Stream Monitoring

A stream is a combination of all of its physical, chemical, and biological characteristics, characteristics which respond to natural and human-caused events, such as flooding, drought, construction, or channelization. We can measure the extent to which these conditions have affected a stream by observing the number and type of organisms living in the stream and relating that information to the surrounding habitat. The biological monitoring procedures in this publication are for wadeable, small to medium-sized streams.

Biological Survey

Biological monitoring focuses on the organisms living in a stream. Scientists observe changes in the types of organisms in a stream to determine the richness of the biological community. They also observe the total number of organisms present, which is a measure of the density of the biological community. If community richness and community density change over time, it may indicate the effects of human activity.

Biological stream monitoring is based on the fact that different species react to pollution in different ways. Pollution-sensitive organisms are more susceptible than others to the effects of physical or chemical changes in a stream. Pollution-tolerant organisms can cope with adverse conditions more easily.

The presence or absence of such indicator organisms is an indirect measure of pollution. When a stream becomes polluted, pollution-sensitive organisms decrease in number or disappear, while pollution-tolerant organisms remain stable or increase in number.

The indicator organisms are benthic macroinvertebrates, animals big enough to see with the naked eye (macro). Benthic macroinvertebrates lack backbones (invertebrates) and live at least part of their life cycles in or on the bottom of a body of water (benthos).

Benthic macroinvertebrates include aquatic insects (such as mayflies, stoneflies, caddisflies, midges, and beetles), snails, worms, freshwater clams, mussels, and crayfish. Some benthic macroinvertebrates, like midges, are small and may grow no larger than one-half inch in length. Others, like the three-ridge mussel can be more than ten inches long.

In addition to being sensitive to changes in the stream's overall ecological integrity, benthic macroinvertebrates have other advantages as indictor organisms.

- They are relatively easy to sample. Benthic macroinvertebrates are abundant and can be easily collected and identified.
- They are relatively immobile. Animals such as fishes can escape toxic spills or degraded habitats by swimming away, and migratory animals may spend only a small portion of their life cycle in a particular stream before moving on. Changes in populations of mobile species thus do not necessarily signal changes in the stream.
- In contrast, most macroinvertebrates spend a large part of their life cycle (often more than a year) in the same part of a stream, clinging to surfaces so as not to be swept away with the water's current. When such stable communities change over time, it often indicates problems in the stream.
- They are continuous indicators of environmental quality. The composition of benthic macroinvertebrate communities in a stream reflects the stream's physical and chemical conditions over time. In contrast, monitoring for certain water qualities (such as the amount of oxygen dissolved in it) describes the condition of the water only at the time the samples were taken.
- They are a critical part of the aquatic food web. Benthic macroinvertebrates form a vital link in the web that connects

aquatic plants, algae, and leaf litter to the fish species of our rivers and streams. Therefore, the condition of the benthic macroinvertebrate community reflects the stability and diversity of the larger aquatic food web.

Life cycles of benthic macroinvertebrates

Most of the benthic macroinvertebrates that you will encounter are aquatic insects. Aquatic insects have complex life cycles and live in the water only during certain stages of their development.

Aquatic insects may go through one of two kinds of development, or metamorphosis. Aquatic insects that have complete metamorphosis undergo four stages of development. They lay their eggs in water, and they hatch into larvae that feed and grow in the water. (These larval insects do not resemble the adult insects; many appear worm-like.) The fully-grown larvae develop into pupae that do not feed while they develop the many organs and structures they need as adults, such as wings and antennae.

The fully-formed adults of some species (midges and flies, for example) emerge from the water and live in the habitat surrounding the stream. Others, such as riffle beetles, continue to live in the stream itself. After mating, adults of all aquatic insect species lay eggs in the water, beginning the life cycle all over again.

Aquatic insects that have incomplete metamorphosis undergo only three stages of development. The eggs hatch into larvae, which feed and grow in the water while they develop adult structures and organs; they do this in stages, or instars, until they emerge as adults. The life cycle begins again when eggs are laid in the water by the adults.

Habitat Survey

Streams, watersheds and drainage basins
Habitat surveys describe conditions in the stream itself, including the areas immediately surrounding the stream. Information gained from the surveys helps to explain changes in stream life identified by biological monitoring. In much the same way, the number and variety of the organisms present in a stream is a useful measure of the health of that habitat.

Habitat surveys are also useful for classifying streams and for documenting how they change over time. For example, many streams in Illinois have had their channels straightened or dammed and their banks cleared. Such changes have destroyed habitats both within and alongside streams. The loss of these habitats has led to the loss of many aquatic organisms, including whole species of fish, freshwater mussels, crayfish, and aquatic insects. Habitat surveys catalog the nature and extent of these kinds of changes.

Stream habitats are complex and assessing their quality requires understanding their many parts.

Streams. Streams may begin when water flows from ponds or lakes, or they may arise from below-ground, from springs or seepage areas. Such “beginner” streams are small, and are referred to as *headwater streams*. Headwaters flow toward lower-lying land downstream; as they go, they converge with one or more other headwater streams to form medium-sized streams. Medium-sized streams then flow and converge with other streams (either headwater or medium-sized streams) and form rivers.

Watersheds and drainage basins. The area of land from which water drains into a given stream is referred to as that stream’s watershed. A river’s drainage basin is a watershed on a bigger scale—that area of land, including watersheds of headwater streams and medium-sized streams, from which all of the river’s water drains.

Since all of the water in a drainage basin flows to a common point, conditions in the headwater streams affect the larger streams and rivers fed by them. Monitoring the conditions in headwater streams thus gives clues to conditions downstream.

Stream channels. The part of a stream in which the water flows is the stream channel. The physical characteristics of the stream channel will differ depending on the topography and geology of the area around it. Often the same stream will change at different points along its length as the shape and makeup of the surrounding land changes. Such a stream may contain successive segments (or reaches) that are quite different from each other.

Riparian zones. The riparian zone refers to the area of land which is connected with or immediately adjacent to the banks of a stream. It includes the stream banks, wetlands and those portions of floodplains and valley bottoms that support riparian vegetation—the plants found in the riparian zone. The lower stream banks, where the land meets the water, may be home to emergent vegetation—plants that are rooted in the soil below the water, but grow to heights above the water level.

The upper stream banks may have plants that are rooted in the soil, but which can withstand periodic flooding. When the riparian zone is periodically flooded after heavy rains, food, water, and *sediment* are carried into the stream from the surrounding landscape. Plants growing within the riparian zone hold the soil of the stream's banks in place, helping to prevent erosion.

The plants also provide habitat for macroinvertebrates and other organisms, such as fishes, during floods.

Riparian vegetation, such as trees and shrubs, also influences the amount of sunlight and heat reaching the stream channel. If a stream has no trees or shrubs to shade the water, the temperature becomes too high for most macroinvertebrates to survive. Too much shade would block all sunlight, preventing any algae or aquatic plants from growing in the stream.

The amount of shading provided by the trees and shrubs in the riparian zone helps provide the correct amount of heat and light for macroinvertebrates, fishes and plants.

Stream bottoms

In Illinois, the substrate, or bottom, of most stream reaches is either rocky or soft. The bottom along a soft bottom reach is composed of sand, soft mud, or a mixture of both. The bottom of a rocky bottom reach consists of rocks or gravel.

A **rocky bottom reach** is composed of three different but interrelated habitats known as riffles, pools, and runs.

Riffles are areas of turbulent water created by shallow water passing through or over stones or gravel of fairly uniform size. Riffles are excellent places to collect macroinvertebrates. The gravel and rocks of a riffle create nooks and crannies that macroinvertebrates can cling to, crawl under, and hide behind.

Stones in sunlit areas of a riffle are often covered with algae and mosses on which certain stream organisms feed. Leaves and other plant material drifting in the stream current also provide food for some macroinvertebrates in riffle areas. As water tumbles over rocks and gravel in a riffle, oxygen from the air is mixed with it, providing the high levels of dissolved oxygen needed by many benthic macroinvertebrates.

Runs are stretches of quieter water commonly found between riffles and pools in larger streams and rivers. Runs have a moderate current and are slightly deeper than riffles.

Pools are found both upstream and downstream from riffles. Pools are deeper parts of the stream with relatively slower-moving water. Water in pools differs from the water in other stretches of a river in its chemistry, depth, and speed of current. Pools are catch basins of organic materials.

As the current enters a pool it slows down; as it no longer has the energy to carry it, the heavier part of its load of sediment drops to the bottom. Pools usually have larger organisms living in them that have adapted to these habitats. For example, crayfish feed on organic matter that collects in the pool bottoms.

As noted, riffles, runs, and pools are interrelated habitats. The waters of a pool are affected by what occurs in upstream riffles, and the waters of the riffles are affected by upstream pools.

Although pools, runs, and riffles are more or less distinct environments, many organisms inhabit all of them. (Fishes, for example, can move among all three.) Some animals of the riffles are carried by the current to downstream pools and/or runs. Many organisms of rocky bottom reaches find food in the riffles of a stream but take shelter in its pools.

A **soft bottom reach** does not have riffle-run-pool habitats. In these reaches, some macroinvertebrates burrow into the sediment of the stream (midge larvae and worms, for example), while others live in or on submerged and floating logs, submerged roots, vegetation, rip rap along the shore line, or in any leaf or organic debris.

GETTING STARTED

Find a Partner/Form a Team
For safety reasons, you should never monitor without at least one other person present. Individuals should find a monitoring partner. Groups should form teams of three to five volunteers per site.

Select a Monitoring Site

- Identify a site.

Complete Site Documentation
Once a suitable monitoring site has been identified, proper site identification information must be completed.

- **Site Evaluation Form** This form describes specific (on-site) location of the site, access points, suitability of the site, and landowner permission status.
- **Site Identification Form** This form describes the general (roadmap) location of the site, legal description, longitude/ latitude coordinates and other location information.
- **Property Access Agreement Form** This form documents the landowner's or manager's permission to access the site for evaluation and monitoring purposes. It must be completed before monitoring starts.

One or more maps (topographic maps, local road maps, etc.) indicating the location of the site should be included.

Monitoring Equipment

Most items can be obtained from any household or local retail supplier.

- Tape measure or twine at least 50-feet long and marked off in one-tenth foot lengths
- Thermometer
- Compass
- Stopwatch or any watch with a second hand
- Small float to measure velocity - a small orange or practice golf ball will work
- White tray marked with a grid of squares of known area (such as 5 cm by 5 cm) to use in sub-sampling - a photographic developing tray works well
- Jar of 70% alcohol, or isopropyl alcohol
- Bottle of soda water or a thermos of ice cold water (do not use carbonated mineral water or other beverage)
- Several small jars with lids

- Pencils
- Sampling labels (small slips of paper of at least one inch by two inches in size, and some tape)
- 3-5 gallon bucket
- Hand lens or magnifying glass of at least 8x magnification
- Tweezers or forceps
- Fine-mesh (0.5 mm) D-frame or triangular dip net with a frame at least 12 inches wide
- Stream Monitoring Manual
- Field data sheets, photocopied from Appendix D
- Water bottle

Personal & safety equipment

- Reference maps indicating general information pertinent to the monitoring area, including nearby roads
- Walking stick of known length
- Boots or waders; tow line and life jackets - be sure that chest waders have a belt
- Rubber gloves
- Camera
- Calculator
- Insect repellent, sun screen, sun glasses, and a hat
- Whistle
- Towel
- Fire starter
- Small first aid kit, flashlight, and extra batteries
- Water for drinking
- Water and soap for washing hands

Plan

- Make a quick visit to your site at least one day prior to monitoring to ensure safe monitoring conditions.
- **Always** contact the owner or manager of the property on which your site is located to notify him/her of your plans. This should be done a week in advance of your monitoring date, but no less than 24 hours prior to monitoring.

Conduct Your Survey

Procedures for conducting your habitat and biological surveys are described in the chapters that follow.

Safety

The following precautions should be observed while doing field sampling of any kind.

- Before leaving for your site, let someone know where you are going and when you will be expected back.
- Always work in groups, or with partners; do not collect information alone, reschedule for a time when other volunteers are available.
- Do not collect samples under difficult conditions. Make allowances for your own physical limitations.
- Do not walk on unstable banks. Be careful when stepping on rocks and wood, as they may be slippery when wet. Bring along or find a suitable walking stick for balance while climbing down steep banks or wading.
- Do not attempt to cross streams that are swift and above the knee in depth. A stream bed can be very slippery and dangerous in places. If you are unsure about the velocity of the water, take a quick velocity and depth measurement (see page 9) and multiply the numbers. If they equal nine or above, the stream is not safe.
- Do not cross private property without the landowner's permission. Use the public access points (e.g., city or state roads and parks) to approach a monitoring site.
- Bring your own fresh water to drink.
- Disturb streamside vegetation as little as possible. Watch out for poison ivy, which commonly grows on stream banks.
- Wash hands with soap and potable water at the end of the monitoring exercise, and before eating.

- Wear shoes rather than sandals or open-toed shoes. If chest waders are worn, they must be secured at the waist with a belt.
- Wear a life vest.
- If for any reason you do not feel safe monitoring your stream, reschedule to monitor at another time.

HABITAT SURVEY

YOU WILL NEED

- Site Sketch Sheet and Habitat Survey Data Sheet
- Clip board and pencil or pen
- Graduated 50-foot length of rope, or a measuring tape in engineering rule (marked off in tenths of a foot)
- A watch with a second hand or a stopwatch
- An orange or similar biodegradable object or a practice golf ball
- Thermometer
- Empty jar
- Calculator

Mark Off Your Site

If the site is located by a bridge, measure 100 feet upstream from it. If for some reason a sample cannot be taken upstream from the bridge (for example, no safe access or owner permission) then measure 100 feet downstream from the bridge, noting it on your Habitat Survey Sheet. Begin mapping the area at this point. If the site is in an area of public ownership, such as a state park or forest preserve, and there are no physical obstructions nearby (such as bridges or dams), map the site beginning at the location assigned.

Make a Site Sketch

Sketch a map of your monitoring site to become familiar with the terrain and stream features and to provide a record of conditions.

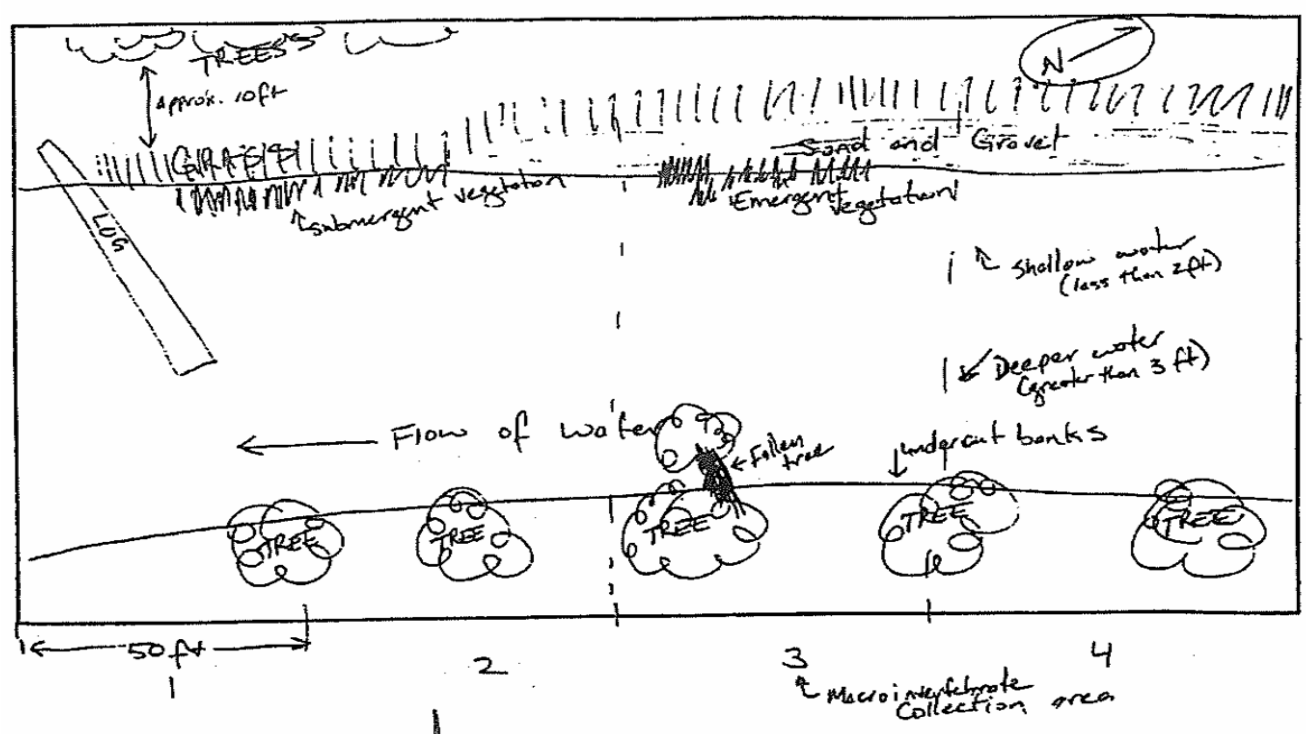


Figure 1. A sketch of a 200-foot study reach.

1. Using a tape measure or your 50-foot length of string, measure four 50-foot lengths along either side of the stream upstream from the starting point (for a total of 200 feet). This marks the study reach that will be the focus of your sampling activities.
2. Make a sketch of the study reach on the Site Sketch sheet. Draw the sketch to appear as if you are observing the area from above (Figure 1).
3. Use a compass or topo map to determine which direction is North and note it on the sheet.
4. Draw an arrow to indicate the direction the water is moving. Note the location of riffles, runs, pools, ditches, wetlands, dams, rip rap, tributaries, landscape features, vegetation, and roads. Include important features outside the 200-foot study reach, but show that they are outside the reach.
5. Take a photo of the 200-foot study reach to document conditions at the site or on that date. The photo will be compared to future photos to illustrate conditions over time.

Complete the Habitat Survey Data Sheet

1. **Present weather/weather in past 48 hours.** If conditions were mixed over the past 48 hours (e.g., stormy two days ago, clear and sunny one day ago) select the weather condition that describes the worst recent weather.

2. **Water appearance.** Select the term or terms that best describe the physical appearance of the water, which can be an indicator of water pollution. Because the stream bottom can alter the apparent color of the water, put some stream water in a white tray or bucket, or fill a clear bottle and place a white sheet of paper behind the bottle. Then check all of the following that apply.
    - **Clear** – colorless, transparent.
    - **Milky –** cloudy-white or gray; not transparent. May be natural or due to pollution.
    - **Foamy –** caused by both nature or pollution from excessive nutrients or detergents.
    - **Dark Brown –** may indicate that acids are being released into the stream from decaying plants. This process occurs naturally in the fall of the year.
    - **Oily Sheen –** a multicolored reflection on the surface of the water. Can occur naturally or may indicate oil floating in the stream.
    - **Reddish –** may indicate acids draining into the water.
    - **Green –** may indicate excess nutrients being released into the stream.
    - **Other –** any other observation regarding water color not described above.

3. **Turbidity.** Turbidity describes the amount of sediment suspended in the water. Turbid water is usually cloudy or brown due to the presence of excessive silt or organic material.

    Check the level of turbidity that best describes the amount of suspended sediment present.

4. **Water Odor.** Odor can also be a physical indicator of water pollution.
    - None – indicates good water quality.
    - Sewage – may indicate the release of human waste material. (See note below.)
    - Chlorine – may indicate that a sewage treatment plant is over-chlorinating its effluent.
    - Fish – may indicate the presence of excessive algal growth or dead fishes.

- Rotten Eggs – a sulfurous smell that may indicate sewage pollution, as hydrogen sulfide gas is a product of sewage decomposition. (See note below).
- Petroleum – may indicate an oil spill from marine or terrestrial sources.
- Other

Note: If you smell sewage or rotten eggs, do not enter the water.

5. Temperature. Temperature can limit biological activity in streams because many aquatic organisms need water of specific temperatures (for example, to breed). Also, since cold water holds more dissolved oxygen than warm water, temperature directly affects the amount of oxygen available to organisms.

To measure water temperature, submerge a thermometer in a stream run for at least two minutes. To measure air temperature, hold a thermometer in the air for about two minutes.

6. Algal Growth. Algae are an important food source and a habitat for many organisms. However, excessive algal growth is an indicator of possible nutrient problems. Estimate what percentage of the bottom of the 200-foot site is covered by algae.

7. Submerged Aquatic Plants. These plants have their roots in the stream bottom, and the whole plant remains under water. Indicate by yes or no if you notice any rooted, vascular plants underneath the water's surface in your 200-foot site. If you know the names of these plants, whether common or scientific, write them in the space provided.

8. **Riparian (streamside) Vegetation.** Identify the riparian vegetation by name. If you do not know the specific names of the plants that you see, describe them generically as "ferns" or "small bushes" or "grasses," etc.

9. **Canopy Cover.** Estimate the percentage of the 200-foot study reach that is presently shaded by trees and shrubs.

10. **Bottom Substrate**. Bottom substrate is the material in and on the stream bottom that macroinvertebrates attach to, feed from, or crawl on. Estimate the percentage of each substrate material present; your estimate should equal 100% for all substrates.

- Bedrock
- Boulder (any rock larger than 10 inches in diameter)
- Cobble (2.5-10 inches)
- Gravel (0.1-2 inches)
- Sand (smaller than 0.1 inch)
- Silt
- Other (includes organic debris such as logs, sticks, and leaves)

11. **Embeddedness** Embeddedness describes how much of the surface area of large materials (boulders, cobbles, and gravel) is covered by sediment. Embeddedness indicates how suitable the stream substrate is for benthic macroinvertebrate habitat and for fish spawning and egg incubation.

Observe the stream bottom of the 200-foot site, with little regard for the very edges of the stream. Estimate the percentage of stream bottom which is covered by silt. Select the description that best describes your estimate.

12. **Stream Discharge.** Discharge is a measurement of the amount, or volume, of water flowing past a point.

To calculate stream discharge, multiply the average stream depth (feet) by stream width (feet) by average velocity (feet/second), using the formula on the data sheet. Record the result in units of cubic feet per second ($feet^3$/second).

To obtain these measurements:

a) Within the 200-foot study reach, find a 10-foot stretch of stream with a relatively smooth bottom where the water flows uniformly. (A run works best.)
b) Measure the stream width with a tape measure or a string marked in tenths of a foot. Either tie the string across the stream, or place sticks on opposite banks to indicate the points between which the width was measured. (Estimates of stream discharge will be measured from this line.)

   Be sure to indicate on your site sketch where the width measurement was taken. If a stream is too deep or wide to measure directly, estimate by measuring from the bridge, but indicate this information on the data sheet.
c) Measure stream depth along the line representing stream width at three evenly spaced spots. Add the three depth values and divide by three to determine the average depth in feet.
d) Calculate velocity**:**
   1. Mark off a spot five feet upstream and another spot five feet downstream from the first spot where stream depth was measured.
   2. Measure the time it takes an orange or a perforated velocity sphere to float the 10-foot distance from the upstream spot to the downstream one.
   3. Record the time in seconds in the appropriate space on the Habitat Survey Sheet.
   4. Determine the water velocity in feet per second by dividing 10 feet by the time measured (in seconds). For example: if it took an orange 23 seconds to travel from your partner to you, divide 10 feet by 23 seconds, which is 0.43 feet per second.
   5. Repeat steps 2-4 for the two remaining spots in the stream.
e) Add the three velocities and divide by three to determine the average velocity in feet per second.
f) Calculate estimated stream discharge.

13. Watershed Features. Record all land uses in the watershed area upstream and on either side of the study reach as far as you can see. Indicate which land uses are dominant (D) and which affect only small areas (X).

Also note the presence and approximate distance of dams, sewage treatment plants, pig farms, etc. upstream from your study reach.

14. Channel Alteration. Indicate whether or not the stream segment has been channelized, or straightened. If the site does show channelization, estimate the portion of the 200-foot section that has been affected.

15. Notes. Enter here any characteristics that you feel are important to the quality of the stream and its environs.

BIOLOGICAL SURVEY

At the study site, you will sample for macroinvertebrates in the same 200-foot section of the stream that was used for the habitat survey.

You will need:

- Dip net
- Bucket (3- or 5-gallon)
- Forceps
- Biological Survey Data sheet
- Wash bottle.

More specifically, you will sample from two different habitats within the study site that contain the highest diversity of macroinvertebrates. These habitats are listed in Table 1 in order of highest diversity to lowest diversity.

Observe the study site prior to sampling to identify the best sampling habitats. The type of habitats you sample will depend upon the characteristics of the particular stream segment you are monitoring.

For example, if you have a rocky bottom reach, a riffle area with various leaf packs would offer the best collecting habitat. If the stream segment has a soft bottom reach, a fallen tree that offers built-up debris (a snag area) and undercut banks may be the best places to collect.

Table 1.

Most Diverse Habitat	**Riffles**
⇧	**Snag areas, submerged logs, tree roots**
⇩	**Undercut banks**
Least Diverse Habitat	**Sediments**

Sampling Procedures
Riffles

1. Have one member of the team walk down the center of the riffle. Compare all of the areas in the riffle in terms of speed of water flow and size of rocks.

Select two areas in the riffle from which to sample – one with the greatest flow speed and the largest rocks (up to 14 inches in diameter) and the other with the slowest flow speed and the smallest rocks.

Collecting samples from both a fast riffle and a slow riffle constitute one riffle sample.

Sample the riffle area that is positioned farthest downstream first. Follow steps 2-6 below for the first riffle area, and then repeat the procedures for the remaining area.

Note: If you cannot differentiate between fast and slow riffles, sample from the downstream edge of the riffle first, then from the upstream edge.

2. Fill a plastic 3-gallon bucket approximately one-third full with clean stream water. Fill the wash bottle with clean stream water.

3. Position one volunteer with a dip net on the downstream edge of the riffle. Place the bottom of the net flush on the stream bottom, with the net handle perpendicular to the current of the stream. A second volunteer should pick up large rocks within a 1 foot by 1 foot area directly in front of the net and rub gently to remove any clinging organisms into the net. Place these rocks in the bucket.

4. With the first volunteer ("netter") still holding the dip net in the riffle, the second volunteer ("kicker") approaches the netter from approximately one foot upstream and "kicks" with his or her toes so as to disturb the substrate to a depth of about two inches.

As the kicker approaches, the netter sweeps the net in an upward fashion to collect the organisms. This procedure should only take about one or two minutes.

5. Carry the net and bucket to the shoreline. Wash the net out in the bucket and pick off those organisms clinging to the edges of the net and place them in the bucket.

6. With your hands, clean the entire surfaces of rocks, leaves and twigs in the bucket to remove any clinging macroinvertebrates. Make sure to check each item for remaining organisms before going on to the next item. Once an item has been cleaned thoroughly and checked for remaining organisms, set it aside.

Do not toss rocks into the stream. You may disturb the area and upset further sampling. Simply place the rock in the water on the edge of the stream, or place all rocks collected on the shore until sampling is completed.

Sampling procedures
Leaf packs

Look for leaf packs that are about four to six months old. These old leaf packs are dark brown and slightly decomposed. A handful of leaves is all you need.

1. Position the dip net on the bottom of the stream, immediately downstream from a leaf pack.

2. Gently shake the leaf pack in the water to release some of the organisms, then quickly scoop up the net, capturing both organisms and the leaf pack in the net.

3. Place the macroinvertebrates in the bucket. Before returning leaves and other large objects to the stream, inspect them for organisms.

Sampling procedures
Snag areas, tree roots, and submerged logs

Snag areas are accumulations of debris caught or "snagged" by logs or boulders lodged in the stream current. Caddisflies, stoneflies, riffle beetles, and midges commonly inhabit these areas.

1. Select an area on the snag, tree roots, or submerged log which is approximately 3 feet by 3 feet in size. This will be the sampling area for these types of habitats.

2. Scrape the surface of the tree roots, logs, or other debris with the net while on the downstream side of the snag. You can also disturb such surfaces by scraping them with your foot or a large stick, or by pulling off some of the bark to get at the organisms hiding underneath. In all cases, be sure that your net is positioned downstream from the snag, so that dislodged material floats toward the net, not away from it.

3. Rinse the net contents with the wash bottle filled with stream water to remove any sediment, and then place organisms in the bucket. Carefully inspect any leaf litter and organic debris which may have been collected for organisms.

4. Spend 15 minutes inspecting the chosen sampling area for any organisms not collected previously. Using your hands or forceps, remove any organisms still clinging to tree roots, logs, or other debris. You may remove a log from the water to better see what may be found, but be sure to put it back.

Sampling procedures
Undercut banks

Undercut banks are areas where moving water has cut out vertical or nearly vertical banks, just below the surface of the water. In such areas you will find overhanging vegetation and submerged root mats that harbor dragonflies, damselflies, and crayfish.

1. Move the net in a bottom-to-surface motion, jabbing at the bank five times in a row to loosen organisms.

2. Inspect and clean any debris collected and place the collected organisms in the bucket.

Sampling procedures
Sediments

Areas of mostly sand and/or mud can usually be found on the edges of the stream, where the water flows more slowly.

1. A netter stands downstream of the sediment area with the dip net resting on the bottom. A kicker disturbs the sediment to a depth of about two inches as he or she approaches the net.

2. The netter sweeps the net upward to collect the organisms as the kicker approaches.

3. Wash out the sediment from the net by gently moving the net back and forth in the water of the stream, keeping the opening of the net at least an inch or two above the surface of the water.
.
4. Place the organisms captured by the net in the bucket.

Subsampling Procedures

If you have a large sample, counting and identifying the collected organisms is easier if you remove a random subsample of at least 100 organisms. If you have fewer than 100 organisms, there is no need to subsample.

YOU WILL NEED

- Biological Survey Data Sheet
- Clip board and pencil or pen
- White, gridded subsampling pan
- Forceps
- Ice water or soda water
- Bucket with collected organisms
- A jar containing alcohol (70% ethanol or isopropyl alcohol) and labels
- Wash bottle filled with stream water
- Calculator

If less than 100 organisms are collected:

1. Transfer the organisms from the bucket to the gridded pan. To do this, pour the bucket's contents through the dip net. Then wash the organisms out of the net into the pan using the wash bottle. Remove any clinging organisms from the net and place them in the pan as well.

2. Place the pan on an even surface, preferably one that you can sit next to. (You can place the pan on an upturned bucket, for example, and sit on another upturned bucket beside it.) The availability of a level surface will vary with the sample site, so use your imagination.

3. Add ice cold water to the pan until it is one inch deep (measure to the first joint of your index finger), or add a couple capfuls of soda water to the pan.

4. Remove all crayfish, mussels, or clams – *do not place them in alcohol*. Indicate in the Macroinvertebrates of Special Interest section of the Biological Survey Sheet that you collected them. If you know their scientific or common names, write them in the space provided, then release the crayfish, mussels and clams back to the stream.

5. Place all macroinvertebrates in the labeled sample jar containing alcohol.

If more than 100 organisms are collected:

1. Transfer the organisms from the bucket to the gridded pan. To do this, pour the bucket's contents through the dip net. Then wash the organisms out of the net into the pan using the wash bottle. Remove any clinging organisms from the net and place them in the pan as well.

2. Place the pan on an even surface, preferably one that you can sit next to. (You can place the pan on an upturned bucket and sit on another upturned bucket beside it.) The availability of a level surface will vary with the sample site, so use your imagination.

3. Add ice cold water to the pan until it is one inch deep (measure to the first joint of your index finger), or add two capfuls of soda water to the pan.

4. Remove any crayfish, freshwater mussels, zebra mussels, or Asiatic clams and indicate that you found these. Place the rest of the organisms in the labeled sample jar. Continue until all organisms have been removed from the selected square. Record on the Biological Survey Sheet the total number of organisms picked. Release all crayfish, mussels and clams back to the stream.

5. Gently rock the subsampling pan to evenly distribute organisms across the bottom. Try to avoid "clumps" of organisms in the corners of the pan.

6. Collect all large organisms that may be scurrying about and place them in a jar of alcohol. In the NOTES section, indicate how many large organisms you remove.

7. Select a numbered square and begin removing organisms lying within that square, counting them as they are removed.

Any organism that straddles a line separating two squares is considered to be in the square that contains its head. In the case of organisms whose head is impossible to locate (such as worms), consider the organism to be in the square that contains the largest portion of its body.

8. Select a second numbered square and remove and count the organisms within it, using the above procedures. Clear as many squares as are needed to provide at least 100 organisms. Record the square numbers and the number of organisms picked from each on the data sheet, as you did for the first square. After removing 100 organisms, continue to remove organisms from within the last square until it is empty.

9. Look through the organisms remaining in the pan for any type of organism that was not collected as part of the subsample.

You should collect only one organism of each uncollected type you find. If you find any additional types, indicate in the Subsampling Procedure section of the Biological Survey Sheet which organisms were collected after Step 5 of the subsampling was completed. If you are not sure what type of organisms they are, at least indicate how many types were collected after subsampling.

10. Discard any organisms remaining in the pan by draining the contents of the pan through the net onto the ground. Place the discarded organisms in another large container containing stream water. Now return these organisms to the stream.

11. Now estimate the total number of organisms collected by using the equations on the data sheet. Let's say you picked organisms from four squares on the tray to obtain the 100 organisms needed for your subsample.

The density per square is calculated like this:

Organisms divided by 4 squares equals 25 organisms per square

12. To find the density of the whole sample, the number of organisms per square is multiplied by the number of squares in the tray. For example, if the above sample tray had nine squares, its projected organism density per sample would equal:

Organisms per square multiplied by 9 squares equals 225 organisms per tray.

This number is an estimate of the total number of organisms that you collected.

MACROINVERTEBRATE IDENTIFICATION

All of the macroinvertebrates that you collected will be identified to the appropriate taxonomic level such as family or order. This should be done in a laboratory setting.

Information on the Biological Survey Data Sheet will be used to calculate various *metrics* that assess stream integrity. These metrics are defined below.

Taxa richness measures the abundance of different types of organisms as determined by the total number of taxa represented in a sample. Generally, taxa richness increases as water quality, habitat diversity, and habitat suitability increase. However, some pristine headwater streams naturally harbor few taxa, while the number of taxa can actually increase in polluted streams.

Sample density estimates the total number of organisms collected from your stream site after subsampling. If you did not subsample, your sample represents the total number of organisms collected. If you did subsample, you estimated a sample density before, but the number of subsampled organisms is needed to calculate the Macroinvertebrate Biotic Index.

Nutrient-enriched water has a high density of organisms, while water polluted with toxic chemicals or silt or sand usually has a lower density.

The **Macroinvertebrate Biotic Index** score (MBI) and the **percent composition** of taxa in a stream determine the presence or absence of taxa which have a high pollution tolerance. MBI values reflect stream quality as follows:

1. Less than 6.0 = good water quality
2. 6.0 to 7.5 = fair water quality
3. 7.6 to 8.9 = poor water quality
4. Greater than or equal to 9.0 = very poor water quality

The percent composition (%C) of macroinvertebrate taxa also reflects stream quality. Streams with high percentages of mayflies and stoneflies are considered to be in good health. Those that harbor a high percentage of midge larvae and aquatic worms are considered to be in poor health, since these organisms are tolerant to some types of pollution that reduce dissolved oxygen levels.

YOU WILL NEED

- Biological Survey Data Sheet
- Stereoscope, or dissecting microscope
- Pencil or pen
- Petri dishes
- Macroinvertebrate sample
- Forceps
- Macroinvertebrate Key (or aquatic insect identification key)
- Bottle of alcohol
- Calculator
- Extra jars

Biological Survey Data Sheet

Identify the Organisms
The data sheet provides boxes with common names of macroinvertebrate indicator taxa found in Illinois streams. It is in these boxes that you record the number of organisms collected within each taxon. It is not expected that you will have found organisms from each taxon listed on the data sheet. Mark only those taxa identified from the sample.

The taxa list is not inclusive; only indicator organisms used to assess stream quality are included. If other macroinvertebrates are collected, write their names and how many were collected in the section labeled "NOTE." To identify organisms by taxa, first separate them by general appearance, then identify the taxa to which they belong with the help of an identification key. Appendix C contains a simple key.

Write the number of organisms identified from each taxon in the column marked "No. of Organisms (N)."

Label the collection
Once the macroinvertebrates have been identified and counted, place them in a properly labeled container. The label should be written in permanent, non-alcohol soluble ink (pens can be purchased from a biological supplier or art supply stores), and taped to the outside of the jar.

All labels should contain the following information:

Date, Stream Name, County, Location, Name of Identifier

An example label is given below:

July 5, 2007	
Kerton Creek	Fulton Co.
0.5 mi. West of SR 100 on CR 1200 E	
M. Smith	

Calculate the Biotic Indices
Calculate the values which will measure your site's biological integrity. To do this:

1. Multiply the number of organisms identified from each taxon by its tolerance rating. The "Tolerance Rating (T_i)" is printed on the data sheet in the column next to "No. of Organisms (N)." Enter the resulting number in the last column titled "Tolerance Value (T_v)."

2. Add the numbers in each column and place the results in the corresponding boxes marked "Totals." You should now have numbers representing the total number of taxa ("∑Taxa"), the total number of organisms ("∑N"), and the total tolerance value ("∑(Tv)"). (The Greek letter ∑ sigma is the symbol for "total.")

To calculate

"Macroinvertebrate Biotic Index" is the total tolerance value divided by the total number of organisms – MBI = $\sum(T_v) \div \sum N$

"Taxa Richness" is the total number of taxa that you identified -- $\sum$ Taxa

"Sample Density" is the total number of indicator organisms collected or subsampled --$\sum$N.

"Percent Composition" reflects which organisms were most prominent in the stream.

Enter in column "(N)" the number of organisms collected from each taxon listed. Divide the "No. of Organisms (N)" in each taxon by its community density ("$\sum$N") and multiply by 100 to obtain the percent composition - %C = (N) ÷ $\sum$N X 100 Add the "% C" of each taxon to obtain a subtotal percentage ("% subtotal"). Subtract "% subtotal" from 100% to obtain the percentage of other organisms in your sample.

FINISHING UP

Wrapping Up Your Monitoring Session

- **Follow Up with Landowner/Property Manager**

If you or your group monitored a site owned or managed by someone else, it is strongly recommended that a thank-you note be sent once your monitoring is complete. You may also like to show a copy of your data sheets and a summary of your results. This will help ensure a willingness on the part of the landowner or property manager to allow the site to be monitored in future years.

APPENDIX A
FACTORS THAT AFFECT STREAM QUALITY IN ILLINOIS

Pollutants

Pollutants are unwanted materials ranging from litter to industrial waste. Stream pollution in particular comes from a variety of sources and has many complex effects. Benthic macroinvertebrate communities for example can be affected by pollutants such as sediment, organic wastes, excess nutrients such as phosphates from detergents, and toxic substances.

Several types of pollutants affect Illinois rivers and streams. They include the following sources.

Sediment from soil erosion has long been considered the most serious threat to water quality in Illinois. Farmfields, mines, cut-over forests, and unpaved roads are sources of sediment in streams in rural areas. In urban areas, ill-managed construction sites can greatly elevate sediment levels in streams.

Excessive amounts of sediment in the water can destroy macroinvertebrate habitats by filling the spaces between boulders and rocks in which many of these organisms live. Sediment can also harm the filter-feeding mechanisms of some aquatic organisms, clog the gills of others, or bury macroinvertebrates entirely.

Organic wastes originate from industrial operations such as pulp mills, sugar refineries and some food processing plants. The most common source of organic wastes in Illinois, however, is the discharge from municipal sewage treatment plants. When organic wastes enter a stream, they are decomposed by bacteria in the sediments and water. These bacteria consume the oxygen dissolved in the water. The amount of oxygen needed to decompose a given amount of organic waste in a stream is called its biological oxygen demand, or BOD. The decomposition of an organic waste in a stream that has a high BOD leaves very little dissolved oxygen for the fishes, aquatic insects, and other organisms that live in the stream.

Nutrient enrichment refers to the addition of nitrogen and/or phosphorous to an aquatic ecosystem. Wastewater from sewage treatment plants, fertilizers from agricultural runoff, and urban runoff add nitrogen and phosphorous to streams. Other sources of nutrient enrichment include septic tank leakages and farm animal wastes.

Nutrients occur naturally in stream water. But because nitrogen and phosphorous are key elements in the growth of aquatic plant life such as algae, an increase in these nutrients can significantly increase growth by the plants and animals in the stream. Rapid plant growth in streams results in algal blooms. Besides being unsightly, algal blooms can cause water to smell and taste bad. Because algal masses are organic, their decomposition depletes the available oxygen in water like any other organic waste. Nutrient enrichment usually increases the number of macroinvertebrates in a stream at first, but these numbers decline as dissolved oxygen levels decrease.

Temperature elevation stresses many species of fishes and macroinvertebratres that have limited tolerances to high temperatures. Two main factors contribute to temperature elevation in Illinois streams. The loss of riparian zones removes shade-providing plants, exposing streams to direct sunlight for many hours. Also, streams receive some part of their water from groundwater sources. This (usually) cooler groundwater helps to cool the warmer surface waters entering streams from runoff or rainfall. Irrigation and stream channelization cause water tables to drop, decreasing the volume of cooler groundwater entering streams.

Channelization converts natural meandering streams with varied habitats to straight-sided ditches of nearly uniform width, depth, current velocity, and substrate. Fewer habitats mean fewer species capable of living in such modified streams. Bankside vegetation is removed when a stream is channelized, further reducing the biodiversity of the stream.

Toxic chemicals have helped degrade many stream ecosystems throughout the United States. Truly safe levels of many toxic chemical contaminants have never been determined, and their long-term effects on ecosystems are largely unknown. These chemicals enter streams as a result of irresponsible discharge of industrial wastes, indiscriminate use of agricultural pesticides, and careless dumping of household cleaners. Although toxic chemicals are still getting into Illinois' streams, their concentrations have been reduced to the point where most authorities now consider other pollutants (such as sediment and excess nutrients) more immediate environmental threats.

However, the concentration of toxic chemicals in stream waters is not necessarily a true reflection of their presence in a stream. Plants and animals often absorb these pollutants either from the water or sediment and accumulate them in their tissues. Monitoring only stream waters for toxic chemicals does not reliably assess stream quality, since most such chemicals are concentrated not in the water but in the bodies of the organisms living in the stream and in sediments.

Over time, toxic substances in the tissues of stream organisms may reach levels many times higher than in the stream's water or sediments. When stream organisms that have accumulated toxic chemicals are eaten by other organisms (such as raccoons or fish-eating birds), the toxic chemical is passed along the food chain, leading eventually to humans.

Point vs. nonpoint source pollution

Pollution is classified according to its source. Point source pollution comes from a single identifiable point such as a factory discharge pipe that empties into a river. Nonpoint source pollution does not come from a clearly defined source. Nonpoint source pollution is primarily runoff from land that contains pesticides, fertilizers, metals, manure, road salt, and other pollutants. Nonpoint source pollution originates on farms, lawns, paved streets and parking lots, construction sites, timber harvesting operations, landfills, and home septic systems. "Acid rain" is another nonpoint pollutant.

Nonpoint source pollution is a major factor in the deterioration of Illinois' streams. It occurs wherever and whenever soils cannot sufficiently absorb and filter pollutants contained in storm water drainage and runoff. Nonpoint source pollution can quickly kill a stream by introducing organic and inorganic pollutants that silt streambeds, decrease dissolved oxygen, and poison aquatic organisms.

APPENDIX B
THE LIFE HISTORY OF MACROINVERTEBRATES

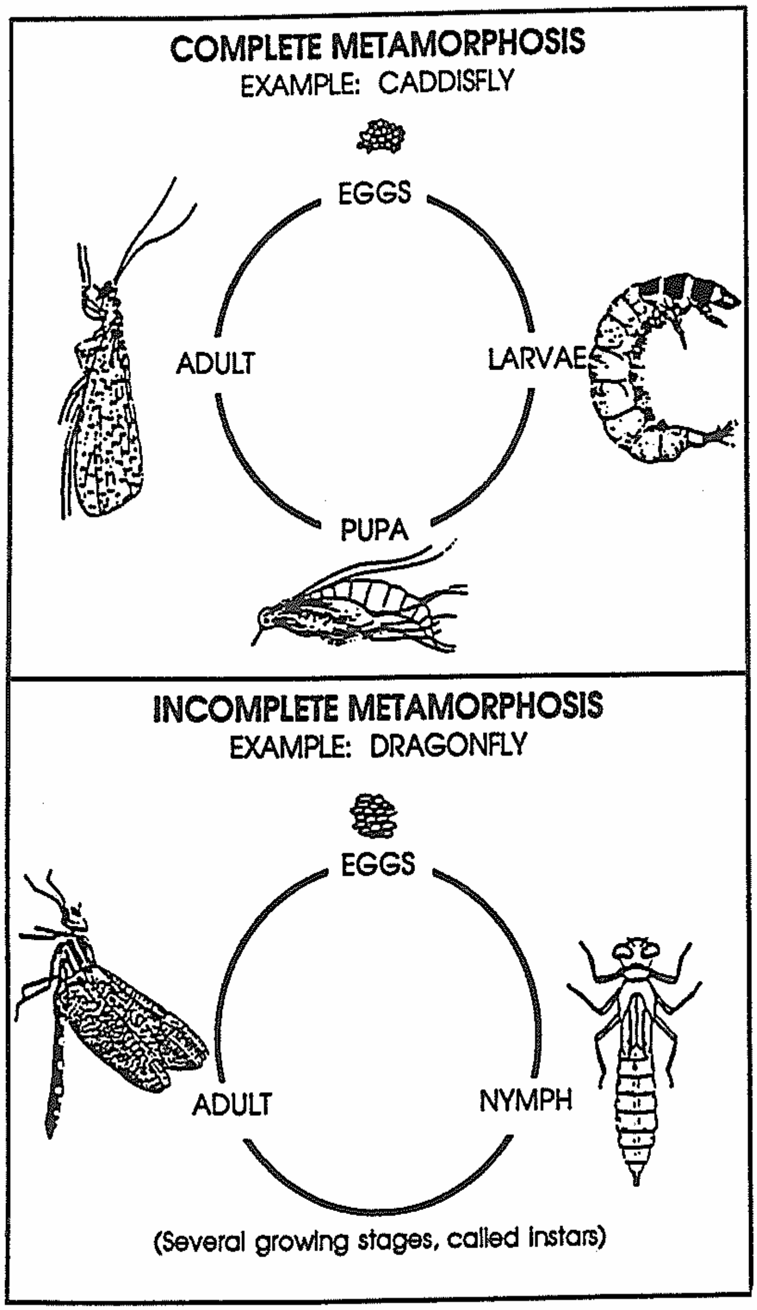
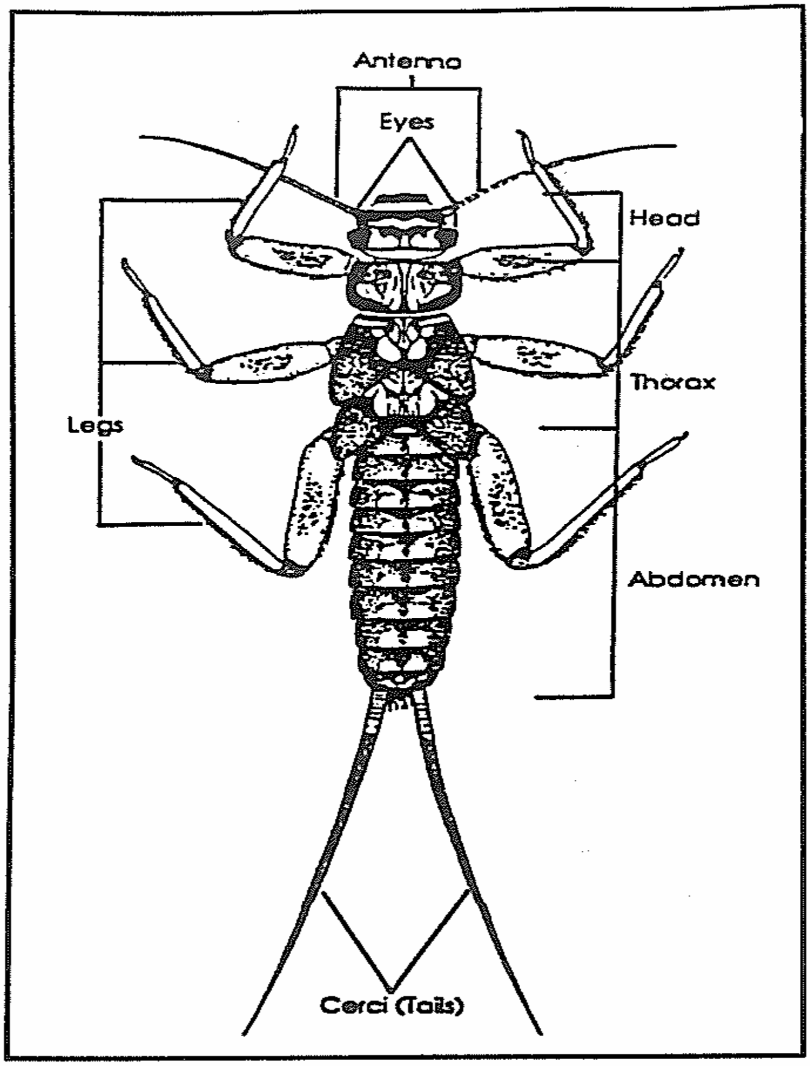


Figure 2. Insect Life Cycles

Aquatic Insects

The aquatic insects comprise the bulk of benthic macroinvertebrate communities in healthy, freshwater streams. These insects are mostly in their immature form and live their adult life on land, sometimes for only a few hours. Most aquatic insects can be divided into two separate groups: ones that develop through complete metamorphosis, and ones that develop through incomplete metamorphosis.

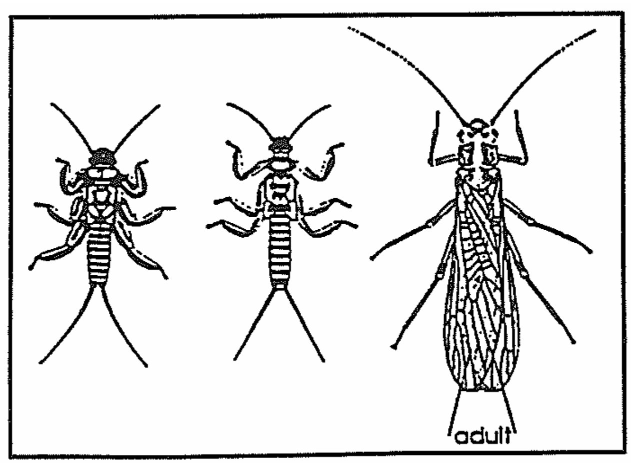
Metamorphosis is the change that occurs during the organism's development from egg to adult (see Figure 2). Some aquatic insects develop through complete metamorphosis, which consists of four stages. These immature insects are called larvae and they do not resemble the adults and, in fact, may look grossly different. During the pupae stage, the organisms inhabit a "cocoon-like" structure where the transformation from larva to adult occurs. Incomplete metamorphosis has three main stages of development (except for the mayfly which has two winged growing stages). These immature insects are called nymphs, and they undergo a series of molts until the last decisive molt transforms the organism into an adult or imago. There is no intermediate pupae stage where transformation occurs. The nymphs resemble the adults closely except for wing development.



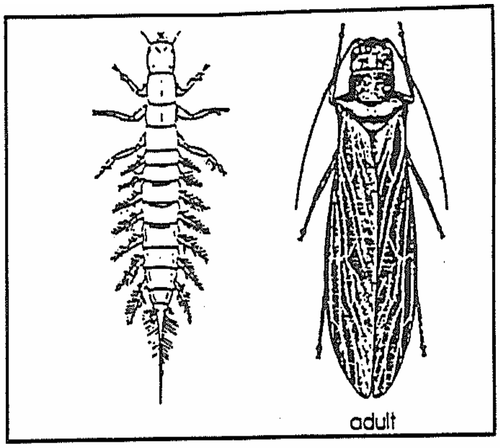
All insects (whether they are adult or immature or whether they develop through complete or incomplete metamorphosis) have three main body parts: head, thorax, and abdomen (Figure 3).

Figure 3. Aquatic Insect Body Parts: Main parts consistent in all aquatic insects

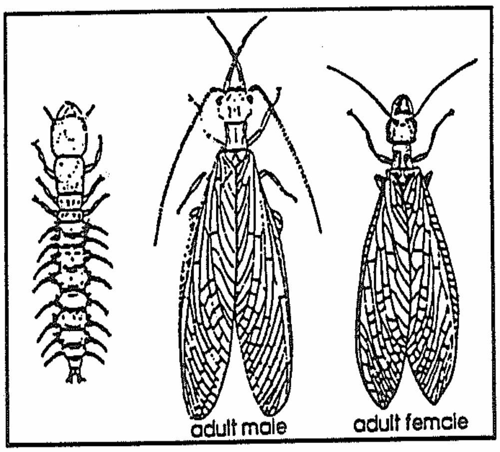
Aquatic Insects



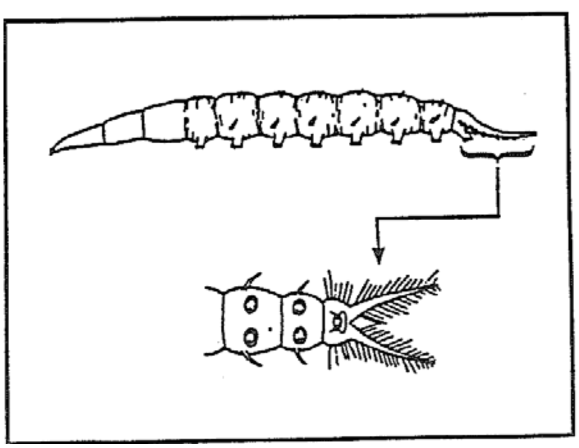
Stoneflies
Metamorphosis: incomplete
Nymphs: possess two distinct "tails" called cerci, which are actually sensory feelers; brightly colored in tan, brown, gold and black; length varies, up to 1 inch
Reproduction: females deposit eggs on top of water where they drift down to the bottom
Adults: resemble nymphs, but possess a long pair of wings folded down the length of the body
Food: some are carnivorous, others feed on algae, bacteria, and vegetable debris; eaten by a variety of fish species



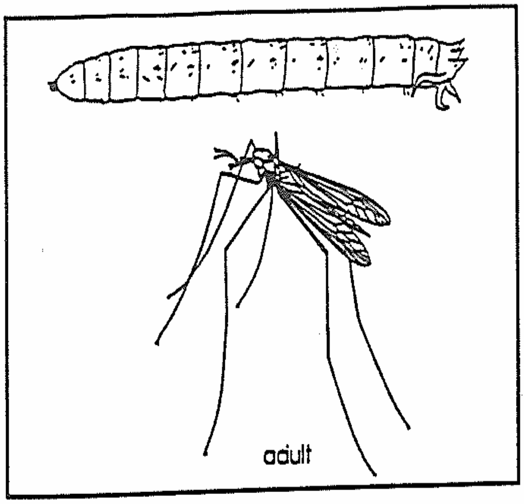
Alderflies
Metamorphosis: complete
Larvae: possess a single tail filament with distinct hairs; body is thick-skinned with 6 to 8 filaments on each side of the abdomen; gills are located near the base of each filament; color brownish
Reproduction: female deposits eggs on vegetation that overhangs water, larvae hatch and fall directly into water
Adults: dark with long wings folded back over the body
Food: larvae are aggressive predators, feeding on other aquatic macroinvertebrates; as secondary consumers, they are eaten by other larger predators



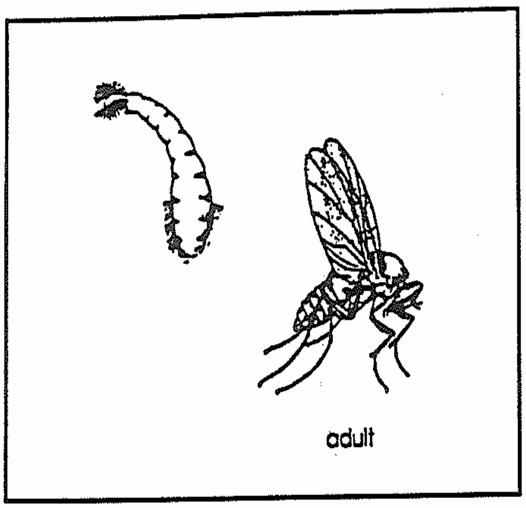
Dobsonflies
Metamorphosis: complete
Larvae: often called hellgrammites, possess two large mandibles; several filaments are located along the sides of the abdomen; one pair of short tail filaments used for grasping: color brown to black with a large dark "plate" behind base of head; six legs; length up to 3 inches
Reproduction: female attaches eggs on overhanging vegetation; when eggs hatch, the larvae fall directly into the water
Adults: possess two pairs of extremely long, colorful wings folded back the length of the body; males possess a pair of long mandibles that can cross that are used to grasp the female during copulation; females possess one pair of mandibles smaller than those of the male
Food: predaceous larvae feed upon other aquatic macroinvertebrates; larvae widely used as fish bait; important food source for larger game fish



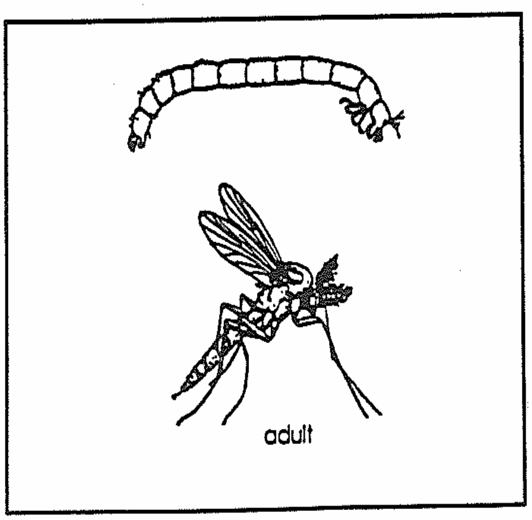
Snipe Flies
Metamorphosis: complete
Larvae: elongated, cylindrical, slightly flattened; cone-shaped abdomen is characteristic; two, long, fringed filaments at end of abdomen; color varies; length up to ½ inch
Reproduction: female deposits eggs on overhanging vegetation and immediately dies and remains attached to egg mass; larvae hatch and drop into water
Adults: a moderately sized fly that is usually found around low bushes, shrubbery, and tall grasses
Food: larvae are predaceous, adults mostly feed on blood



Crane Flies
Metamorphosis: complete
Larvae: definitely "worm-like," thick-skinned, and brownish-green to somewhat transparent or whitish; pointed or rounded at one end and a set of disk-like spiracles at the other; color may be stained greenish or brownish; length up to 3 inches
Reproduction: female deposits eggs on submerged vegetation or other debris
Adults: best described as "giant mosquitoes;" possess long legs and plump bodies, but are harmless
Food: mostly plants and plant debris; some are predaceous

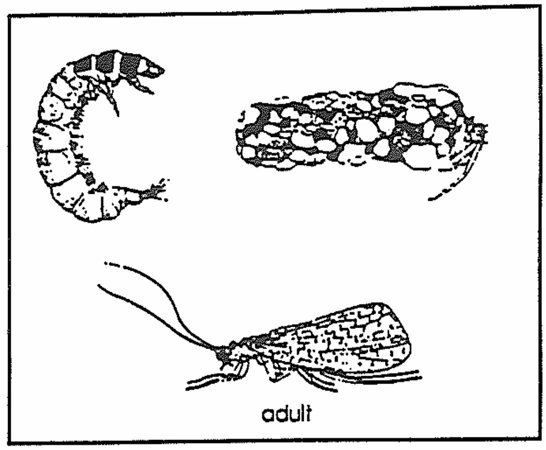


Black Flies
Metamorphosis: complete
Larvae: small, worm-like and bulbous at one end; when out of water, they fold themselves in half while wiggling; color may be green, brown or gray but is usually black; length up to 1/3 inch
Reproduction: females deposit eggs on submerged vegetation or other debris
Adults: fly-like; known as a serious pest because it inflicts painful bites to warm-blooded animals
Food: larvae eat organic debris filtered from water; adult females of many species feed on blood

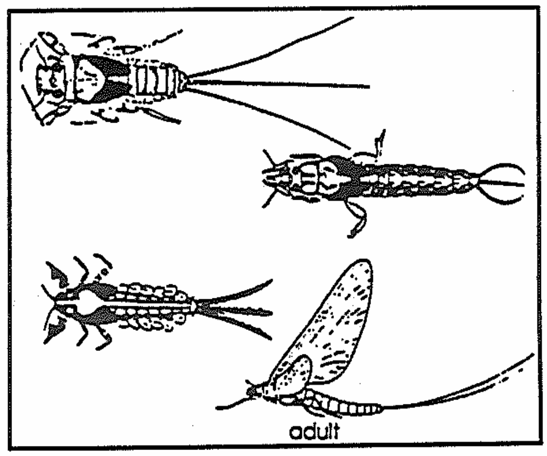


Midges (flies)
Metamorphosis: complete
Larvae: most species extremely small and thin; worm-like and wiggle intensely when out of water; color varies from gold, brown, green, and tan to black; length is usually less than ½ inch
Reproduction: female deposits a gelatinous mass of eggs on the water surface or attaches it to submerged vegetation
Adults: resemble small mosquitoes with fuzzy antennae on males
Food: primarily algae and other organic debris; many feed on other insect larvae

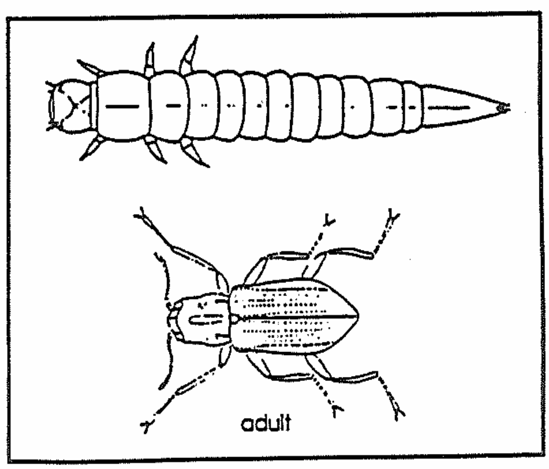
Caddisflies
Metamorphosis: complete
Larvae: worm-like, soft bodies; head contains a hard covering; color can vary from yellow to brown, but usually green; larvae are known for their construction of hollow cases that they either carry with them or attach to rocks; cases are built from sand, twigs, small stones, crushed shells, rolled leaves, and bark pieces; cases used for protection and pupation; length up to 1 inch
Reproduction: eggs encased in a gelatinous mass and are attached to submerged vegetation or logs
Adults: moth-like, brownish and usually nocturnal; wings thickly covered with hairs
Food: larvae feed on algae, small bits of plant material, and animals; some species build nets to catch drifting food; fed upon by several species of fishes

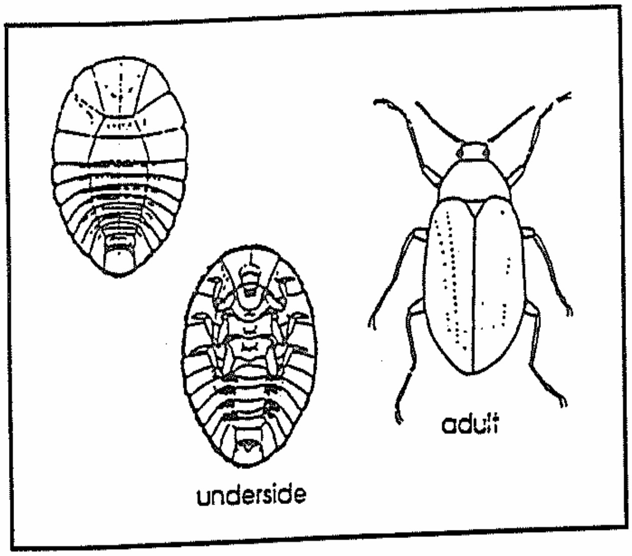


Mayflies
Metamorphosis: incomplete
Nymphs: three distinct cerci (tails), occasionally two; cerci may be fuzzy or thread-like, but never paddle or fan-like; color varies from green to brown to gray, but is usually black; total length up to 1 inch
Reproduction: female deposits eggs on top of water where they drift to the bottom; some species crawl under water and attach eggs to submerged objects
Adults: resemble nymphs, but usually possess two pairs of long, lacy wings folded upright; adults usually have only two cerci
Food: consists of small plant and animal debris, such as algae, diatoms, and plankton; preyed upon by fishes and play an important role in the food chain

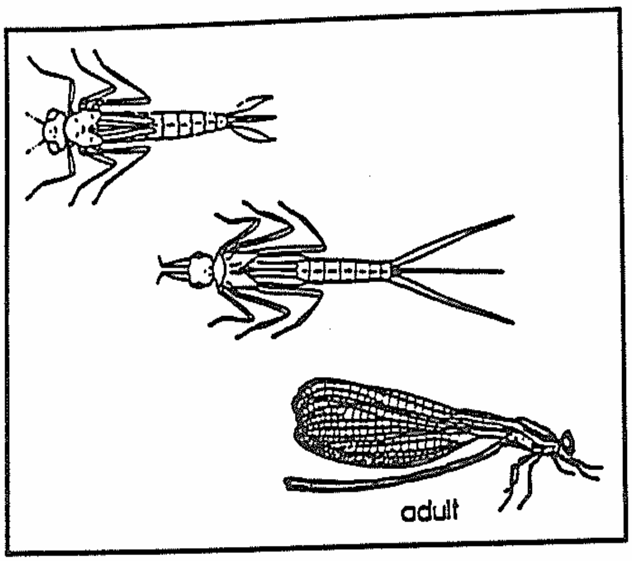


Riffle Beetles
Metamorphosis: complete
Larvae: resemble small “torpedoes” with circular stripes or rings around body; pointed at both ends with a “fuzzy” mass at one end; color usually grayish; length less than ½ inch
Reproduction: females deposit eggs on plant materials under water
Adults: unique in that they are aquatic and are found more often than the larvae; adults are beetle-like, tiny, and usually black
Food: primarily plant material such as diatoms and algae

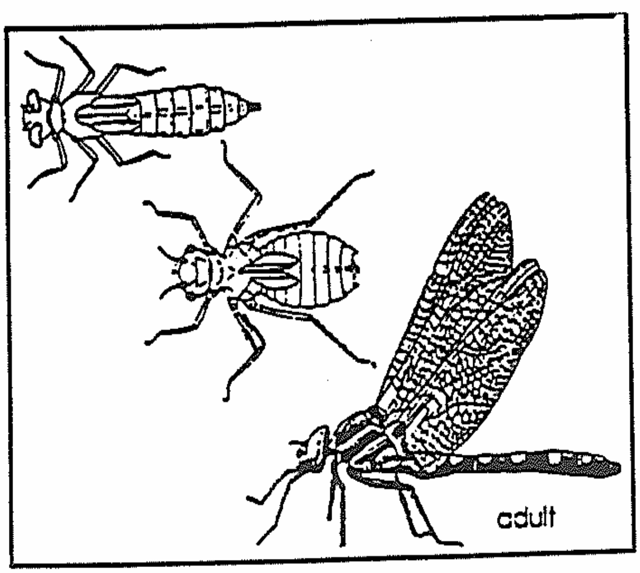




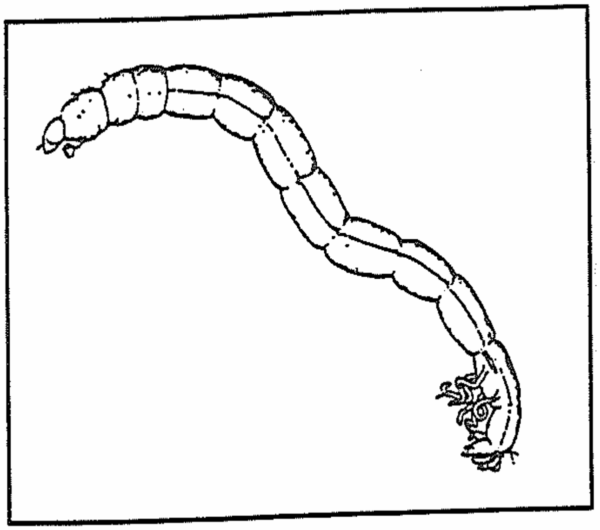
Water Penny Beetle
Metamorphosis: complete
Larvae: resemble circular incrustations on rocks; sucker-like; color green, black, tan or brown; length usually no more than ½ inch
Reproduction: adult females crawl into water and deposit eggs on undersides of stones
Adults: typical beetle-shaped body; resemble an extremely large riffle beetle (not truly aquatic; can be found on emergent rocks in riffles)
Food: primarily plant debris such as algae and diatoms



Damselflies
Metamorphosis: incomplete
Nymphs: bodies elongated with three distinct paddle-like tails (actually gills) located at the end of abdomen; six legs positioned near front of body; two large eyes on top of head; colors range from green to brown and black; some are robust, others slender; length up to 2 inches
Reproduction: females deposit eggs on top of water where they drift to the bottom
Adults: possess extremely long abdomens; two pairs of wings that are held upright at rest; very colorful in greens, blues, and reds
Food: predaceous, nymphs feed on other aquatic macroinvertebrates

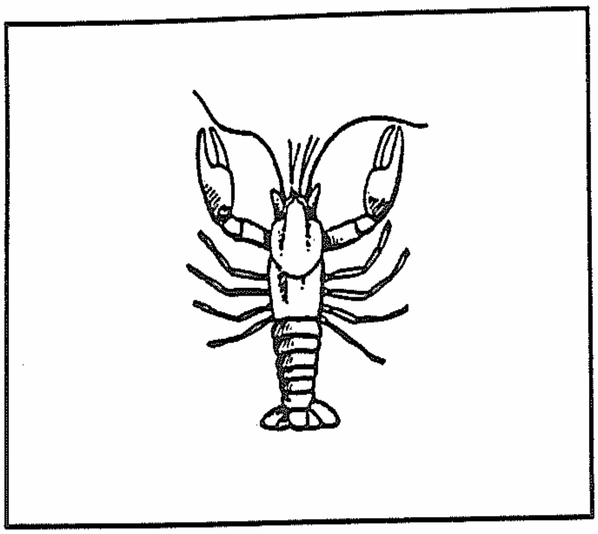


Dragonflies
Metamorphosis: incomplete
Nymphs: vary in shape, but most have robust, elongated, or "spider-like" bodies, often with algae growing on their back; six legs at side of body or near front on elongated species; two large eyes at sides of head; a pair of small wings begins to develop on back; color varies from brown and black to green; length up to 2 inches
Reproduction: eggs are deposited on surface of water and drift to bottom
Adults: similar to adult damselflies, but the two pairs of wings are laid flat or horizontal at rest; some species can attain length of over 4 inches
Food: predaceous; nymphs feed upon other aquatic macroinvertebrates, small fishes, and tadpoles

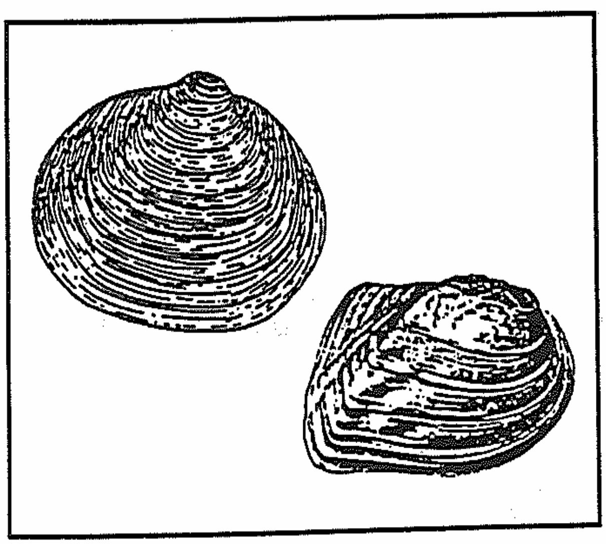


Blood Worm Midges
Metamorphosis: complete
Larvae: similar to other midges, but are larger, robust, and distinctly red in color; length up to 1 inch
Reproduction: female deposits gelatinous mass of eggs on the surface of water or on submerged vegetation.
Adults: resemble small mosquitoes with fuzzy antennae on males
Food: primarily algae and other organic debris

Other Aquatic Macroinvertebrates

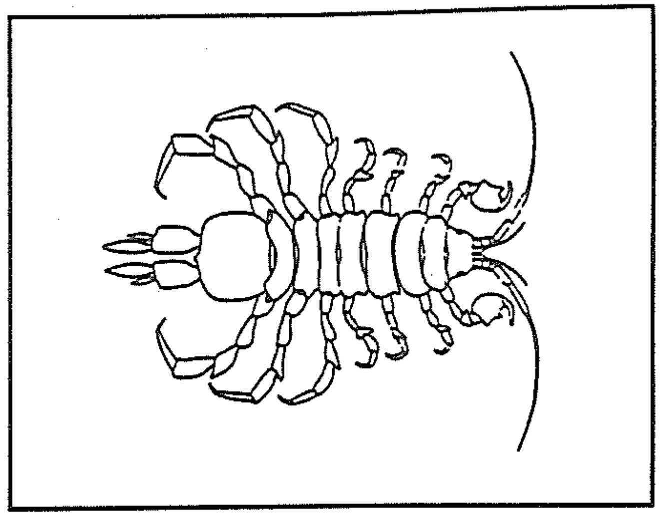


Crayfishes
Description: resemble miniature "lobsters;" possess four pairs of walking legs and a pair of strong pinchers; color can be brown, green, reddish, or black; length up to 6 inches
Reproduction: females carry eggs in a mass underneath their tail; mass resembles a large "raspberry"
Food: omnivorous, eating plants and animals; pinchers are used for tearing food into edible chunks; crayfish are preyed upon by larger game fishes

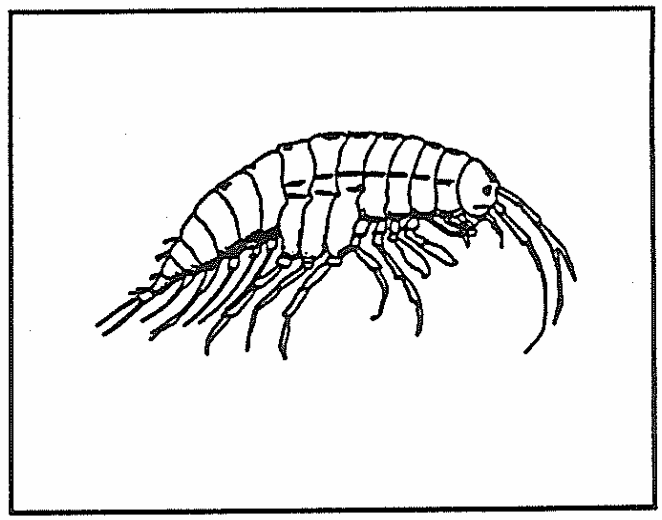


Freshwater Clams and Mussels
Description: include the small fingernail clams, European clam (Corbicula), and the larger pearly naiad mussels; fingernail clams are small (no more than ½ inch in diameter), fragile, and are whitish or grayish in color; Corbicula can be larger, 1 to 2 inches in diameter, light-colored; mussels are large (up to 9 inches in diameter), robust, thick- or thin- shelled, and usually dark in color
Reproduction: fingernail clams are self-fertilizing, the young developing inside the water tubes of the adult; the larvae, called glochidia, develop inside the adult female and are released into the water where they eventually attach onto a host fish; they then parasitize the fish for about two weeks until they drop off and develop on the stream bottom into an adult
Food: primarily filter feeders; filter organic debris and plankton out of water; preyed upon by numerous fishes and mammals

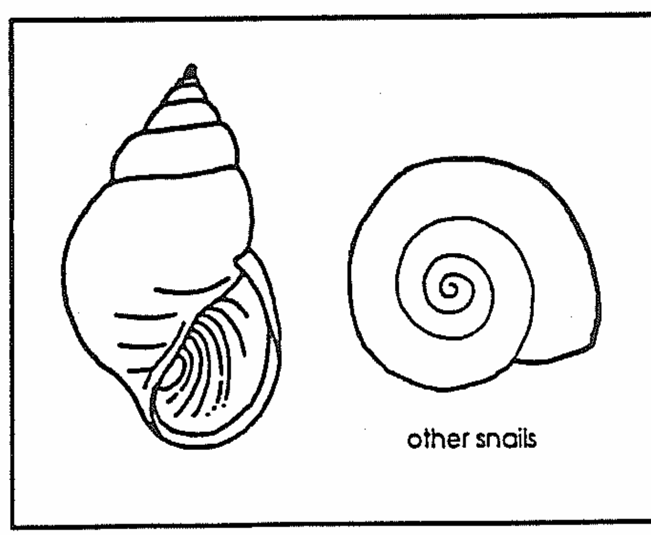
Sowbugs or Aquatic Pill Bugs
Description: somewhat flattened; resemble their terrestrial cousins; seven pairs of legs; color varies, usually gray, but sometimes brown; length less than 1 inch
Reproduction: eggs carried under the female's abdomen until they hatch
Food: characterized as scavengers, eating both dead and live plant and animal debris



Scuds or Sideswimmers
Description: possess extremely flattened sides and a hump back; somewhat resemble large "fleas;" several pairs of legs; color varies from white to brown but usually gray; most are very small, but some can reach ½ inch in length
Reproduction: eggs held by the female in a marsupium (sac) until they hatch
Food: characterized as scavengers, eating both plant and animal debris; an important food source for a variety of fish species



Right-handed and other Snails
Description: generally gill-breathing snails; right-handed snails identified by their swirling shell opening on the right-hand side as the point is straight up in the air and the opening faces you; color is black, brown or gray, often covered with algae; length up to 1 inch; other snails have shells resembling ram's horns
Reproduction: eggs are laid in gelatinous masses usually attached to rocks or other debris
Food: primarily algae that grows on rocks and other debris; occasionally feeds upon decaying plant and animal matter; preyed upon by fishes, turtles, predatory invertebrates, and leeches



APPENDIX C
MACROINVERTEBRATE IDENTIFICATION KEY

The following key was adapted from *A Naturalist's Key to Stream Macroinvertebrates for Citizen Monitoring Programs in the Midwest,* by Joyce E. Lathrop (Proceedings of the 1990 Midwest Pollution Control Biologists Meeting, Chicago, Illinois, April 10-13, 1990). It is suggested to use more than one taxonomic key when identifying any organism.

The key is composed of sets of choices. Read each choice carefully and compare the organism to the description. Once you find the description that matches your organism's features, go to the next description indicated. For example, let's say that the figure below is the organism you are trying to identify.

The first set of descriptions read:

1. A. With a hard calcareous shell of one or two valves.
MOLLUSKS……………………………………………………………………………...2
Mollusca: Bivalvia (Clams and Mussels), Gastropoda (Snails and Limpets). In general, mollusks are found in hard waters with a pH near or above neutral (pH7).

   B. With a spiral (snail-shaped) case of sand; animal hidden within case; body with 6 jointed legs; small and inconspicuous, often overlooked …………….……SNAIL-CASE CADDISFLIES
Tricoptera: Helicopsychidae (Helicopsyche)
INTOLERANT

   C. Without a hard, calcareous shell or spiral-shaped sand case; may or may not have non-spiral case of sand, pebbles or plant material ………………………………..…..…7

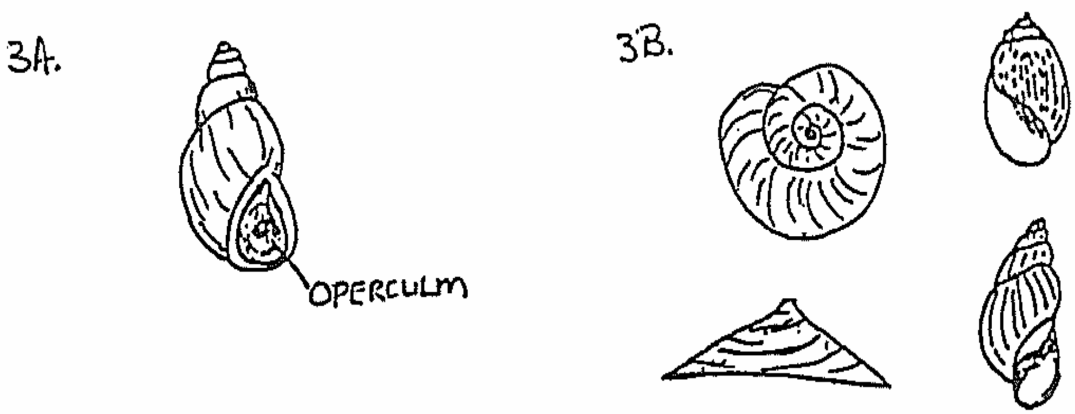
You would select choice "C" because your organism does not have a hard, calcareous shell or a spiral-shaped sand case. Also, your organism does not have any type of case. Therefore, you would go on to description #7. You continue with your search until you come upon a description which tells you what type of organism you have, and no more additional descriptions are given.

Size range estimates of the organisms are given beneath many of the descriptions. Variations in size ranges are common, however, and all organisms of a species may not be covered by the sizes listed.

Numbers in parentheses next to the description's number (see example) indicate which description was used to reach your present position. This information is provided to help you back track your search in case you made a mistake in the identification of the organism.

An example of a macroinvertebrate description:

Description number
↓ Description which was used to reach this point
↓ ↓ ↓ Description Choice
3 (2). A. Snails with an operculum (a hard covering used to close the aperture or opening) ……………………………………………………..……....OTHER SNAILS
Gastropoda; Prosobranchia: Six families. (Operculate Snails) ↑
MODERATELY TOLERANT **←Tolerance** **Final destination for this organism**
0.3 cm – 4.3 cm ← Size Range
B. Snails without an operculum; lung-breathing snails (Pulmonata) ………….……….4
Description choices ↑
Go to this description

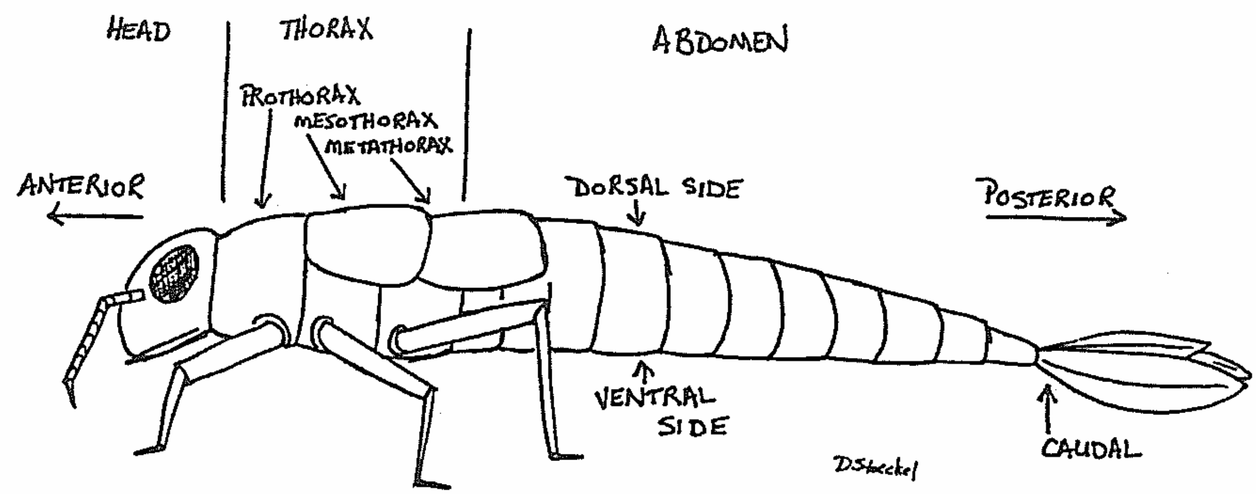


Basic Insect Morphology

An insect's body is generally divided into three major sections: the head, the thorax, and the abdomen. The thorax of an insect is separated further into three more sections named the prothorax, mesothorax and metathorax. Wings or wing pads are found on the mesothorax and metathorax. One pair of legs is generally found on each of the thoracic segments. The legs of an insect have parts which are similar to our legs. The first leg segment coming from the body is called the femur. The next leg segment is called the tibia. The feet of an insect are referred to as tarsi. The tarsi are separated further into segments called tarsal segments.

The words below are used in the key. These words indicate where to look on an insect's body for a particular identifying mark.

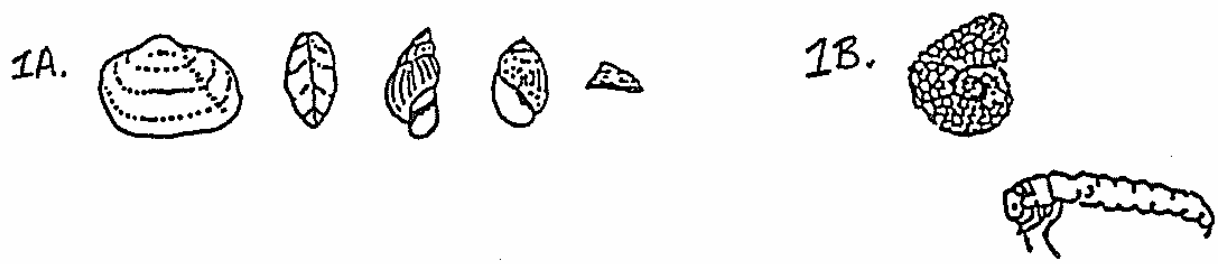
1. Anterior – In the direction of the head
2. Posterior – In the direction of the anus (or end of abdomen)
3. Caudal – Found at the tip of the abdomen
4. Dorsal – Refers to the back, or top of the organism
5. Ventral – Refers to the belly, or bottom of the organism



1A. With a hard calcareous shell of one or two valves
MOLLUSKS …………………………………………………………..…......................2
Mollusca: Bivalvia (Clams and Mussels), Gastropoda (Snails and Limpets) In general, mollusks are found in hard waters with a pH near or above neutral (pH 7).

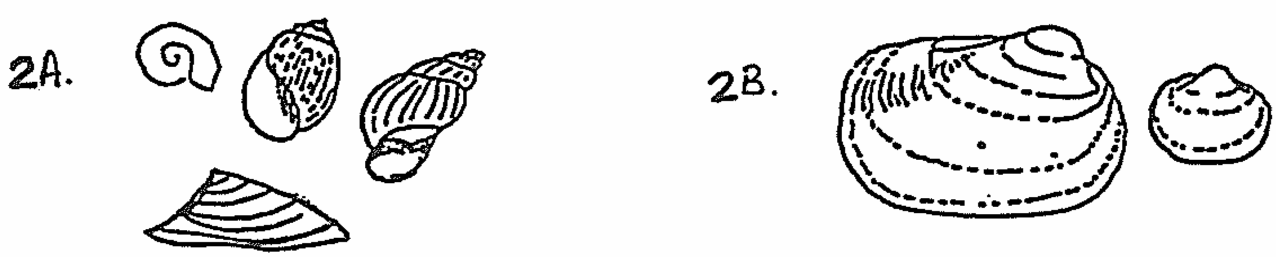
B. With a spiral (snail-shaped) case of sand; animal hidden within case; body with 6 jointed legs; small and inconspicuous, often overlooked………………OTHER CADDISFLIES
Tricoptera: Helicopsychidae (*Helicopsyche*) Snail Case Caddisflies.
INTOLERANT
0.5 cm

C. Without a hard, calcareous shell or spiral-shaped sand case; may or may not have a non-spiral case of sand, pebbles or plant material …………………………….…………..7



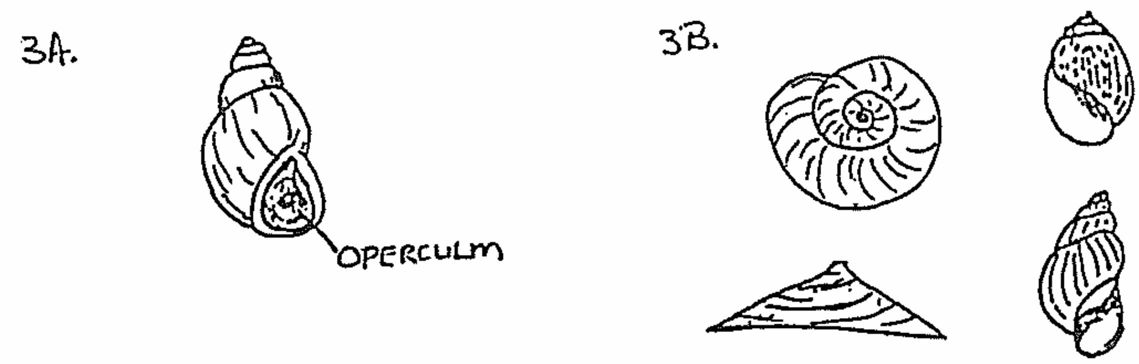
2(1)A. Shell of one valve. SNAILS ………………………………………………...……3

B. Shell of two valves held together by a non-calcareous ligament.
CLAMS AND MUSSELS……….…………………………………………………6
2.0 cm – 14.0+ cm



3(2)A. Snails with an operculum (a hard covering used to close the aperture or opening) …………………………………………………..….……………….OTHER SNAILS
Gastropoda: Prosobranchia Six families (Operculate Snails)
MODERATELY TOLERANT
0.3 cm – 4.4 cm

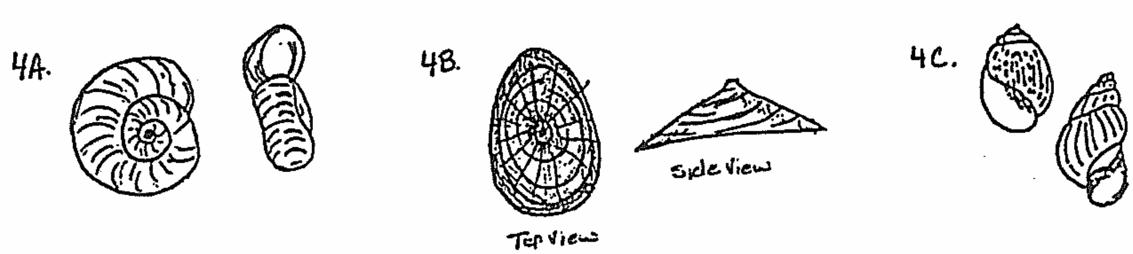
B. Snails without an operculum; lung-breathing snails (Pulmonata) ……………………….4



4(3)A. Shell discoidal (coiled in one plane) ………………………..…..PLANORBID SNAILS
Gastropoda: Planorbidae Generally found in slower waters such as runs
MODERATELY TOLERANT
0.6 cm – 2.7 cm

B. Shell patelliform (cup shaped), limpet-like …………………FRESHWATER LIMPETS
Gastropoda: Ancyclidae Found in riffles
MODERATELY TOLERANT
0.4 cm

C. Shell with a distinct spiral …………………………………………………………..…5

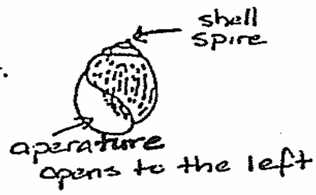


5(4)A. Shell sinistral ("left-handed") ……………………………..……………..POUCH SNAILS
Gastropoda: Physidae (*Physella*) Often found in slower waters
GENERALLY TOLERANT
1.0 cm – 1.8 cm

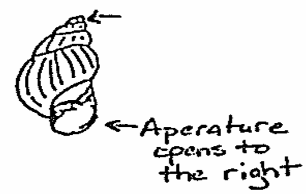
B Shell dextral ("right-handed") …………………………..……RIVER AND POND SNAILS
Gastropoda: Lymnaeidae.
GENERALLY TOLERANT
0.5 cm – 2.5 cm

NOTE: "Handedness" is determined by holding the shell spire up and the aperture facing you. If the aperture is on the right, the snail is "right-handed" or dextral; if the aperture is on the left, the snail is "left-handed" or sinistral.

5A.



5B.

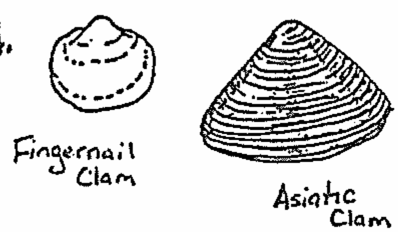


6(2)A. Small bivalves, adults < 2 cm long ………….……FINGERNAIL & ASIATIC CLAMS
Bivalvia: Sphaeriidae and Corbiculidae Fingernail clams are very small with thin fragile shells. Asiatic clams have larger, thicker shells with obvious growth rings.
FAIRLY INTOLERANT
0.4 cm – 2.0 cm

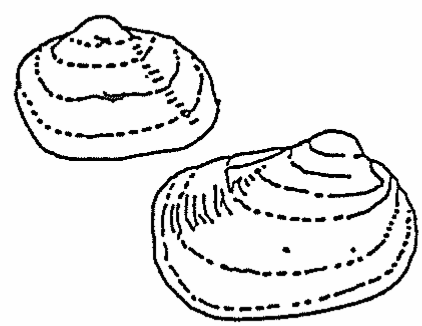
B. Large bivalves, adults mostly > 2 cm long ……………...……CLAMS & MUSSELS
Bivalvia: Unionidae Very young individuals may be less than 2 cm long
2.0 cm – 14.0+ cm

NOTE: Characteristics used to distinguish different bivalves are internal but most have distinct shells and can be roughly picture keyed.

6A.



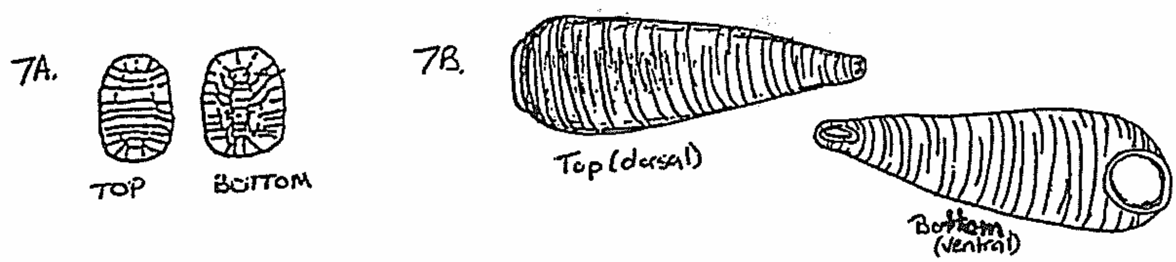
6B.



7(1)A. Entire body distinctly segmented, flattened and oval in shape; the head, 6 pairs of jointed legs and gills are hidden ventrally (beneath the body); copper or brown in color; cling tightly to rocks ……..……………………………..…….WATER PENNIES
Coleoptera: Psephenidae
INTOLERANT
1.0 cm

B. Body oval or elongate, soft and indistinctly segmented; head, legs and gills lacking; with anterior and posterior ventral (bottom) suckers………………………….………LEECHES
Hirudinea
MODERATELY TOLERANT
0.5 cm – 4.2 cm

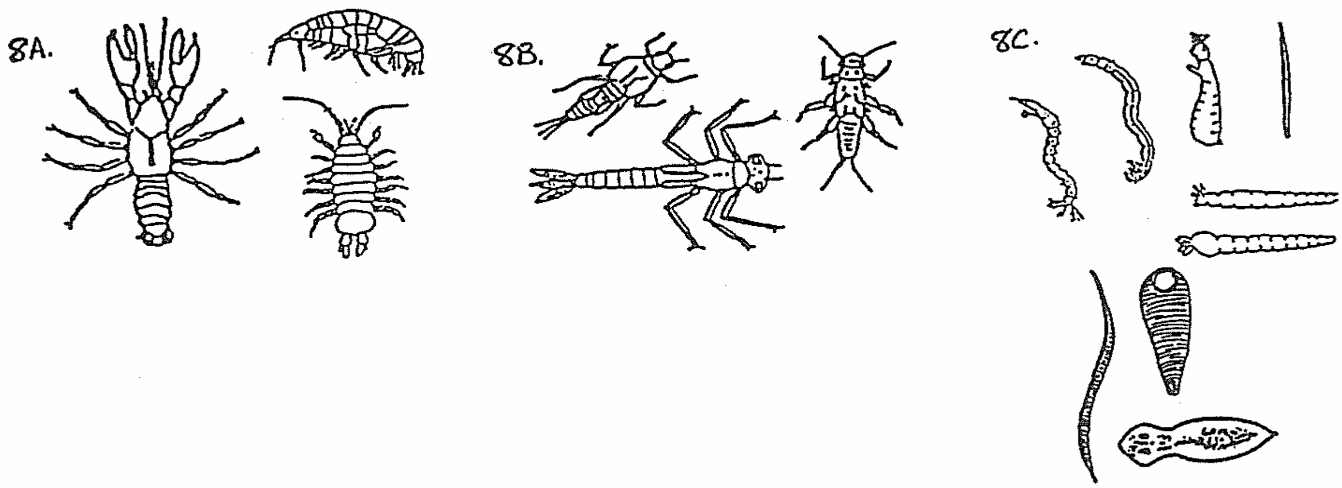
C. Body not a distinctly flattened oval shape; with or without legs; without suckers……………………………………………………………………………… ..8



8(7)A. With more than 6 true, jointed legs. CRAYFISH, SCUDS AND SOWBUGS…………9

B. With 6 true, jointed legs. (Insecta: except Diptera) ………….………………..…………11

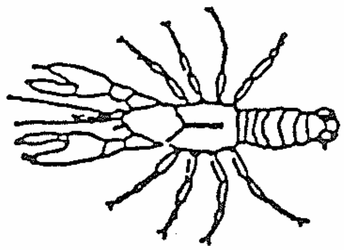
C. With less than 6 true, jointed legs, although non-jointed legs (prolegs) may be present; body often worm-like ……………………………………………………………….…....31



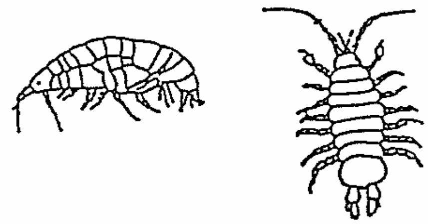
9(8)A. Generally large organisms with 2 large claws (chelipeds), one or both of which may be missing. Small (young) individuals are common in some areas in spring ….CRAYFISH
Crustacea: Decapoda (Cambaridae)
FAIRLY INTOLERANT
1.0 cm – 16.0 cm

B. Smaller organism, lacking large claws ………………………………………..….10

9A.



9B.



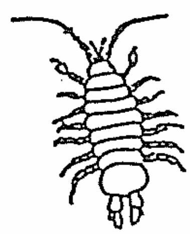
10(9)A. Flattened laterally (from side to side); tan, white or gray in color, ……………...SCUDS
Amphipoda
INTOLERANT
0.5 cm – 2.0 cm

B. Flattened dorsoventrally (top to bottom); gray in color ……………….…….SOWBUGS
Isopoda: Sowbugs resemble the terrestrial "pill bugs" which belong to the same order.

MODERATELY TOLERANT
0.5 cm – 2.0 cm

10A.

10B.

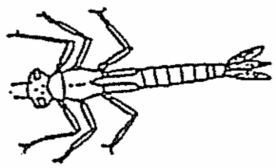


11(8)A. With three broad, oar-like “tails” (gills); body long and thin; wing pads present
DAMSELFLIES ……………………………………………………………..………12
Odonata (Zygoptera)

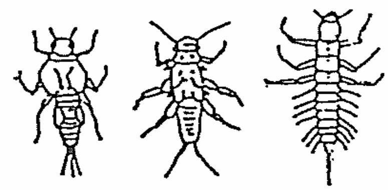
B. With 1, 2, or 3 thin caudal filaments (“tails”) …………………………….…..……………13

C. With no thin caudal filaments; prolegs or other appendages such as spines or hooks (tarsal claws) may be present ……………………………………………………………………18

11A.



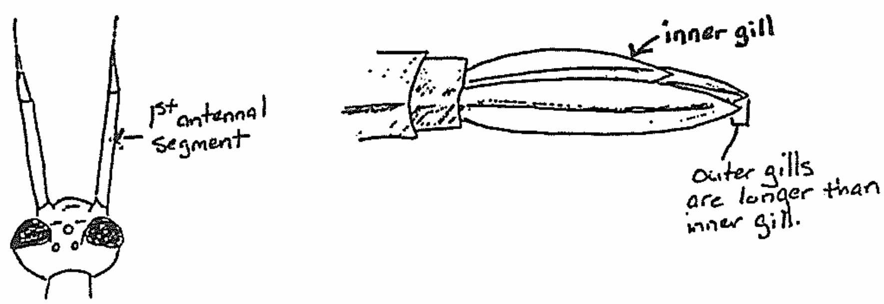
11B.



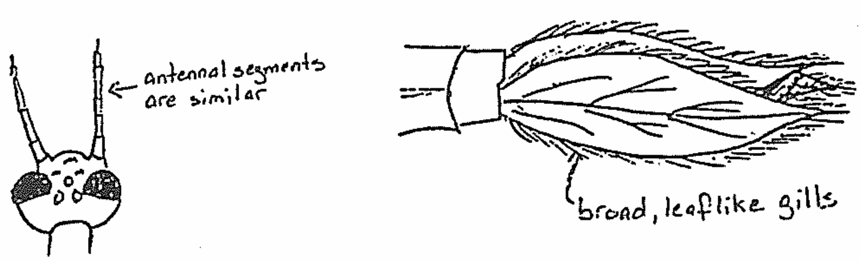
12(11)A. Long, slender body with long legs; first antennal segment is much longer than the other segments; caudal gills are long and slender with the outer gills being longer than the inner gill ……………………………………..…..……BROADWINGED DAMSELFLIES
Odonata (Zygoptera): Calopterygidae
INTOLERANT

B. Body is relatively short; antennae are made of segments of similar size; gills are broad and leaflike, and pointed at tips ……………………..NARROWWINGED DAMSELFLIES
Odonata (Zygoptera): Coenagrionidae
FAIRLY INTOLERANT
0.8 cm – 3.0 cm

12A.



12B.

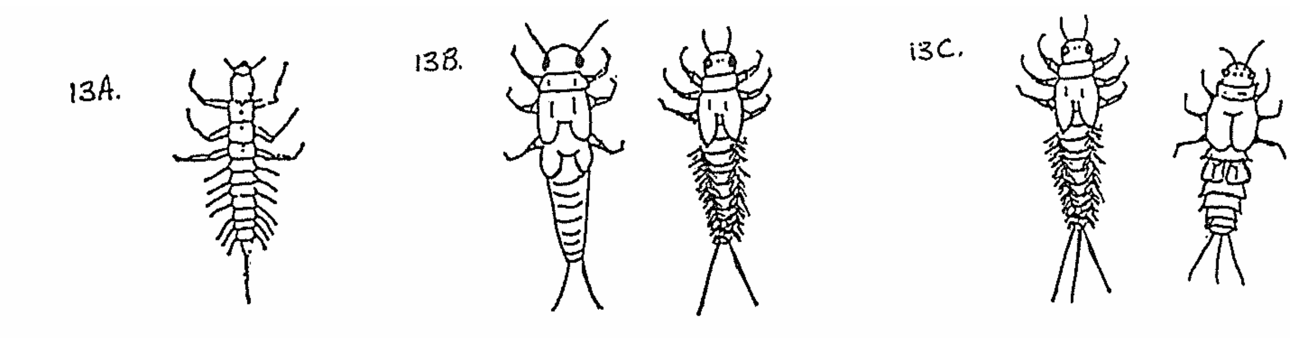


13(11)A. With 1 caudal filament; body brown or copper in color, head and “tail” lighter in color …………………………………………………………………...…ALDERFLIES
Megaloptera: Sialidae (*Sialis*)
INTOLERANT
2.0 cm – 2.5 cm

B. With 2 caudal filaments. STONEFLIES and OTHER MAYFLIES ……………..…..14

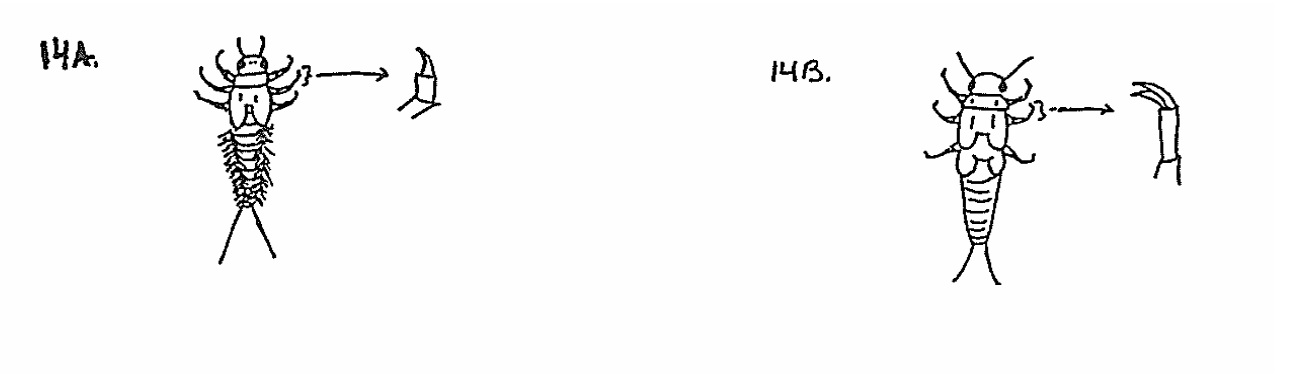
C. With 3 caudal filaments. MAYFLIES ………………………………...…………...15

NOTE: The caudal filaments of mayflies often break off easily; look for “tail stubs.” You will need a hand lens to see the tarsal claws.



14(13)A. One tarsal claw; gills present on abdominal segments; individuals are generally more flimsy……………………………………………………….……..…OTHER MAYFLIES
Ephemeroptera: Some members of the families Heptageniidae and Baetidae
SOMEWHAT INTOLERANT
0.5 cm – 2.0 cm

B. 2 tarsal claws; gills, if visible, are not located on abdomen; body tan, brown or yellow, sometimes patterned; size varies but most are robust……………………STONEFLIES
Plecoptera: Several families
INTOLERANT
0.5 cm – 4.5 cm

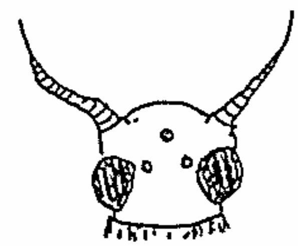


15(13)A. Mandibles modified into tusks (elongated past head); body creamy white, tan or with brown and white pattern; gills forked …………………..…..BURROWING MAYFLIES
Ephemeroptera: Ephemeridae, Potamanthidae Found in soft substrates burrowing in sand, mulch, silt, etc.
FAIRLY INTOLERANT.
1.0 cm – 3.3 cm

B. Without tusks ……………………………………………………………….…………..16

15A.

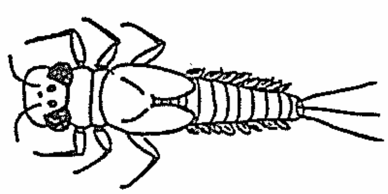
15B.



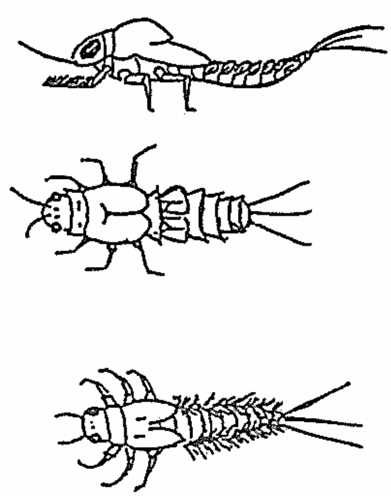
16(15)A. Body flattened dorsoventrally (top to bottom); eyes large and located on top of head ……………………………………………………………..CLINGING MAYFLIES
Ephemeroptera: Heptageniidae Tolerance ranges from intolerant to somewhat tolerant; three common genera (*Stenacron, Stenonema and Heptagenia*) are intolerant.
0.5 cm – 2.0 cm

B. Body not flattened dorsoventrally ………………………..………………………17

16A.



16B.

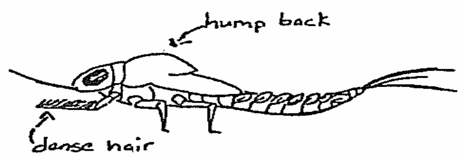


17(16)A. Body slightly compressed from side to side; thorax slightly humped; torpedo-shaped; front legs with a dense row of hairs …………………………TORPEDO MAYFLIES
Ephemeroptera: Oligoneuridae One of the swimming mayfly groups
INTOLERANT
1.0 cm – 2.5 cm

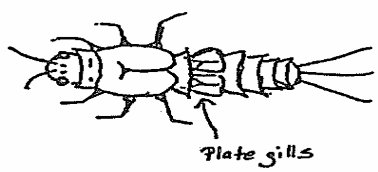
B. Body not compressed from side to side; front legs without a dense row of hairs; gills on abdomen resemble two plates ………………………………CRAWLING MAYFLIES
Ephemeroptera: Caenidae and Tricorythidae
FAIRLY INTOLERANT
0.5 cm – 1.5 cm

C. Body not compressed from side to side; front legs without a dense row of hairs; no plate gills on abdomen ……………………………..….………SWIMMING MAYFLIES
Ephemeroptera: Baetididae and Siphlonuridae
INTOLERANT
0.5 cm – 1.5 cm

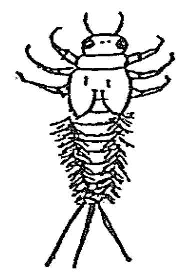
17 A.



17B.



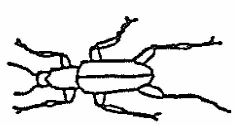
17C.



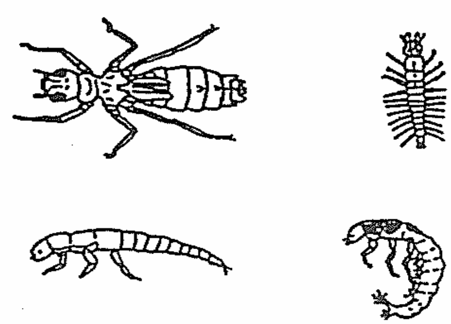
18(11)A. Entire body, including the front wings, is hard; small, dark beetles that are long and thin, or ovoid in shape …………………………..…….ADULT RIFFLE BEETLES
Coleoptera: Elmidae and Dryopidae
0.5 cm – 2.5 cm

B. Entire body not hard ……………………………………………………..……….19

18A.

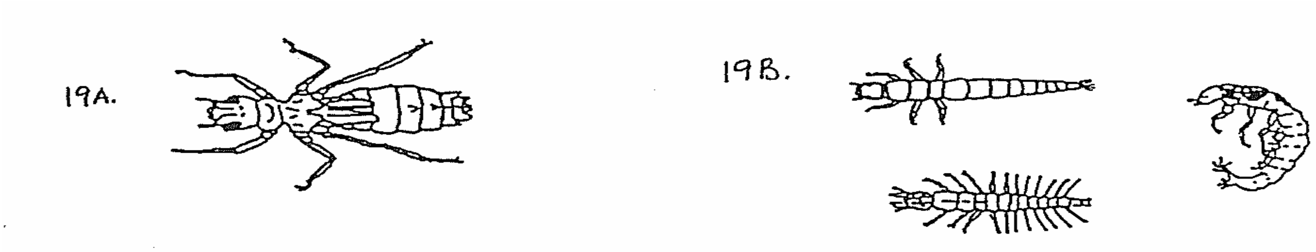


18B.



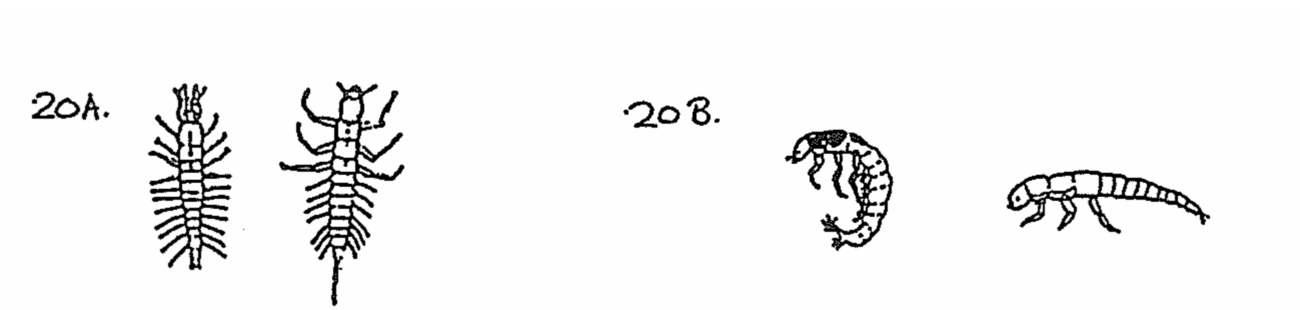
19(18)A. With external wing pads; lower jaw (labium) large, hinged and folded up on itself concealing other mouthparts …………………………………………..…..DRAGONFLIES
Dragonflies are seldom found in riffles, but may be found buried in soft sediments (e.g., sand, silt or mud) or in vegetation and detritus along the stream edge or in slightly slower waters.
Odonata: Anisoptera
FAIRLY INTOLERANT
1.2 cm – 6.0 cm

B. Without external wing pads; labium not hinged …………………………………..……20



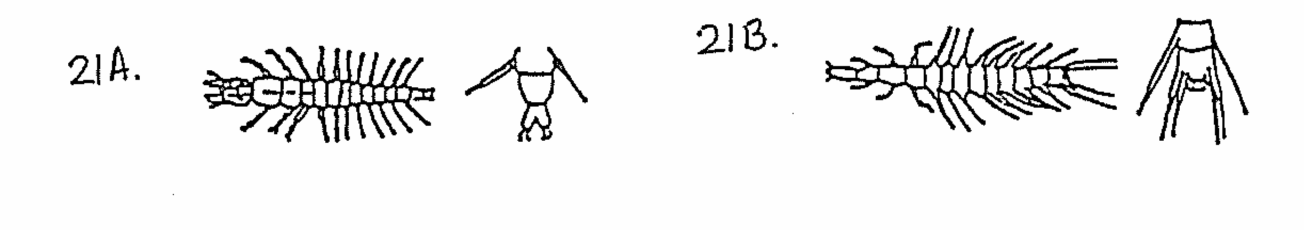
20(19)A. Abdomen with lateral appendages ………………………………………………..…..21

B. Abdomen without lateral appendages (ventral gills may be present) ………….……23



21(20)A. Lateral appendages long and thick; abdomen terminating in a single slender filament, or in prolegs, each with two terminal hooks; body dark brown to black; most are large, some to 10 cm long………..……………………………………..………………………..22

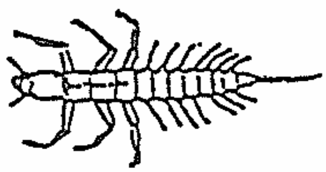
B. Lateral appendages long and thin, or short and thick; abdomen terminating in 2 slender filaments, or in a median proleg with 4 hooks; body lighter in color, tan, whitish or yellow; mostly smaller (< 2 cm long) ……………………………BEETLE LARVAE
Coleoptera: Gyrinidae (Whirligig Beetles)
INTOLERANT
0.7 cm – 3.5 cm



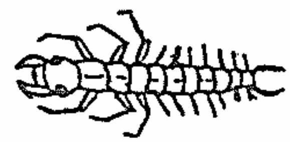
22(21)A. Abdomen with a single caudal filament ………………….…..ALDERFLY LARVAE
Megaloptera: Sialidae (*Sialis*)
INTOLERANT
2.0 cm – 2.5 cm

B. Abdomen with hooks on short appendages ……….…….DOBSONFLY LARVAE or HELLGRAMMITES
Megaloptera: Corydalidae One genus (*Corydalus*) has abdominal gill tufts under the lateral appendages.
INTOLERANT
3.0 cm – 8.0 cm

22A.



22B.

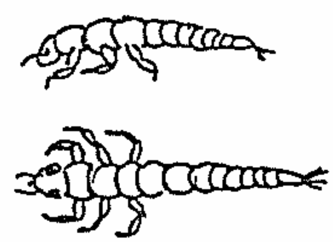


23(20)A. With hooks at end of abdomen; individuals often curl into a "C" shape when held or preserved; body color variable, but head usually brown or yellow; abdomen whitish, tan or green; pronotum (first dorsal thoracic segment) with a distinctly scleriterized plate; abdomen membranous and of a different color from thoracic plates; many build some sort of portable or stationary case of plant material, sand or pebbles
CADDISFLIES ………………………………………………………………..…..25

B. Without hooks at the end of the abdomen; no gill structures on abdomen; 6 true (segmented) legs on thorax and no prolegs on abdomen…………………………….24

23A.

23B.



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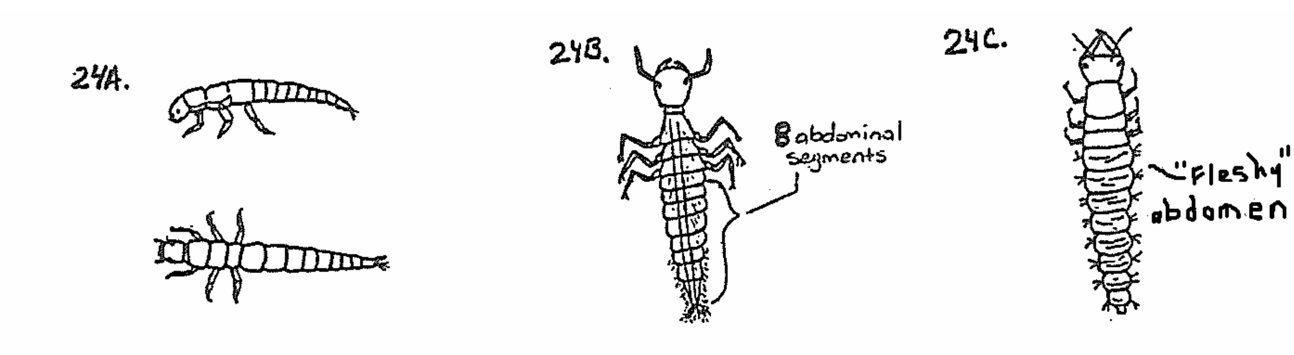
24(23)A. Thorax and abdomen are similar in width giving the organisms a "tube-like" shape; body brown, copper-colored or tan; body somewhat "leathery" in appearance……..RIFFLE BEETLE LARVAE

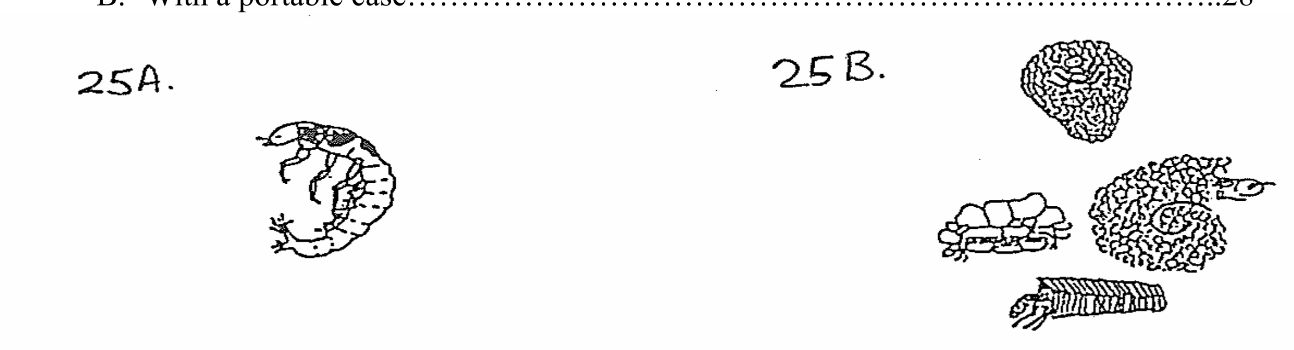
Coleoptera: Elmidae and Dryopidae Riffle beetle larvae resemble midge larvae and are about the same size but riffle beetle larvae are leathery rather than membranous and have segmented legs (true legs) on the abdomen.
FAIRLY INTOLERANT
1.0 cm – 1.8 cm

B. Body is "submarine-shaped;" abdomen made up of 8 segments; legs on thorax have 5 segments with two claws………………PREDACIOUS WATER BEETLE LARVAE
Coleoptera: Dyticidae
NOTE: No tolerance value is given for this family, but indicate the number of larvae you collected for trend assessment.
0.5 cm – 6.5 cm

C. Abdomen is largely membranous and wrinkled, sometimes with long filaments; mandibles are large and well developed; legs on thorax have 4 segments with one claw ……………………………………..…WATER SCAVENGER BEETLE LARVAE
Coleoptera: Hydrophilidae.
NOTE: No tolerance value is given for this family, but indicate the number of larvae you collected for trend assessment.
0.5 cm – 6.0 cm

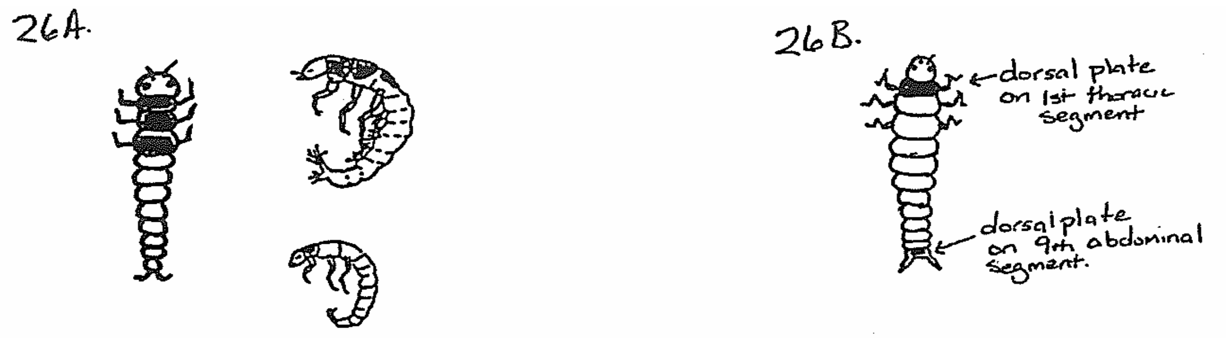


25(23)A. Without a portable case (some build stationary cases made of small rocks and sand) ………………………………………………………………………………………...26
B. With a portable case……………………………………………………………………..28



26(25)A. Head as wide as thorax; dorsal plates found either on the first thoracic segment or on all three thoracic segments; builds stationary cases of stone and sand on rocks………..27

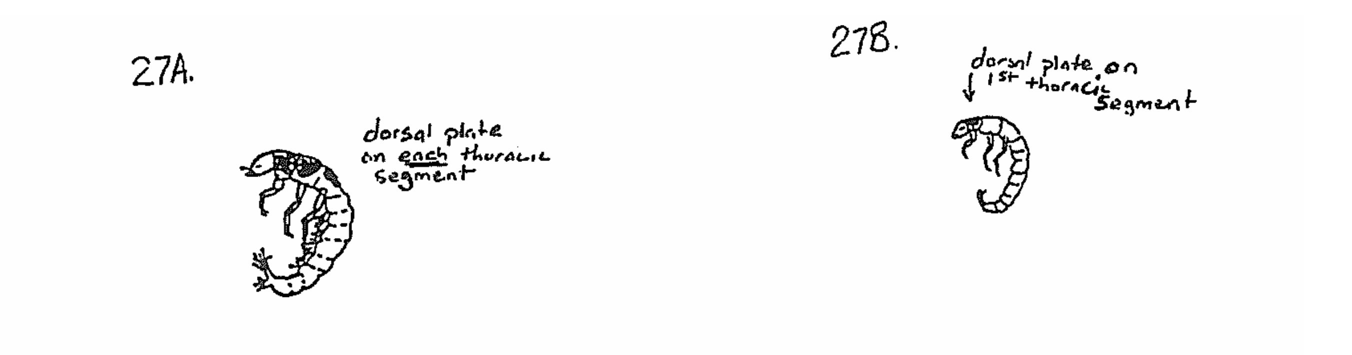
B. Head narrower than thorax; dorsal plates on first thoracic segment, and on last abdominal segment; free-living caddisfly; builds no case ………………OTHER CADDISFLIES
Trichoptera: Rhyacophilidae (Free-living caddisflies)
INTOLERANT
1.5 cm – 3.3 cm



27(26)A. Each thoracic segment with a single dorsal plate; abdomen with gills ventrally (on bottom); > 5 mm in length …………………………………….HYDROPSYCHIDAE
Trichoptera: Hydropsychidae Net spinning caddisflies
FAIRLY INTOLERANT
0.8 cm – 2.0 cm

NOTE: Microcaddisflies, which also have 3 dorsal plates on the thorax, resemble Hydropsychids when the former are out of their cases. Microcaddisflies are very small (mostly < 5 mm), lack abdominal gills, and their abdomens are swollen (larger than thorax). They build cases of silk which are sometimes covered with sand or other substrates.

B. Prothorax with a dorsal plate, mesonotum (second thoracic segment) and metanotum (third thoracic segment) partly or entirely membranous……OTHER CADDISFLIES
Trichoptera: Three families, Psychomyiidae, Philopotamidae and Polycentropodidae (Net-spinning caddisflies)
INTOLERANT
0.8 cm – 2.0 cm

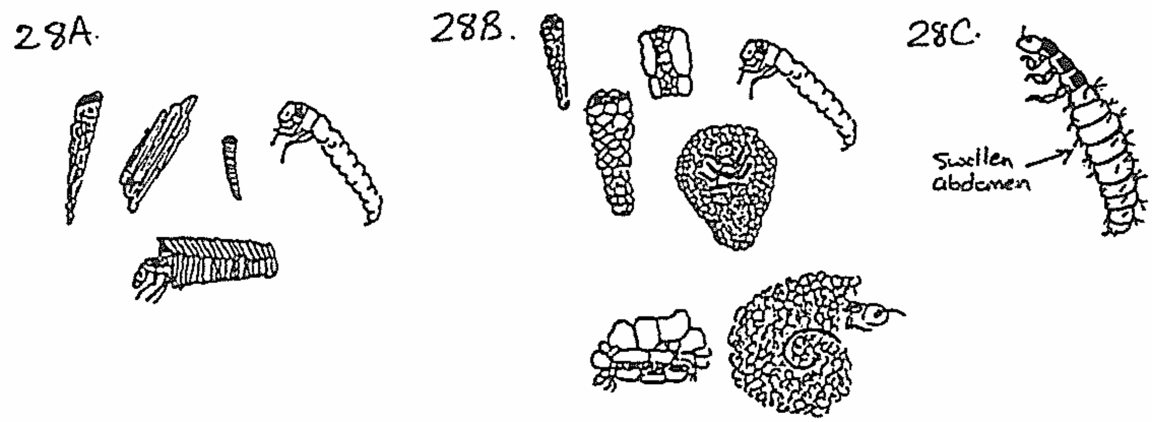


28(25)A. Case of organic detritus (e.g., small sticks, leaves) …………………………….………29

B. Case of sand or small stones …………………………………………………………30

NOTE: There are two groups of Tube-case Caddisflies, one builds organic tubes and the other mineral tubes.

C. Case of silk, may be covered with sand or organic material; animal very small (2-5 mm); each thoracic segment with a single dorsal plate; no ventral abdominal gills ………………………………………………………..…OTHER CADDISFLIES
Trichoptera: Hydroptilidae (Purse-case or Microcaddisflies) Resemble the Hydropsychidae but much smaller and without ventral abdominal gills.
INTOLERANT



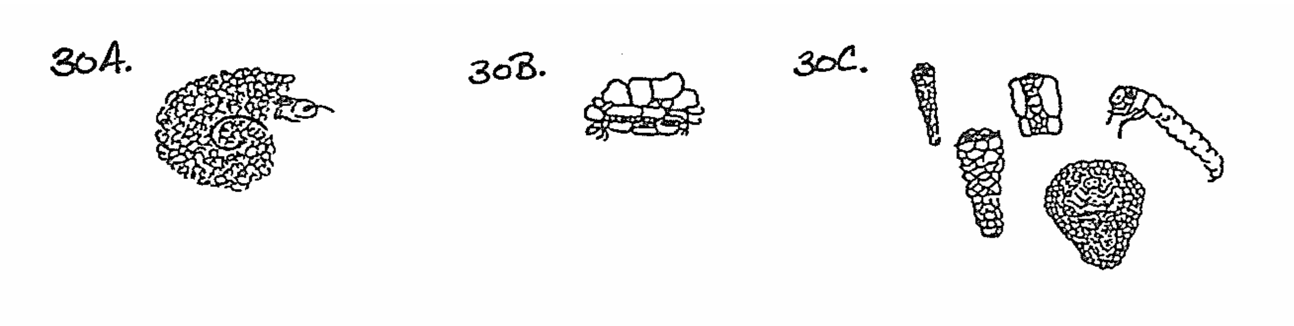
29(29)A. Case is square in cross section ……………………..…..……OTHER CADDISFLIES
Trichoptera: Brachycentridae (Brachycentrid Caddisflies)
INTOLERANT
0.8 cm – 1.3 cm

B. Case is cylindrical…………………………………………OTHER CADDISFLIES
Trichoptera: Leptoceridae, Phryganiidae, Limnephilidae, and Lepidostomatidae (Tube-case Caddisflies)
INTOLERANT
0.8 cm – 4.0 cm

30(28)A. Case shaped like a snail shell and made of sand ……..………OTHER CADDISFLIES
Trichoptera: Helicopsychidae (Snail-case Caddisflies)
INTOLERANT
0.5 cm

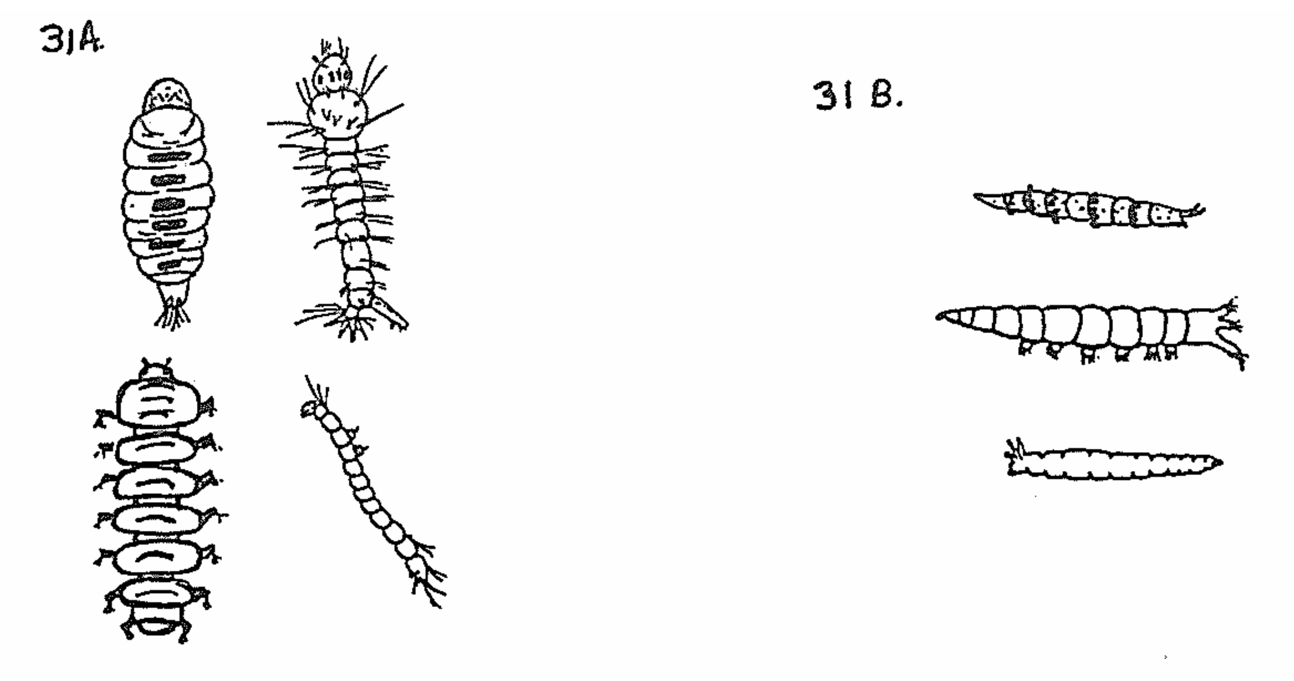
B. Case made of small stones and turtle-shell shaped (top is dome-shaped; underside is flat)……………………………………………………………OTHER CADDISFLIES
Trichoptera: Glossosmatidae (Saddle-case Caddisflies)
INTOLERANT
1.0 cm

C. Tube made of sand or stone, and shaped like a tube…………OTHER CADDISFLIES
Trichoptera: Three families: Molanidae, Limnephilidae, and Odontoceridae.
INTOLERANT
0.5 – 1.5 cm



31(8)A. Body with a distinct, visible head capsule……………………………..…………32

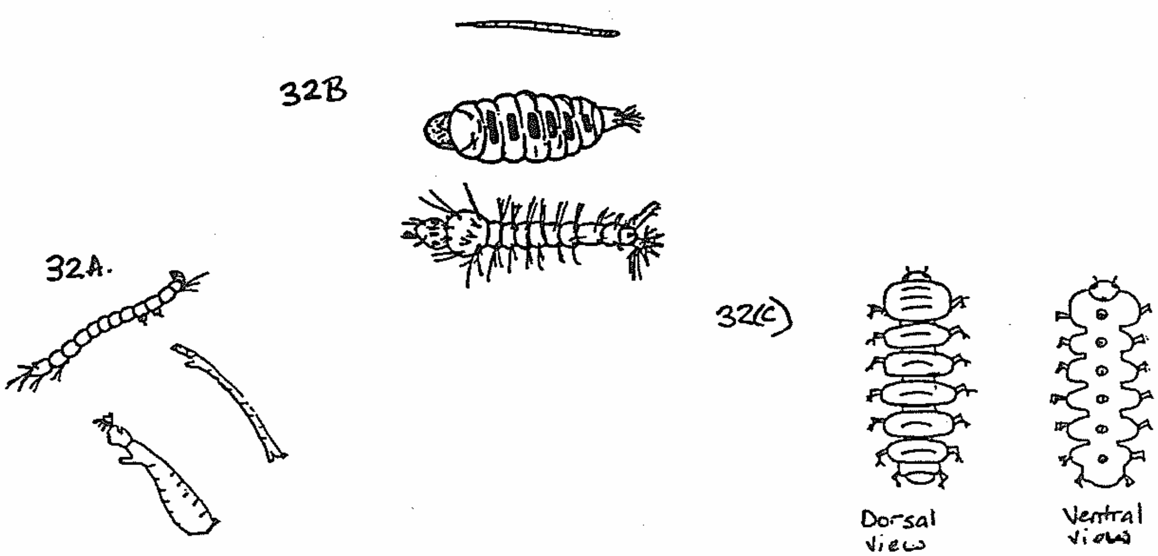
B. Body without a distinct head capsule or head capsule retracted……………………..36



32(31)A. Body with 1 or 2 pairs of prolegs either of which may appear as a single leg……………………………………………………………………………….…………35

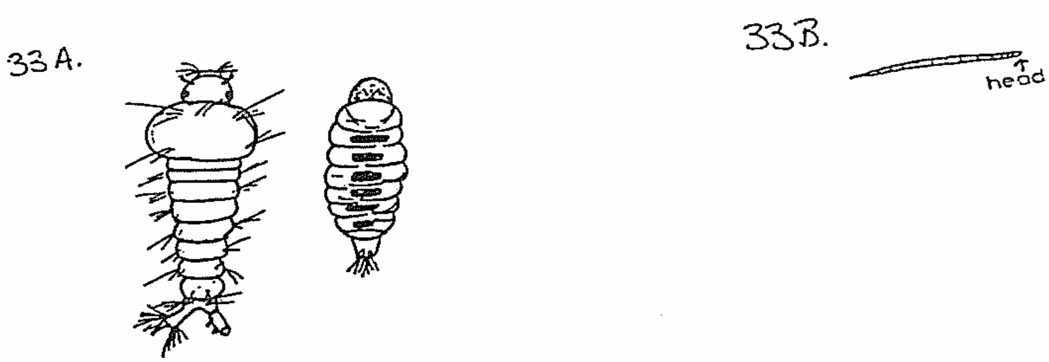
B. Body without prolegs…………………………………………………….…………..33

C. Body made up of 6 segments; with a row of "suckers" on the underside (ventral) of the body…………………………………………………….……………OTHER FLIES
Diptera: Blephariceridae (Net-winged midges)
0.5 cm – 1.3 cm



33(32)A. End of abdomen with a breathing tube or a tube-like process …………………….…..34

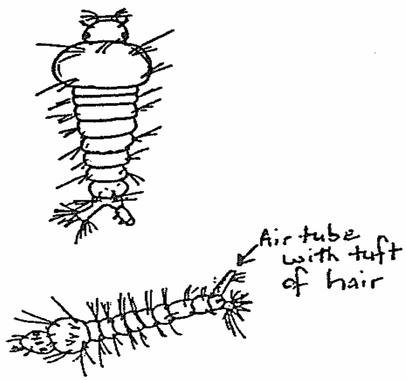
B. No breathing tube or tube-like process found at the end of abdomen. Body is straight and slender…………………………………………….…………….…BITING MIDGES
Diptera: Ceratopogonidae. Also known as "punkies" or "no-see-ums."
FAIRLY INTOLERANT
1.5 cm – 2.8 cm



34(33)A. Body segment behind head (or first thoracic segment) is enlarged. Tip of abdomen with a breathing tube and hair-like bristles……………………………………OTHER FLIES
Diptera: Culicidae (Mosquitoes)

B. Head is completely visible. Tip of abdomen with a large tube and a tuft of hair. Organism is small in size (under 4 mm). Dorsal plates can be found on each segment ………………………………………………………………………OTHER FLIES
Diptera: Psychodidae (Moth Flies)
0.5 cm

34A.



34B.

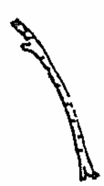
35(32)A. With 1 pair of anterior prolegs; abdomen with a distinct bulge posteriorly (abdomen is swollen at end); usually gray or mottled brown in color………………..BLACK FLIES
Diptera: Simuliidae Usually found in very fast moving water.
MODERATELY TOLERANT
0.5 cm – 1.5 cm

B. With 1 pair anterior (near head) and 1 pair posterior (on abdomen) prolegs; body tubular, width about equal throughout (no posterior bulge); color variable but usually white, green or red …………………………………………………………………………..37
Diptera: Chironomidae (True Midges)

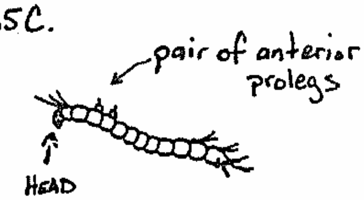
C. With 2 pairs of prolegs on body segments behind head. Tip of abdomen with two hair-fringed lobes and a tube-like process ……………………………….………OTHER FLIES
Diptera: Dixidae (Dixid Midges)
0.3 cm – 0.8 cm

35A.

35B.



35C.

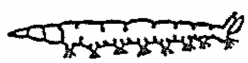


36(31)A. Body with tubercles (small thin tubes) on top (dorsal) and sides (lateral) of the body or abdomen. With 8 pairs of abdominal prolegs and a pair of long terminal appendages; head region is long in length ……………………………………..……………SNIPE FLIES
Diptera: Athericidae (*Atherix*)
FAIRLY INTOLERANT

B. Body without dorsal and lateral tubercles; with 8 or less pairs of prolegs; abdomen terminates in 1-4 rounded lobes tipped with short hairs ……………....OTHER FLIES
Diptera: Empipidae (Dance Flies)

C. With characteristics other than those listed in A; if prolegs are present, then without a pair of long terminal appendages and head is not long in length; prolegs may be lacking altogether……………………………………………………………………..….38

36A.

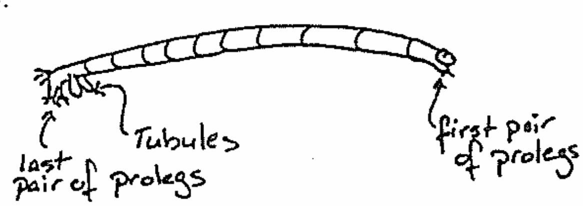


36B

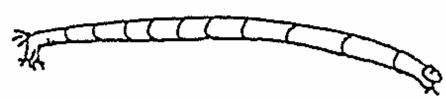
37(35)A. Body is red in color (may be clear or tan if organism is preserved); end of abdomen has four tubules positioned before the last pair of prolegs………………BLOOD WORMS
Diptera: Chironomidae
TOLERANT

B. Body is white or green in color; end of abdomen does not possess four tubules before last pair of prolegs…………………………………………..……..…….……MIDGES
Diptera: Other Chironomidae
MODERATELY TOLERANT

37A.



37B.

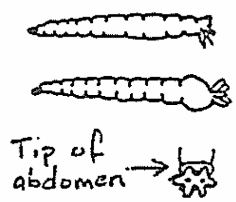


38(36)A. Head is small, dark and usually retracted into thorax; usually with 4 to 8 short tubes at one end (posterior, or on the abdomen) arranged in a circular pattern, although some generally have less than 4 tubes; body usually soft and membranous…….………CRANEFLIES
Diptera: Tipulidae
INTOLERANT

B. Head is small and fleshy (not dark) and not retracted into thorax; body appears leathery and yellow or brown and covered with tubercles (or bumps); tip of abdomen has lobes surrounding the spiracular disk at the tip…………………..………..OTHER FLIES
Diptera: Sciomyzidae (Marsh Flies)

C. Spindle-shaped body; no tubercles on end of abdomen; may have prolegs…………39

38A.



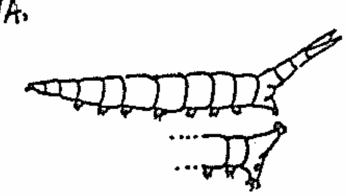
38B.

39(38)A. Possess prolegs and some type of caudal process which may be a long process extending from tip of abdomen, a fleshy bifurcated tail (split in two) or a tube-like structure…………………………………………………………………..OTHER FLIES
Diptera: Empididae (Dance Flies), Ephydridae (Shore Flies)
0.3 cm – 0.8 cm

B. Body is spindle-shaped with no type of structure on the tip of the abdomen. A "girdle" of false legs on each segment ……………………………………………..OTHER FLIES
Diptera: Tabanidae (Deer Flies and Horse Flies)
1.0 cm – 4.5 cm

C. Body does not have any characteristics listed above. May possess 2 suckers (one anterior and one posterior). May have eyespots…………………………..……………….…40

39A.



39 B.

40(39)A. Body segmented, thin and hairlike, not flattened; resemble earthworms…..AQUATIC WORMS

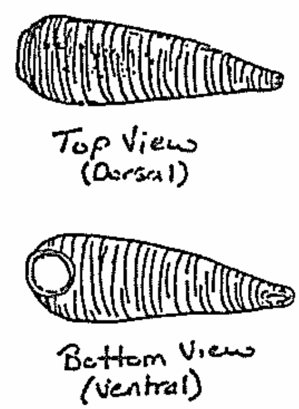
Annelida: Oligochaeta Better known as aquatic oligochaetes, they are related to the terrestrial earthworms.
TOLERANT
0.2 cm – 3.0 cm

B. Body flattened and indistinctly segmented (segmentation may not be seen); long or oval in shape; with anterior and posterior ventral suckers (suckers may be found on the bottom of the animal; one located at the head and the other at the end of the abdomen) ………………………………………………………………………………….LEECHES

Annelida: Hirudinea
MODERATELY INTOLERANT
0.5 cm – 4.0 cm

C. Body wide, flattened, and not segmented, often gray; visible eye spots……………………………………………………….…………….FLATWORMS

Platyhelminthes: Turbellaria
MODERATELY TOLERANT
0.5 cm – 2.5 cm



APPENDIX D
DATA SHEETS

STREAM NAME ____
COUNTY: ____
DATE: ____________________

Habitat Survey Sheet
Names ____

Start Time ________ **am pm**
(STT)

End Time _______ **am pm**
(ENT)

*Please circle the correct time period

PRESENT WEATHER (PRW)
______1. Clear/Sunny
______2. Overcast
______3. Showers (intermittent rain)
______4. Rain (steady rain)
______5. Storm (heavy rain)

WEATHER IN PAST 48 HOURS (WIP)
______1. Clear/Sunny
______2. Overcast
______3. Showers (intermittent rain)
______4. Rain (steady rain)
______5. Storm (heavy rain)

TEMPERATURE
Water _____°F °C (WTF or WTC)
Air _____°F °C (ATF or ATC)

Circle the unit of measurement.

WATER APPEARANCE (WAP)
______1. Clear
______2. Milky
______3. Foamy
______4. Dark Brown
______5. Oily Sheen
______6. Reddish
______7. Green
______8. Other _________________

WATER ODOR (WOD)
______1. None
______2. Sewage
______3. Chlorine
______4. Fishy
______5. Rotten Eggs
______6. Petroleum
______7. Other ___________________

TURBIDITY (TUR)
______1. Clear
______2. Slight
______3. Medium
______4. Heavy

Algal Growth (ALG) _____% of stream bottom covered

Are there Submerged Aquatic Plants? (SAP) Yes No (Circle)
Types? ____

List the types of the riparian (streamside) vegetation present at your stream site (RSV).

____

____

Estimate Canopy Cover (CNC). ______% of stream site shaded.

Bottom Substrate. Record percentage of each of the materials that make up the stream bottom. Note all that are present.

_____ Bedrock (BDK) _____ Cobble (2.5 in. – 10 in.) (CBB) _____ Sand (< 0.1 in.) (SND)
_____ Boulder (> 10 in) (BLD) _____ Gravel (0.1 in – 2.5 in.) (GRV) _____ Silt (SLT)
_____ Other (OBS) ______________________________

EMBEDDEDNESS (EMB) Check the description that best describes the percentage of gravel, cobble, and boulder surface covered by fine sediment or silt.

_____ 1. 0 to 25% _____ 2. 25 – 50% _____ 3. 50 – 75% _____4. 75 – 100%

Stream Discharge Estimate

Stream width (STW):___ feet
A

Depth Measurement
1. _____ feet
2. _____ feet
3. _____ feet

Velocity Calculation
10 ft ÷ _____ seconds = _____ ft/sec
10 ft ÷ _____ seconds = _____ ft/sec
10 ft ÷ _____ seconds = _____ ft/sec

Average Depth _____ feet
(ASC) B

Average Velocity _____ ft/sec
(ASV) C

Discharge (width x depth x velocity) ______ feet x ______ feet x _____ ft/sec = ______ ft^3/sec
A B C (SDG)

Watershed Features

Indicate whether the following land uses are dominant (D) or occur in just small areas (x) upstream and surrounding your stream site. If a listed land use is not present, leave blank.

	Forest		Logging		Golf Course
	Grassland		Ungrazed Fields		Commercial/Industrial
	Scattered Residential		Urban		Cropland
	Sewage Treatment		Park		Mining
	Sanitary Landfill		Livestock Pasture		Housing Construction

Upstream Dam? Yes No If Yes, how far upstream is the dam? ___________________________
Wastewater treatment discharge upstream? Yes No If Yes, How far upstream? ______________
Any pipes emptying directly into or near your study site? Yes No
Channel Alteration. Has the stream been channelized (straightened) at your study site? Yes No
If Yes, what percentage of your study site has been channelized? ______%

Habitat Survey Notes (include sediment odors, appearance, and/or the presence of silt, watershed features present but not used on this data sheet, and any other information you feel is important or interesting to mention):

Biological Survey Sheet

STREAM NAME ____________________________
COUNTY: ______________________________
DATE: ________________________________

Which two habitats did you sample? (Check the two answers that apply.)

1. RIFFLES ______2. LEAF PACKS ______3. SNAG AREAS, ETC. _______ 4. UNDERCUT BANKS _____
5. SEDIMENT ______

MACROINVERTEBRATES OF SPECIAL INTEREST

Indicate whether or not you noticed any of the following organisms at your stream site by circling YES or NO.

NATIVE MUSSELS	YES	NO
ZEBRA MUSSELS	YES	NO
FINGERNAIL CLAMS	YES	NO
ASIATIC CLAMS	YES	NO
RUSTY CRAYFISH	YES	NO

SUBSAMPLING PROCEDURE

NOTE: If you collect 100 or less organisms, there is no need to subsample. Simply preserve the whole sample. If you collect more than an estimated 100 organisms, then proceed with subsampling procedures. Use the subsampling grid below to help you.

1 ________	**2** ________	**3** ________	**4** ________
5 ________	**6** ________	**7** ________	**8** ________
9 ________	**10** ________	**11** ________	**12** ________

A. Total # of Organisms Subsampled: ___________

B. # of Squares Selected: ______________

C. Organisms per Square (A÷B): ____________ organisms/square

D. Organisms in Tray (C x 9 OR C X 12): ___________ organisms/tray
(TRY)

MACROINVERTEBRATE IDENTIFICATION

ORGANISM	N	T_i	T_v
Flatworm		6.0	
Aquatic Worm		10.0	
Leech		8.0	
Sowbug		6.0	
Scud		4.0	
Dragonfly		4.5	
Broadwinged Damselfly		3.5	
Narrowwinged Damselfly		5.5	
Hellgrammite		3.5	
Torpedo Mayfly		3.0	
Swimming Mayfly		4.0	
Clinging Mayfly		3.5	
Crawling Mayfly		5.5	
Burrowing Mayfly		5.0	
Other Mayfly		3.0	
Stonefly		1.5	
Hydropsychid Caddisfly		5.5	
Non-Hydropsychid Caddisfly		3.5	
Riffle Beetle		5.0	
Whirligig Beetle		4.0	
Water Penny Beetle		4.0	
Crane Fly		4.0	
Biting Midge		5.0	
Bloodworm		11.0	
Midge		6.0	
Black Fly		6.0	
Snipe Fly		4.0	
Other Fly		10.0	
Left-Handed Snail		9.0	
Right-Handed Snail		7.0	
Planorbid Snail		6.5	
Limpet		7.0	
Operculate Snail		6.0	
TOTALS			
TAXA = ________	ΣN		ΣT_v

MBI = $\Sigma T_v \div \Sigma N$ = $\boxed{}$

< 6.0 = GOOD Water Quality
6.1 – 7.5 = FAIR Water Quality
7.6 – 8.9 = POOR Water Quality
> or = 9.0 = VERY POOR Water Quality

SAMPLE DENSITY = ΣN = $\boxed{}$

TAXA RICHNESS = ΣTAXA = $\boxed{}$

PERCENT COMPOSITION OF INDICATOR ORGANISMS

ORGANISM	N	÷	ΣN	X 100 =	%C
MAYFLIES		÷		X 100 =	
STONEFLIES		÷		X 100 =	
CADDISFLIES		÷		X 100 =	
BLOODWORMS		÷		X 100 =	
AQUATIC WORMS		÷		X 100 =	

SUBTOTAL % = ________

% ALL OTHERS (100% - SUBTOTAL %) = __________

NOTES:

Site Sketch Sheet

STREAM NAME ___________________________
COUNTY: ________________________________
DATE: ___________________________________

Sketch an aerial view of your 200 foot stream site. Be sure to mark the direction of North and the direction of stream flow. Indicate features such as riffles, runs, pools, ditches, wetlands, dams, riprap, tributaries, landscape features, vegetation, and roads. Also indicate where macroinvertebrates were collected in the stream site. Write notes and observations below the sketch or on back.