chemical wastes from DO, chloride and alkalinity titrations
Safety goggles	Teacher provides	For LaMotte test kits
Gloves	Teacher provides	For LaMotte test kits
Data sheets	Teacher downloads from website	

Glossary Terms

Aeration – the process by which oxygen is dissolved into water through the rapid and aggressive disruption of the water's surface. This can be seen in action in the riffle sections of streams as the water bubbles over the substrate.

Benthic – the region at the bottom of a body of water (oceans, lakes, or streams), including the sediment. Benthos are organisms that live in the benthic region.

Biomonitoring – regular sampling of living organisms as act as markers of environmental impact.

Bioindicator – a living organism that has a known ability to tolerate certain environmental conditions which, by its presence or absence, can indicate environmental impacts.

Biotic index – a summary metric or score that indicates community health and extent to which a stream community is impacted.

Bottom substrate –the first layer of sediment that directly interacts with the water and the organisms found therein.

Community – populations of interacting species found in the same geographic region at the same time.

Decomposition – the natural breakdown of organic matter through the metabolic activity of bacteria, fungi, and other small organisms. Decomposition converts bound nutrients in the form of solid organic material into free nutrients that may be consumed by plants.

Discharge – the volume of water that flows through the river channel in a given second.

Discharge (m3/s) = Stream Width (m) x Average Stream Depth (m) x Average Stream Velocity (m/s)

Eroded banks – exposed soil on stream banks from erosive power of water or bank sloughing. The degradation of bank stabilization through the removal of vegetation and the increase of terrestrial runoff can causes banks to give way and drop into the stream channel.

Eutrophication – Large influxes of nutrients into a body of water from agricultural runoff and sewage seepage causing algal blooms, decreased oxygen levels, and eventual build up of organic matter.

Impaired (vs Non-impaired) – streams containing high environmental impact and low community health amongst organisms that live there. Streams that contain little environmental impact and have a thriving community are said to be "non-impaired."

Invasive Species – non-native sepcies that have the potential to cause serious harm to the environment, economy and even human health.

Macroinvertebrate – organism that does not have a backbone (invertebrate) and that are generally visible to the naked eye but can be caught in a 500 µm (0.5mm) net or sieve. This term many times refers to aquatic macroinvertebrates which include snails, clams, crayfish, worms, and insects, as well as others.

Photosynthesis – the conversion of light, water, and carbon dioxide into glucose, a highly prized energy source, and oxygen.

$$6H_2O + 6CO_2 + \text{Sunlight Energy} = C_6H_{12}O_6 + 6O_2$$

Pollutant – any foreign substance found in an ecosystem, but generally refers to foreign substances that cause environmental degradation.

Pool – Relatively deep (>0.5 m) areas in streams and rivers where the water's velocity slows and often the current will eddy and swirl. Sediment along the bottom is often quite small because small sediment falls out of the water column and is deposited.

Respiration – the consumption of oxygen and glucose for normal cell functioning.

$$C_6H_{12}O_6 + 6O_2 = 6H_2O + 6CO_2 + \text{Respiration Energy}$$

Riffle – Relatively shallow (<0.5 m) areas in streams and rivers where the current velocity is high and the water's surface is broken and turbulent as it responds to rushing rapidly over a large and uneven substrate. Substrate is typically large as the water velocity is able to carry away smaller particles.

Riprap – man-made structures that enhance bank stabilization in order to prevent erosion. Rip-rap often comes in the form of large slabs of rock laid into the bank.

Siltation – the process by which small inorganic sediments (<0.06 mm) enter the water column and settle onto and cover the native substrate. This is generally the result of soil erosion in adjacent land and can cause severe environmental impacts.

Turbidity – the amount of suspended particulate matter in the water column directly dictates the cloudiness or opaqueness of the water. This is referred to as turbidity and generally reflects an inundation of sediment into the system.

Undercut banks – cave-like overhangs along the banks of streams and rivers. Undercut banks have a positive impact on stream health, providing micro-habitats for many fish in the form of shade, and shelter.

Watershed – the topographically defined area in which all liquid water runs to one consolidating point, be it stream, river, lake, or ocean.

Woody debris – Large logs or dead trees larger than 10 centimeters in diameter that has been pulled into the stream channel. Woody debris will often congregate in piles called log-jams that provide food and cover for many organisms that live within the water.

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Appendices:

Benthic Macroinvertebrate Biomonitoring Assessment –Tier 1

Benthic Macroinvertebrate Percent Model Affinity Data Sheet – Tier 2

Benthic Macroinvertebrate Biotic Index Data Sheet – Tier 2

Physical Stream Habitat & Water Quality Assessment – Tier 1

Physical Stream Habitat & Water Quality Assessment – Tier 2

Benthic Macroinvertebrate ID- Five Major Groups (for Tier 1)

Stream Insects & Crustaceans ID- Save Our Streams (for Tier 1 or 2)

Stream Insects and Crustaceans ID Card- VA Save our Streams (for Tier 1 or 2)

Invasive Species Identification Sheet

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FINGER LAKES PRISM Partnership for Regional Invasive Species Management

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TIER 1 – Benthic Macroinvertebrate Biomonitoring Assessment

Name(s) ____

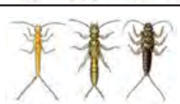
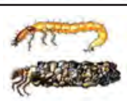
School ______________________________ Stream ______________________

Date(s) Sampled ______________ Location (nearest road, town) ______________

GPS Positioning ____

Methods:

1. Collect a 5 minute D-net sample and spread debris in a sorting tray.
2. Search debris for macroinvertebrates.
3. Make a check in each box where the stream community meets the criteria listed. If the stream community does not meet the criteria, explain why in the "Description" box.

Major Group	Criteria	Check if criteria is met	Description
Ephemeroptera (mayflies) 	must be numerous at least 3 species present		
Plecoptera (stoneflies) 	must be present		
Trichoptera (caddisflies) 	must be present, but not more abundant than mayflies		
Coleoptera (beetles) 	must be present		
Oligochaeta (worms) 	must be absent or sparse		

Summary: • The stream site is: ☐ **Non-Impacted** – all 5 boxes are checked
☐ **Possible Impact** – at least one of the 5 boxes is not checked (needs further study to confirm)

• Record the identity of any other organisms found in the stream in the space below.

Invasive Species: *If you have noticed any invasive species at the sampling location, please describe:*

____

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TIER 2 – Benthic Macroinvertebrate Biotic Index Data Sheet

Name(s) ____

School ______________________________ Stream ______________________

Date(s) Sampled ______________ Location (nearest road, town) ______________________

GPS Positioning ____

Biotic Index Score = total biotic value / total # organisms in subsample

Major Group	Subgroup	# of Organisms	Assigned Biotic Index	Biotic Value for Group
Plecoptera	All Stoneflies		1	
Ephemeroptera	All Mayflies		2	
Trichoptera	All Caddisflies **except** Netspinner Caddisflies		2	
Gastropoda	Gilled Snails		3	
Megaloptera	Dobsonflies, Fishflies, Alderflies		4	
Odonata	Dragonflies		4	
Diptera	Crane Flies		4	
Diptera	Watersnipe Flies		4	
Coleoptera	Water Penny Beetle Larvae		4	
Coleoptera	Whirligig Beetles		4	
Coleoptera	Other Beetles		5	
Trichoptera	Netspinner Caddisflies		5	
Diptera	Black Flies		5	
Diptera	Midges		6	
Odonata	Damselflies		6	
Arachnida	Water Mites		6	
Decapoda	All Crayfish		6	
Bivalvia	All Clams		6	
Amphipoda	All Scuds		7	
Gastropoda	Lunged Snails		7	
Hirudina	All Leeches		7	
Isopoda	All Sowbugs		8	
Oligochaeta	All Aquatic Worms		9	
Totals				

Instructions: Try to pick up at least 100 individual organisms. Count the number of organisms for each subgroup identified in the subsample and record. Sum the total of that column and record as a total. Multiply the number of organisms in each subgroup by the assigned biotic index value and record the results in the last column. Sum the total of that column and record as a total. Calculate the Biotic Index Score with these two totals.

Biotic Index:	0 – 4.50 non-impacted	4.51 – 5.50 slightly impacted	5.51 – 7.00 moderately impacted	7.01 – 10 severely impacted

Invasive Species: *If you have noticed any invasive species at the sampling location, please describe:*

____

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TIER 2 – Benthic Macroinvertebrate Percent Model Affinity Data Sheet

Name(s) ______________________________

School ______________________ Stream ______________________

Date(s) Sampled ______________ Location (nearest road, town) ______________________

GPS Positioning ______________________________

Methods:
1. Collect a 5 minute D-net sample and spread in a sorting tray.
2. Randomly select individuals from the sample. This will be the sub-sample.
3. Group like organisms together. Record the number of individuals identified from each group in the sub-sample.
4. Calculate the percent composition for each major group.
5. Transfer data to the chart on page 2 and compare to the NY “Model Community.”

Calculating Percent Composition: $\% \text{ Composition} = \dfrac{\text{\# of individuals in sub-sample}}{\text{total \# of individuals in sub-sample}} \times 100$

Major Group	# of individuals in Major Group	Total # of all organisms in sub-sample (50-100)	Percent Composition
Ephemeroptera (mayflies)			
Plecoptera (stoneflies)			
Trichoptera (caddisflies)			
Chironomidae (midges)			
Coleoptera (beetles)			
Oligochaeta (worms)			
Other			

Invasive Species: *If you have noticed any invasive species at the sampling location, please describe:*

____

TIER 2 – Benthic Macroinvertebrate Percent Model Affinity Data Sheet

Major Group	Sample Community (Percent Composition)	Model Community (Percent Composition)	Lowest Value
Ephemeroptera (mayflies)		**40%**	
Plecoptera (stoneflies)		**5%**	
Trichoptera (caddisflies)		**10%**	
Chironomidae (midges)		**20%**	
Coleoptera (beetles)		**10%**	
Oligochaeta (worms)		**5%**	
Other		**10%**	
Sum Total	**100%**	**100%**	

Calculating Percent Model Affinity:

1. Enter in the Sample Community Percent Composition for each Major Group from the sub-sample.
2. Compare Percent Composition values for Sample Community. In the Lowest Value column, enter the lower Percent Composition value.
3. Add up the percentages in the Lowest Value Column to determine the Percent Model Affinity.

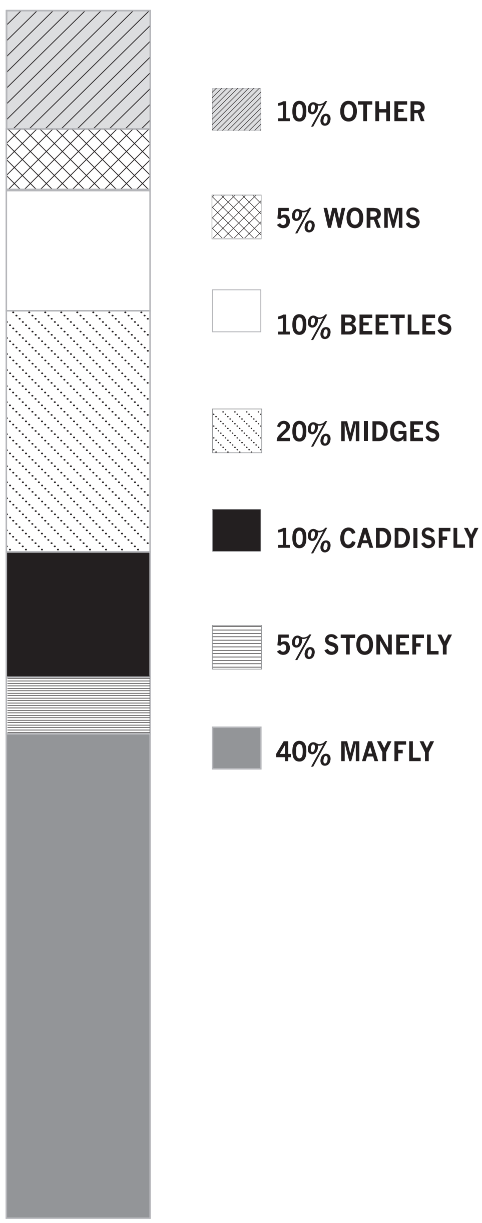
PMA Interpretation:

Not Impacted	Slightly Impacted	Moderately Impacted	Severely Impacted
≥65%	50 - 64%	35 - 49%	< 35%

Finger Lakes Regional Stream Monitoring Network

TIER 2 – Benthic Macroinvertebrate Percent Model Affinity Data Sheet

NYS "Model Community"



Stream name:________________________

Sample Community

Date: ______________

Color in appropriate %

100%	
90%	
80%	
70%	
60%	
50%	
40%	
30%	
20%	
10%	
0%	

Use the blank chart on the right to fill in colors representing benthic macrovertebrate community of sampled stream.

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TIER 1 – Physical Stream Habitat & Water Quality Assessment

Name(s) ____

School ______________________________ Stream ____________________

Date(s) Sampled ______________ Location (nearest road, town) ____________________

GPS Positioning ____

Weather: Current weather conditions ____________________ Current temperature ________ °C

Weather conditions in the past 24 hours ____________________

Land Use: *Check all that apply*

☐ Commercial/Industrial	☐ Landfill	☐ Residential
☐ Forest	☐ Old Field	☐ Wetland
☐ Cropland	☐ Orchard/Vineyard/Nursery	☐ Other
☐ Golf Course	☐ Pasture	explain________________

Stream Stage: ☐ High ☐ Normal ☐ Low

Channel Characteristics

Features	Estimated Total Length	Estimated Average Height
Eroded Bank		
Rip-Rap		
Undercut Bank		

Stream Habitat:

Features	Total Number
Rootwads (tree roots exposed in stream)	
Woody Debris (large logs in stream)	
Pools	
Riffles	

Water Appearance/Odor: *Check all that apply*

☐ Clear ☐ Murky ☐ Tea-Brown ☐ Algae
☐ Oily
☐ Unusual Odor ☐ Other explain______________________________

Water Chemistry

Temperature (°C)	pH	Dissolved Oxygen (ppm)

Invasive Species: *If you have noticed any invasive species at the sampling location, please describe:*

____

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TIER 2 – Physical Stream Habitat & Water Quality Assessment

Name(s) ____

School ______________________________ Stream ______________________

Date(s) Sampled ______________ Location (nearest road, town) ______________________

GPS Positioning ____

Weather: Current weather conditions ______________________ Current temperature ________ °C

Weather conditions in the past 24 hours ____________________

Land Use: *Check all that apply*

- ☐ Commercial/Industrial
- ☐ Forest
- ☐ Cropland
- ☐ Golf Course
- ☐ Landfill
- ☐ Old Field
- ☐ Orchard/Vineyard/Nursery
- ☐ Pasture
- ☐ Residential
- ☐ Wetland
- ☐ Other

explain______________________

Stream Stage: ☐ High ☐ Normal ☐ Low

Channel Characteristics

Features	Estimated Total Length	Estimated Average Height
Eroded Bank		
Rip-Rap		
Undercut Bank		

Stream Habitat:

Features	Total Number
Rootwads (tree roots exposed in stream)	
Woody Debris (large logs in stream)	
Pools	
Riffles	

Water Appearance/Odor: *Check all that apply*

- ☐ Clear
- ☐ Oily
- ☐ Unusual Odor
- ☐ Murky
- ☐ Other explain____________________________________
- ☐ Tea-Brown
- ☐ Algae

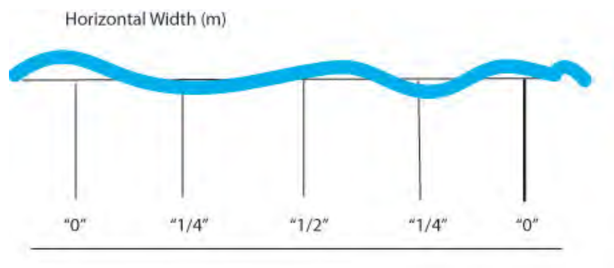
Water Chemistry

Temperature (°C)	pH	Alkalinity (ppm)	Chloride (ppm)	Dissolved Oxygen (ppm)

Invasive Species: *If you have noticed any invasive species at the sampling location, please describe:*

TIER 2 – Physical Stream Habitat & Water Quality Assessment

Channel Dimensions:



1. Measure the stream width at a select section of stream.
2. Measure the stream depth at equal intervals across the stream.
3. Calculate the average depth.
4. Take four readings (including 0) to calculate average.

	Stream Width (m)	Depth at Horizontal 0% (cm)	Depth at Horizontal 25% (cm)	Depth at Horizontal 50% (cm)	Depth at Horizontal 75% (cm)	Depth at Horizontal 100% (cm)	Average Depth (cm)
Section of Stream		0				0	

Average Stream Depth conversion to meter: Average Depth (cm) / 100 = Average Depth (m)
_________cm / 100 = _________m

Velocity: Use a 5 m stretch of stream and drop tennis ball at mid-channel

	Trial 1	Trial 2	Trial 3	Average Stream Velocity (m/s)
Distance Traveled (m)				---------------------
Time of Travel (s)				---------------------
Velocity (m/s)				

Discharge: Stream Width (m) x Average Stream Depth (m) x Average Stream Velocity (m/s) = Discharge (m3/s)
_________m x _________m x _________m/s = _________m3/s

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TIER 2 – Physical Stream Habitat & Water Quality Assessment

Substrate:
Rank the substrate size from least common (1) to most common (6)

Silt/Clay/Mud (fine sediment)	Sand (0.06 - 2.0 mm)	Gravel (2 - 64 mm)	Cobbles (64 - 256 mm)	Boulders (>256 mm)	Bedrock (solid rock)

Pebble Count:
Randomly select 10 rocks from the substrate and measure their widths at the widest diameter to the nearest millimeter

Pebble Number	Width (mm)	Pebble Number	Width (mm)	Average Width
1				----------------------
2				----------------------
3				----------------------
4				----------------------
5				

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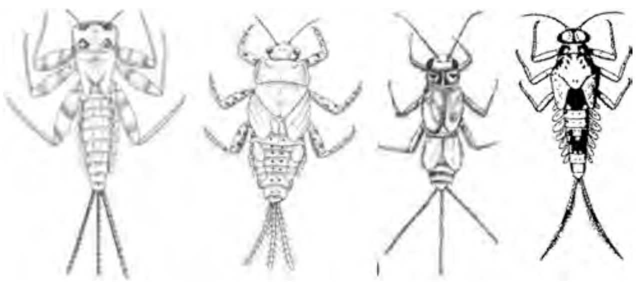
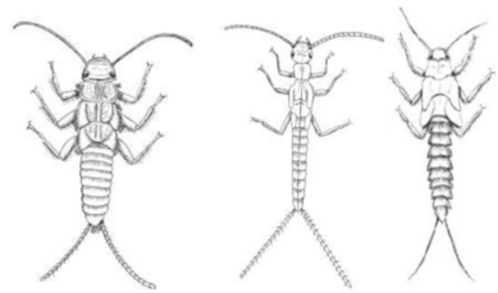
Benthic Macroinvertebrate Five Major Groups For Tier 1 Protocols



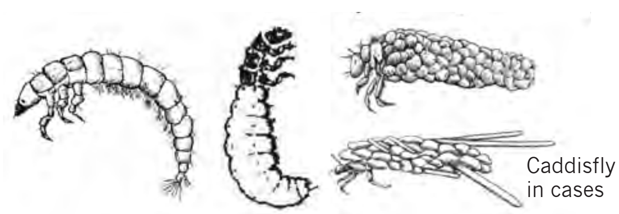
Order: Ephemeroptera

Most Mayflies have three tails, except for the two-tailed mayfly. They all have antennae, and six legs each ending with a single hook. They can be distinguished from stoneflies by their feathery gills located on their abdomen.



Order: Plecoptera (Stonefly)

Stoneflies have two tails, antennae and six jointed legs ending in double hooks. Can be distinguished from mayflies because their gills are located under the legs rather than abdomen.



Order: Trichoptera (Caddisfly)

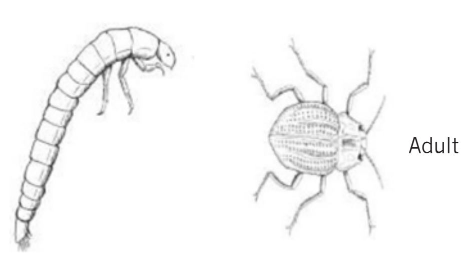
Many in this order build cases of stones or leafy debris. The net-spinning caddisfly (pictured first) has a feathery extension with a hook on their rear end. Six segmented legs under head, no antennae, two small extensions at rear end with hook.

Order: Coleoptera

Waterpennies have three pairs of segmented legs. Disc shaped and commonly found on rocks.

Class: Oligochaeta

Aquatic worms resemble terrestrial worms but are narrower and more threadlike. Their bodies are segmented, no mouths or distinct head.



Coleoptera (Riffle beetle)

Riffle beetles are worm like and can be mistaken for Caddisfly but their bodies are hard and they have tufts of hair on tail end. Adults can also be found in the stream.

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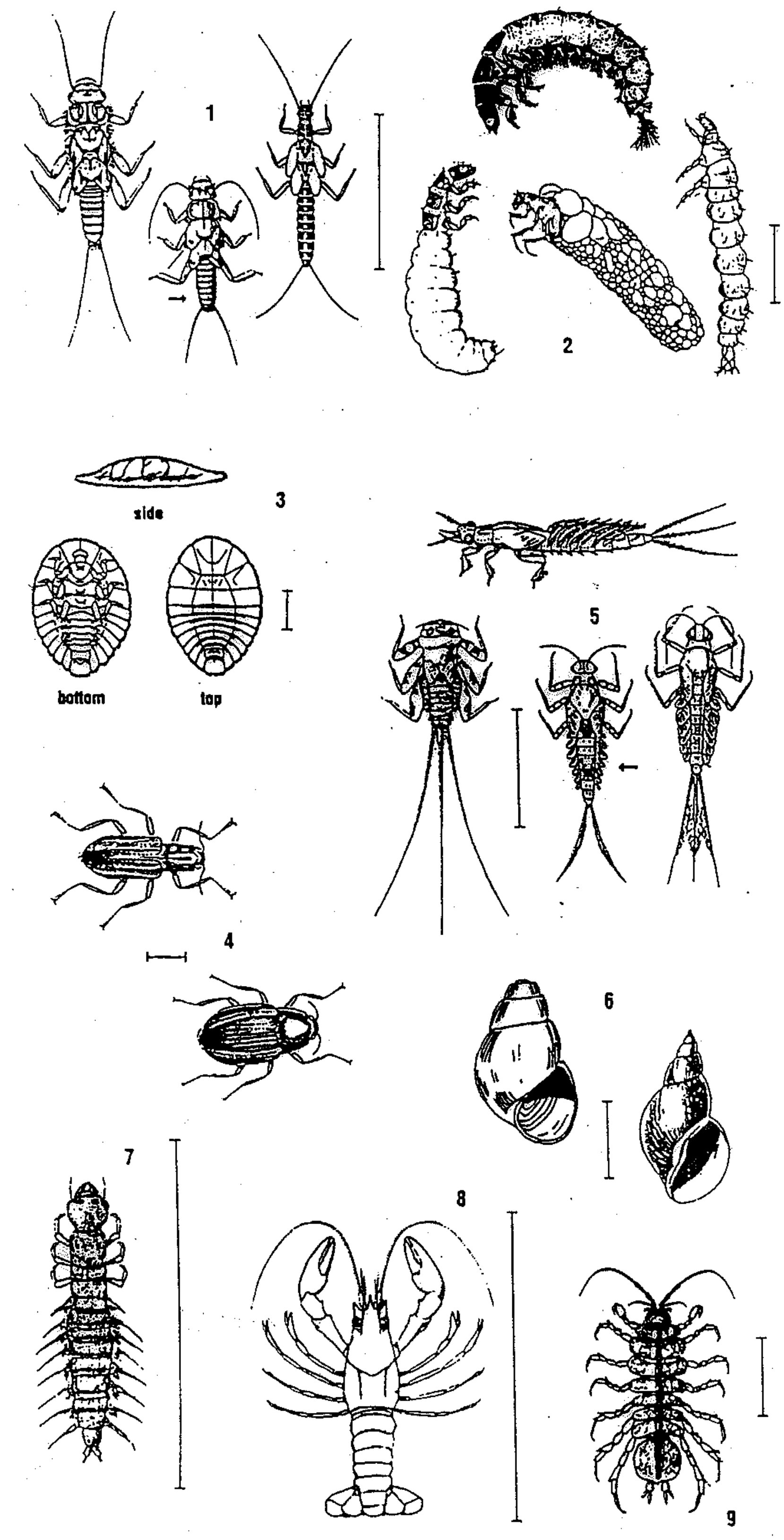

Bar lines indicate relative size

Stream Insects & Crustaceans

GROUP ONE TAXA

Pollution sensitive organisms found in good quality water.

1 *Stonefly: Order Plecoptera.* 1/2" - 1 1/2", 6 legs with hooked tips, antennae, 2 hair-like tails. Smooth (no gills) on lower half of body. (See arrow.)

2 *Caddisfly: Order Trichoptera.* Up to 1", 6 hooked legs on upper third of body, 2 hooks at back end. May be in a stick, rock or leaf case with its head sticking out. May have fluffy gill tufts on lower half.

3 *Water Penny: Order Coleoptera.* 1/4", flat saucer-shaped body with a raised bump on one side and 6 tiny legs on the other side. Immature beetle. Three views.

4 *Riffle Beetle: Order Coleoptera.* 1/4", oval body covered with tiny hairs, 6 legs, antennae. Walks slowly underwater. Does not swim on surface.

5 *Mayfly: Order Ephemeroptera.* 1/4" - 1", brown, moving, plate-like or feathery gills on sides of lower body (see arrow), 6 large hooked legs, antennae, 2 or 3 long, hair-like tails. Tails may be webbed together.

6 *Gilled Snail: Class Gastropoda.* Shell opening covered by thin plate called operculum. Shell usually opens on right.

7 *Dobsonfly (Hellgrammite): Family Corydalidae.* 3/4" - 4", dark-colored, 6 legs, large pinching jaws, eight pairs feelers on lower half of body with paired cotton-like gill tufts along underside, short antennae, 2 tails and two small hooks hooks at back end.

GROUP TWO TAXA

Somewhat pollution tolerant organisms can be in fair quality water.

8 *Crayfish: Order Decapoda.* Up to 6", 2 large claws, 8 legs, resembles small lobster.

9 *Sowbug: Order Isopoda.* 1/4" - 3/4", gray oblong body wider than it is high, more than 6 legs, long antennae.

Save Our Streams

Izaak Walton League of America
1401 Wilson Blvd. Level B
Arlington, VA 22209

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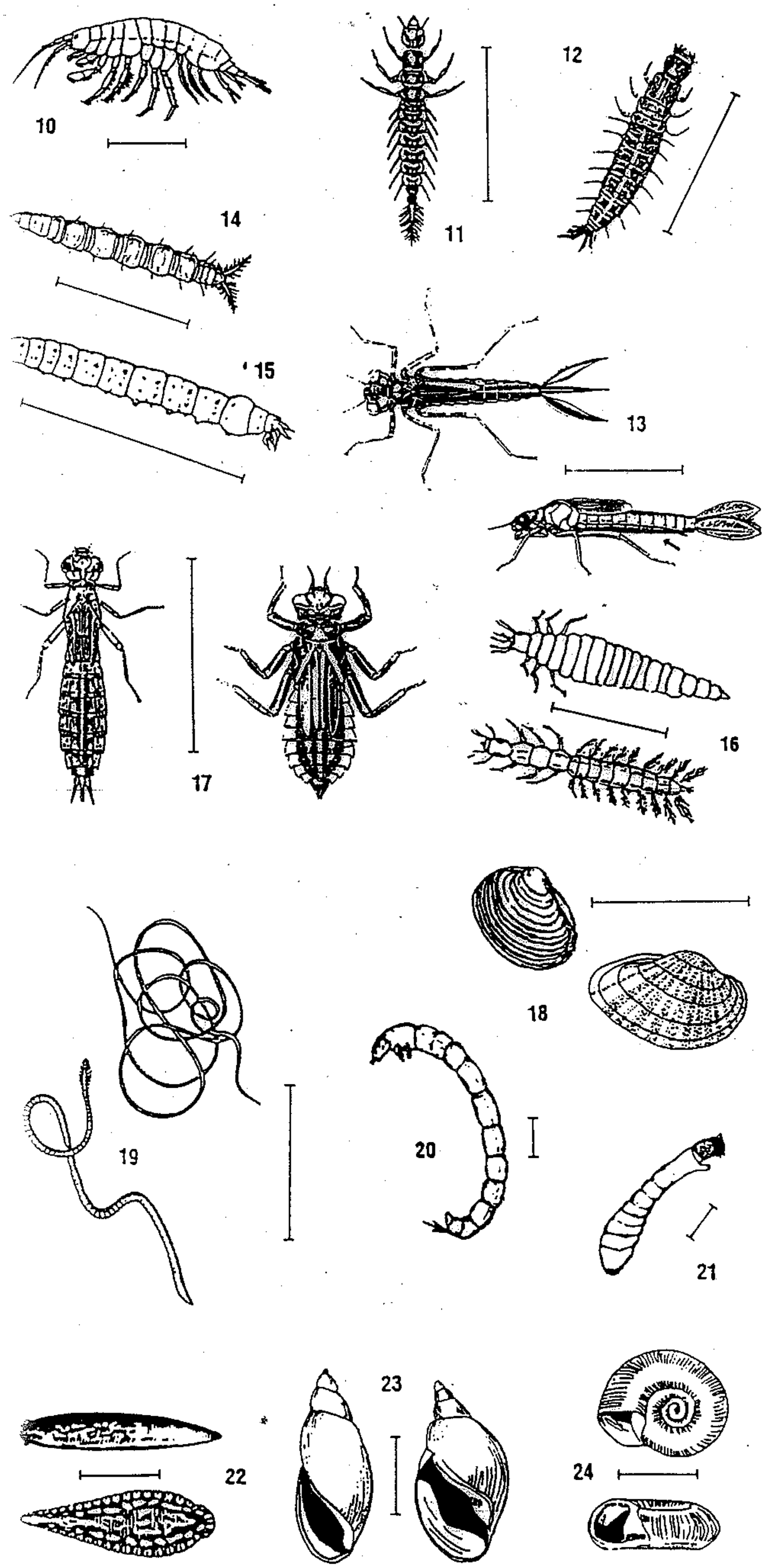

Bar lines indicate relative size

GROUP TWO TAXA continued

10 *Scud: Order Amphipoda.* 1/4", white to grey, body higher than it is wide, swims sideways, more than 6 legs, resembles small shrimp.

11 *Alderfly larva: Family Sialidae.* 1" long. Looks like small hellgrammite but has 1 long, thin, branched tail at back end. No gill tufts underneath.

12 *Fishfly larva: Family Corydalidae.* Up to 1 1/2" long. Looks like small hellgrammite but often a lighter reddish-tan color, or with yellowish streaks. No gill tufts underneath.

13 *Damselfly: Suborder Zygoptera.* 1/2" - 1", large eyes, 6 thin hooked legs, 3 broad oar-shaped tails, positioned like a tripod. Smooth (no gills) on sides of lower half of body. (See arrow.)

14 *Watersnipe Fly Larva: Family Athericidae (Atherix).* 1/4" - 1", pale to green, tapered body, many caterpillar-like legs, conical head, feathery "horns" at back end.

15 *Crane Fly: Suborder Nematocera.* 1/3" -2", milky, green, or light brown, plump caterpillar-like segmented body, 4 finger-like lobes at back end.

16 *Beetle Larva: Order Coleoptera.* 1/4" 1", light-colored, 6 legs on upper half of body, feelers, antennae.

17 *Dragon Fly: Suborder Anisoptera.* 1/2" - 2", large eyes, 6 hooked legs. Wide oval to round abdomen.

18 *Clam: Class Bivalvia.*

GROUP THREE TAXA

Pollution tolerant organisms can be in poor quality water.

19 *Aquatic Worm: Class Oligochaeta.* 1/4" - 2", can be very tiny; thin worm- like body.

20 *Midge Fly Larva: Suborder Nematocera.* Up to 1/4", dark head, worm-like segmented body, 2 tiny legs on each side.

21 *Blackfly Larva: Family Simulidae.* Up to 1/4", one end of body wider. Black head, suction pad on end.

22 *Leech: Order Hirudinea.* 1/4" - 2", brown, slimy body, ends with suction pads.

23 *Pouch Snail and Pond Snails: Class Gastropoda.* No operculum. Breathe air. Shell usually opens on left.

24 *Other snails: Class Gastropoda.* No operculum. Breath air. Snail shell coils in one plane.

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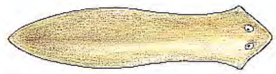
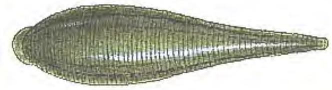
Stream Insects and Crustaceans ID Card

Lines under each picture indicate the relative size of the organisms

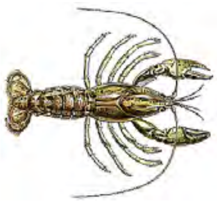
Aquatic Worm:
Class Oligocheata
$\frac{1}{4}$" – 2", can be very tiny; thin, wormlike body, tolerant of impairment



Flat Worm:
Family Planaridae
Up to $\frac{1}{4}$", soft body, may have distinct head with eyespots, tolerant of impairment



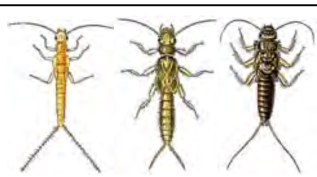
Leech:
Order Hirudinea
$\frac{1}{4}$" – 2", segmented body, suction cups on both ends, tolerant of impairment



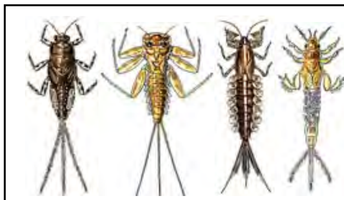
Crayfish: Order Decapoda
Up to 6", 2 large claws, 8 legs, resembles a small lobster, somewhat tolerant of impairment

Sowbug: Order Isopoda
$\frac{1}{4}$" – $\frac{3}{4}$", gray oblong body wider than it is high, more than 6 legs, long antennae, somewhat tolerant of impairment

Scud: Order Amphipoda
$\frac{1}{4}$", white to gray, body higher than it is wide, swims sideways, more than 6 legs, resembles small shrimp, somewhat tolerant of impairment

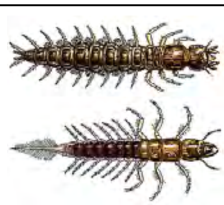


Stonefly: Order Plecoptera
$\frac{1}{2}$" – 1 $\frac{1}{2}$", 6 legs with hooked tips, antennae, 2 hair-like tails, no gills on abdomen, very intolerant of impairment



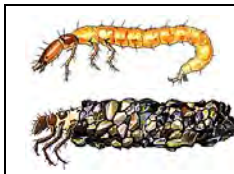
Mayfly:
Order Emphemeroptera
$\frac{1}{4}$" – 1", plate-like or feathery gills on abdomen, 6 hooked legs, 2 or 3 long hair-like tails, tails may be webbed together, very intolerant of impairment

Dragonfly and Damselfly:
Order Odonata
$\frac{1}{2}$ " – 2", large eyes, 6 hooked legs, large protracting lower jaw, 3 broad oar-shaped tails OR wide oval to round abdomen, somewhat tolerant of impairment



Hellgrammite, Fishfly, and Alderfly:
Order Megaloptera
$\frac{3}{4}$" – 4", 6 legs, large pinching jaws, 8 pairs of feelers along abdomen, 2 hooks on tail end OR 1 single spiky tail, somewhat tolerant of impairment

Common Netspinners:
Family Hydropsychidae
Up to $\frac{3}{4}$", 6 hooked legs on upper 1/3 of body, 2 hooks at back end, underside of abdomen with white tufts of gills, somewhat tolerant of impairment



Most Caddisfly:
Order Trichoptera
Up to 1", 6 hooked legs on upper 1/3 of body, may be in stick, rock or leaf case, no gill tufts on abdomen, intolerant of impairment

Illustrations from: Voshell, J. R., Jr. 2001. Guide to the Common Freshwater Invertebrates of North America.MacDonald and Woodward Publishing Co. With permission of the author.

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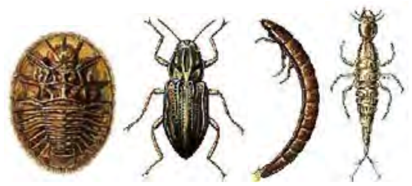
Stream Insects and Crustaceans ID Card

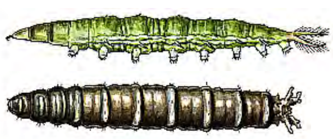
Lines under each picture indicate the relative size of the organisms



Beetles: Order Coleoptera
$\frac{1}{4}$″ – 1″, disk-like oval body with 6 small legs and gill tufts on underside OR small black beetle crawling on streambed OR comma-like brown "crunchy" body with 6 legs on upper 1/3 and possibly gill tuft on back end, OR (miscellaneous body form – rare), somewhat tolerant of impairment

Midges:
Family Chironomidae
Up to $\frac{1}{4}$″, distinct head, worm-like segmented body, 2 leg-like projections on each side, often whitish to clear, occasionally bright red, tolerant of impairment

Black Fly: Family Simuliidae
Up to $\frac{1}{4}$″, end of body wider (like bowling pin), distinctive head, sucker on end, tolerant of impairment



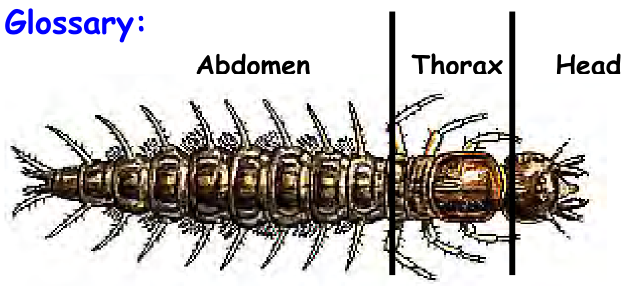
Most True Flies:
Order Diptera
$\frac{1}{4}$″ – 2″, bodies plump and maggot-like, may have caterpillar like "legs" along body, may have lobes or conical tails on end, tolerant of impairment

Gilled Snails:
Class Gastropoda
Up to $\frac{3}{4}$″, shell opening covered by a thin plate called an operculum, with helix pointed up shell opens to the right, intolerant of impairment

Lunged Snails:
Class Gastropoda
Up to $\frac{3}{4}$″, no operculum, with helix pointed up shell opens to the left, tolerant of impairment

Clams:
Class Bivalvia
Up to $\frac{3}{4}$″, fleshy body enclosed between two clamped together shells (if clam is alive, shells cannot be pried apart without harming clam), somewhat tolerant of impairment

Glossary:



Tails: There are many different kinds of macroinvertebrate tails. The thin thread-like tails found on stoneflies and mayflies are called cerci. The oar-shaped tails found on a damselfly are not really tails - they are actually gills called caudal lamellae!

Izaak Walton League of America — Defenders of Soil, Woods, Waters, Air and Wildlife — Member

VA Save Our Streams Program
VA Division of the Izaak Walton League of America
P.O. Box 8297
Richmond, VA 23226
(804) 615-5036 www.vasos.org

These sheets are modified from the National Izaak Walton League of America SOS Program Stream Insects & Crustaceans ID Card.
http://www.iwla.org/SOS/index.html

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Invasive Species of Concern

STREAM INVASIVES	
 *Gambusia affinis* Western Mosquitofish	 *Gambusia holbrooki* Eastern Mosquitofish
 *Neogobius melanostomus* Round Goby	 *Misgurnus anguillicaudatus* Oriental Weatherfish
 *Petromyzon marinus* Sea Lamprey	 *Bithynia tentaculata* Faucet Snail

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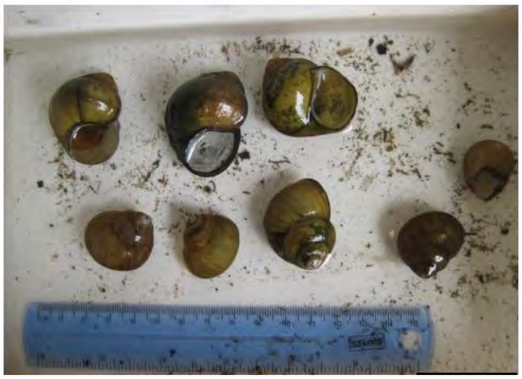
Invasive Species of Concern

STREAM INVASIVES	
 *Bellamya chinensis (Cipangopaludina chinensis)* Chinese Mystery Snail	 *Potamopyrgus antipodarum* New Zealand Mud Snail
 *Procambarus clarkia* Red Swamp Crayfish	 *Orconecte rusticus* Rusty Crayfish
 *Najas minor* Brittleleaf naiad	 *Nitellopsis obtusa* Starry Stonewort

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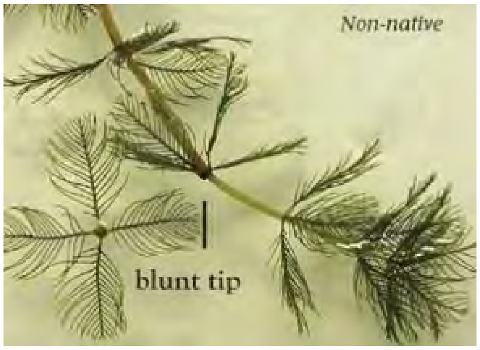
Invasive Species of Concern

STREAM INVASIVES	
 *Myriophyllum spicatum* Eurasian Watermilfoil	 *Hydrilla verticillata* Hydrilla
 *Trapa natans* Water Chestnut	 *Didymosphenia geminata* Didymo (Rock Snot)

Invasive Species of Concern

RIPARIAN/TERRESTRIAL INVASIVES

Butomus umbellatus
Flowering Rush

Heracleum mantegazzianum
Giant Hogweed - Do Not Touch

Fallopia japonica
Japanese Knotweed

Lythrum salicaria
Purple Loosestrife

Phragmites australis
Common Reed

Ranunculus ficaria
Lesser Celandine, Fig Buttercup

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Invasive Species of Concern

RIPARIAN/TERRESTRIAL INVASIVES	
 *Persicaria perfolinata* Mile-A-Minute	 *Vincetoxicum rossicum* Pale Swallow-wort
 *Iris pseudacorus* Yellow Flag Iris	 *Pastinaca sativa* Wild Parsnip - Do Not Touch!

HOBART AND WILLIAM SMITH COLLEGES

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