Alice Ferguson Foundation's

# BRIDGING THE WATERSHED

# WATER CANARIES

## Assessing Benthic Macroinvertebrates

An outreach program of the Alice Ferguson Foundation in partnership with the National Park Service and area schools that offers secondary school students opportunities to study real-world science in national parks.

Teacher's Guide
& Resources

# WATER CANARIES

## Assessing Benthic Macroinvertebrates

### Teacher's Guide & Resources

Alice Ferguson Foundation, 2001 Bryan Point Road, Accokeek, Maryland 20607
Phone: 301-292-5665 • Email: btwinquiries@fergusonfoundation.org • www.fergusonfoundation.org

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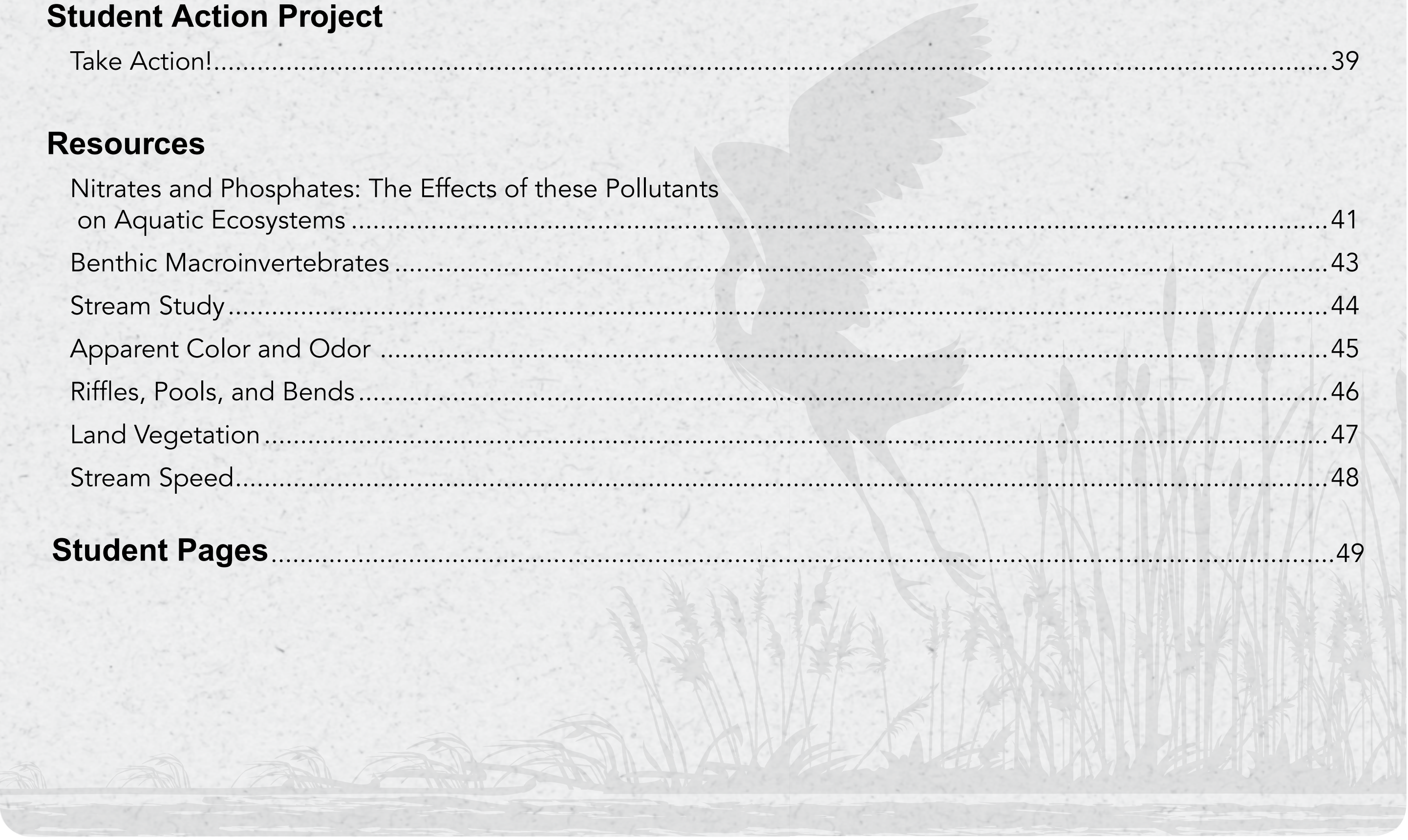


# MODULE ORGANIZER

This module is divided into three sections: activities completed prior to the park visit (Pre-Field Study), activities conducted in the park (Field Study), and activities completed subsequent to the park visit (Post-Field Study). In the Pre-Field Study activities, students learn about benthic macroinvertebrates and how to identify them in an online interactive activity. Once in the park, students will be able to use identification skills to collect macroinvertebrates from a river or stream. They will learn how certain macroinvertebrates can indicate levels of stream pollution. In the context of collecting authentic data in the park, students gain a deeper understanding of the connection between the choices they make and the water quality in their watershed. When students return to the classroom, they will reflect on their visit to the park and compile a group report that will summarize the data collected. Students will also engage in an activity to understand how the trends in populations of various organisms in the Chesapeake Bay watershed are used to monitor the health of an ecosystem.

Note: The teacher guide includes all the lessons, including student sheets. The student materials are included with the supplementary materials and can be printed out as needed.

| TITLE | GOAL(S) | MATERIALS LIST |
|---|---|---|
| PRE-FIELD STUDY | | |
| **Macroinvertebrate ID** | • To learn how to identify macroinvertebrates.<br>• To understand how benthic macroinvertebrates can be used as biological indicators of water quality. | • Computers with Internet access<br>• PowerPoint presentation worksheets<br>• Dichotomous keys |
| **Make-a-Macro** | • To apply understanding of macroinvertebrate adaptations to a critter of student's own design. | • Make-a-Macro cards<br>• Glue<br>• Scissors<br>• Student sheet for describing macro and the conditions under which it will thrive |
| **Macroinvertebrate Mayhem** | • To simulate the effects of environmental stressors on macroinvertebrate populations. | • Identification labels for macroinvertebrate groups<br>• Pillowcases<br>• Paper<br>• Marking pen |
| FIELD STUDY | | |
| **Macroinvertebrates: Collect, Classify, and Count** | To assess water quality by collecting, classifying, and counting, macroinvertebrates found in a stream. | • Appropriate clothing<br>• Adequate food and drink<br>• All other materials will be provided |
| POST-FIELD STUDY | | |
| **Data Analysis** | • To compute the index value of the stream you studied using group data.<br>• To calculate the average index value of the stream using all class data. | • Computer with Internet access |
| **Potomac Confidential** | • To understand how the presence of certain organisms can give us information about the health of the environment. | Each student needs:<br>• Copy of Potomac Confidential graphic novel<br>• Pencil/colored pencils to complete the story |

| | | |
|---|---|---|
| **Now You See Them; Now You Don't** | • To assess the health of three sites on the Potomac River.<br>• To relate macroinvertebrate populations to the degradation of benthic habitat in the Chesapeake Bay watershed.<br>• Using FieldScope, consider implications of a chemical spill and its impact on macroinvertebrates in the Potomac. | • Computer with Internet access<br>• Data sheets from field study |
| **Student Action Project: Take Action!** | To increase awareness of the need for individual environmental action. | Computer with Internet access |
| RESOURCES | | |
| These resources will provide additional information on the subjects of all the activities. Teachers may use them as a personal reference, or may assign them to students as further reading. | | |

NOTE: The overview module, "Potomac River Watershed: Water, Water, Everywhere" contains several activities that introduce the concept of a watershed and nonpoint source pollution that are excellent supplements to this module. "Who Polluted the Potomac?" also in the overview module, provides the basic understanding of nonpoint source pollution.

# Introduction to Water Canaries

## BACKGROUND INFORMATION:

This module and the field study in the park are designed to heighten students' awareness about the watershed in which they live and help them understand the important role they play in its health. The title of this module, Water Canaries, refers to the use of various insects that live out part of their life cycles in water to indicate stream pollution in the same way that coal miners once used canaries to indicate the presence of poisonous gases in the mines. Because the canaries were more sensitive to the gases than humans, they would collapse and die before the miners, warning them of imminent danger. In the aquatic environment, many insects begin their lives as larvae or nymphs before they emerge as terrestrial organisms. Such insects are known as benthic macroinvertebrates - bottom-dwelling organisms without backbones that are large enough to see with the naked eye.

### Goal:

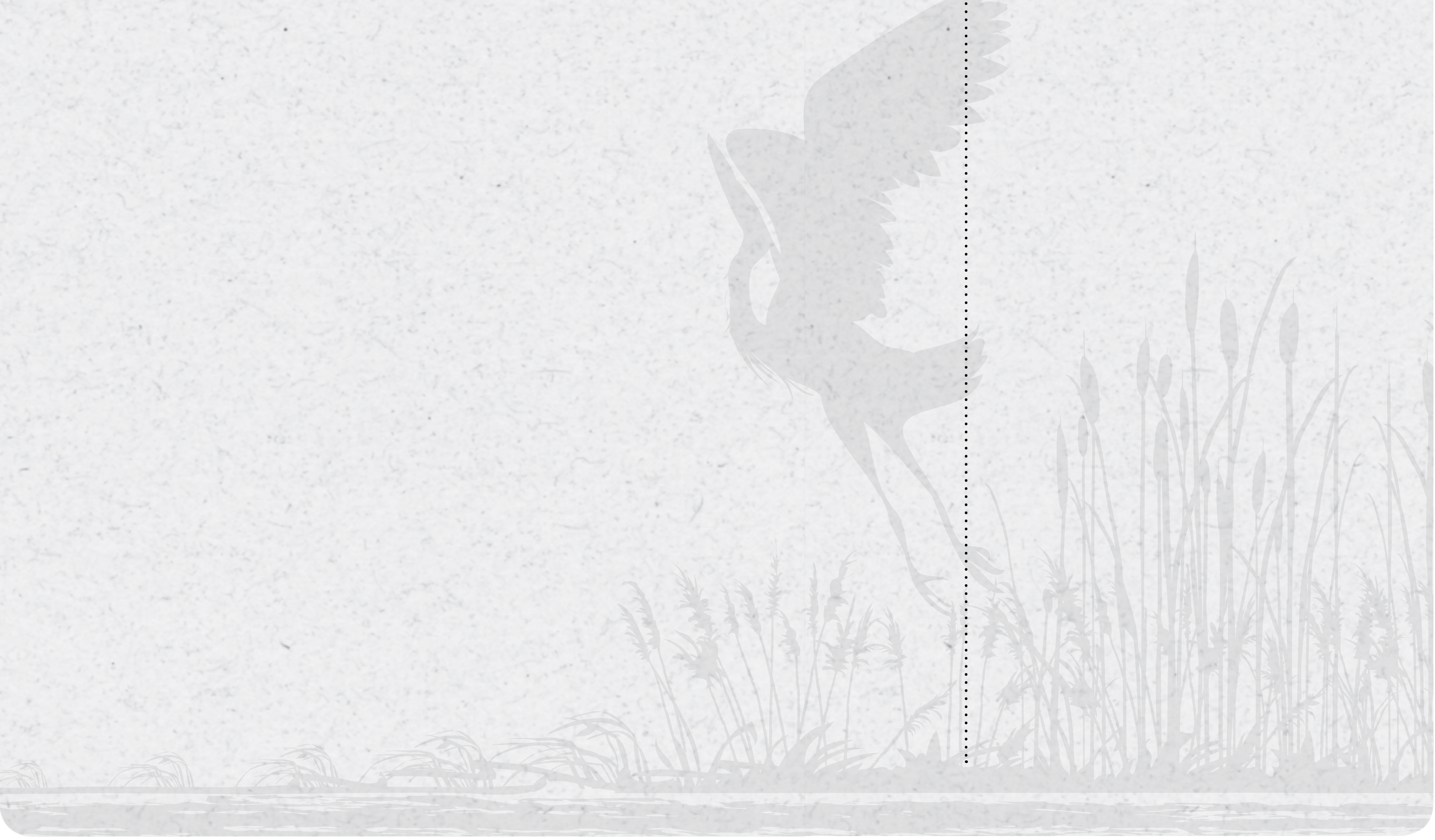
To learn the scientific concepts and activities in this module.

### Class Time:

20 minutes

### Materials:

- Potomac River watershed map
- Use crumpled paper watershed activity, watershed address, and/or FieldScope to introduce concept of watersheds
- The Resources section contains reference material needed to complete the activities
- Review the Bridging the Watershed website at fergusonfoundation.org



# Macroinvertebrate Identification

## EXPLORATION

### BACKGROUND INFORMATION:

Students will be collecting, counting, and classifying macroinvertebrates during their park visit. It is essential that students be familiar with the macroinvertebrates they may find in the park stream, how to identify them, and their relative sensitivities to pollution. The more students know about the macroinvertebrates, the more comfortable they will be handling the organisms, resulting in better data collection, and a more enjoyable and rewarding experience.

Identification of macroinvertebrates is a skill that takes time and practice to develop. This activity, either online or in class with a PowerPoint, will familiarize students with many organisms and how to classify them. Successful identification relies on the skill to quickly observe the most dominant physical features of organisms. The PowerPoint version of the activity, in particular, is intended to assist students with making quick observations that will help them with identification later.

### IMPORTANCE OF OBSERVATION

Observation is a vital skill and very important for macroinvertebrate identification. Many of the macroinvertebrates are quite small. Although visible to the unaided eye, one needs to develop a discriminating eye to pick out key features.

Another obvious reason for careful observation is the simple fact that these organisms are living and therefore actively moving. Encourage the students to look for generalized, broader characteristics. Time is of the essence and is limited in the PowerPoint ID activity.

### PROCEDURE:

1. Visit fergusonfoundation.org/btw/btw_students.shtml.
2. Click on "Student."
3. Click on "Macroinvertebrate ID Activity."
4. Complete the activity. (Students should complete Macroinvertebrate ID for both Lazy Branch and Scrubby Creek.)
5. Refer to "Benthic Macroinvertebrates" in the Resources section and the Macroinvertebrate Survey Data Sheets in the Student Booklet.

   Additional guidance provided in online activity.

### Goals:

- To learn how to identify macroinvertebrates.

### Class Time:

One Class Period

### Group Size:

This lesson can be approached either as a self-directed activity where students, either individually or in groups of two, work through an online dichotomous key.

It can also be approached as a whole group activity in which you lead students through a PowerPoint presentation.

### Materials:

For the teacher–led activity, your class will need the following:

- Macroinvertebrate ID PowerPoint
- A Macroinvertebrate ID worksheet for each group or for each student, if they are doing this individually (sample attached for teacher guide)
- Pencils
- Dichotomous key per group
- Total Index Value data sheet

For the student-led macroinvertebrate online activity:

Go to fergusonfoundation.org/btw/btw_students.shtml, click on interactive lessons, then click on macroinvertebrate **identification.**

# Macroinvertebrate Identification

## EXPLORATION

### PROCEDURE FOR POWERPOINT:

1. Have the students observe the slide "Macroinvertebrate Identification Worksheet." Explain that they will have only 2 minutes to observe and make quick notes and/or sketches to use later on in identifying 15 unknown benthic macroinvertebrates. During the first practice slide, students should focus their observations on a few physical characteristics of benthic macroinvertebrates: body shape, legs, tails, and gills.

**SPECIAL NOTE:**

Students often jump to the end of the key to look for an organism by its picture. This leads to errors in identification due to similarities between organisms.

### WHAT TO OBSERVE:

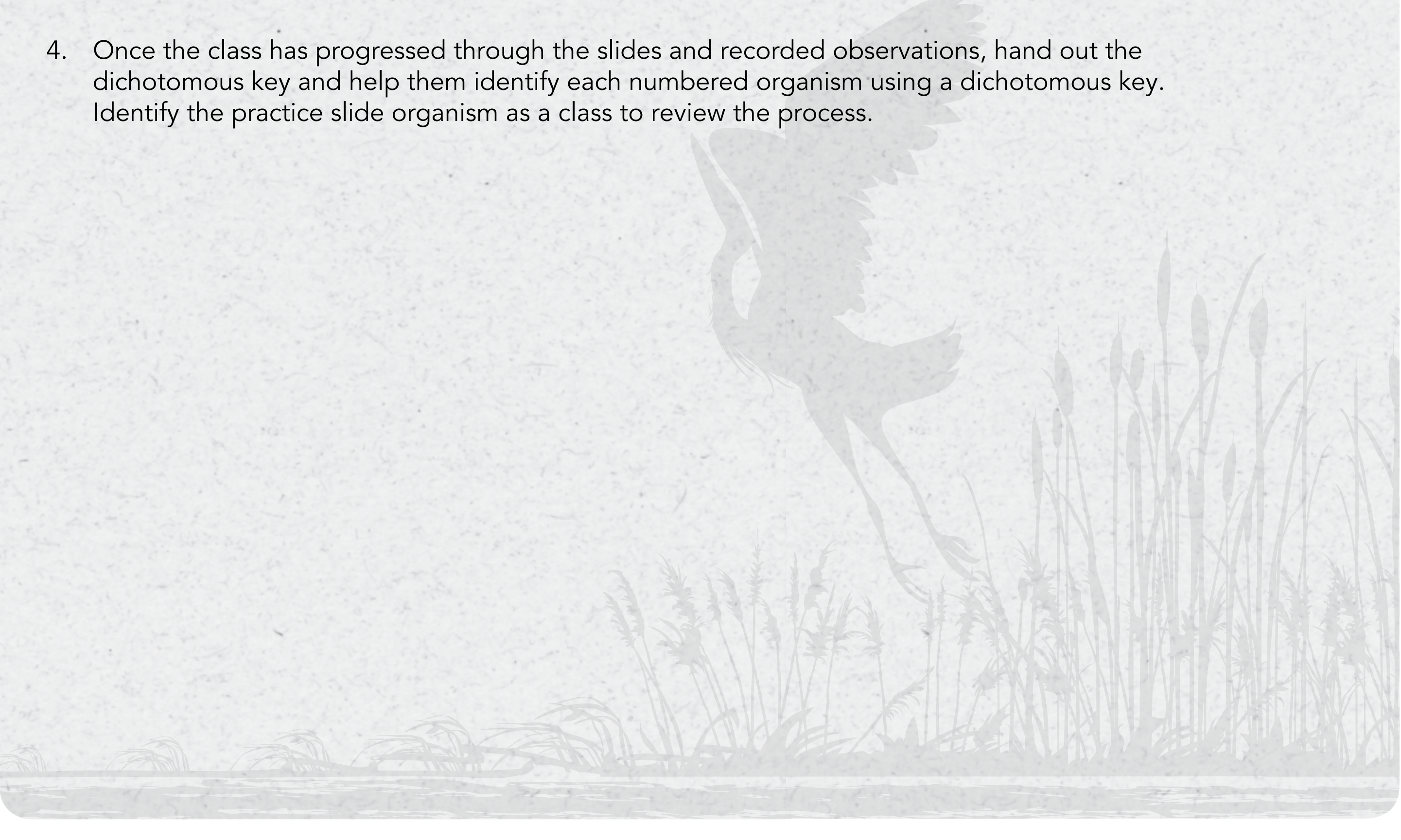
2. On the practice slide, direct the students' attention to the key characteristics listed on the worksheet (body shape, legs, tails, gills, and other noticeable features). Remind students that they should focus on creating sketches that are rough graphical reminders of body shape, legs, tails, gills, or other features, not on drawing perfect works of art.

   Some slides have more than one picture of a type of macroinvertebrate. Students should focus on only one picture, but you should inform them that there are variations within the same animal species.

### IDENTIFICATION PROCESS:

3. Start the PowerPoint, which will automatically shift to the next slide after two minutes.

4. Once the class has progressed through the slides and recorded observations, hand out the dichotomous key and help them identify each numbered organism using a dichotomous key. Identify the practice slide organism as a class to review the process.



# Macroinvertebrate Identification

## EXPLORATION

### MACROINVERTEBRATE IDENTIFICATION CHART

| Characteristics | | | Drawing |
|---|---|---|---|
| Ex. | Body Shape | | |
| | Legs | | |
| | Tail | | |
| | Other | | |

| Characteristics | | | Drawing |
|---|---|---|---|
| Ex. | Body Shape | | |
| | Legs | | |
| | Tail | | |
| | Other | | |

| Characteristics | | | Drawing |
|---|---|---|---|
| Ex. | Body Shape | | |
| | Legs | | |
| | Tail | | |
| | Other | | |

# Make-A-Macro

## EXPLORATION

## BACKGROUND INFORMATION

**What is an Adaptation?**

Adaptations are characteristics that are outcomes of natural selection, and increase chances of survival and reproduction. Adaptations can be physiological (body parts), behavioral (actions that increase survival), or structural (other physical features that aid survival).

**Example of an Adaptation:**

Benthic macroinvertebrates have an array of structural adaptations that aid in their survival. Black fly larvae, for instance, have little feather brushes on their heads that help them collect food. Whirligig beetles have eyes divided horizontally so they can see both on top of and below the water line. The water boatman paddles underwater with long, oar-like legs, covered in hairy fringe, which spread out on the forward stroke and fold in on the return. This allows it to get the most power out of the forward stroke and reduce drag on the recovery.

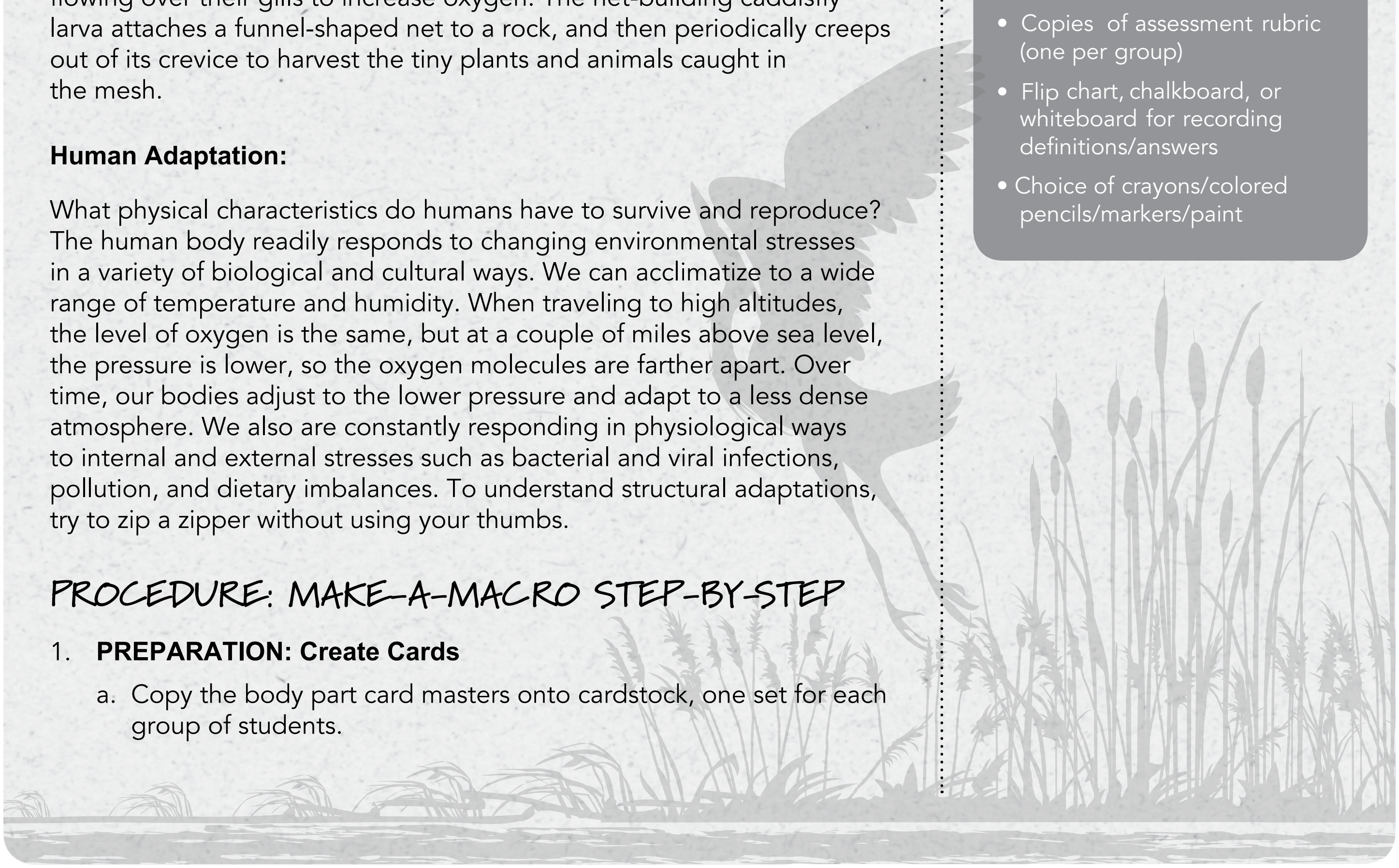
Benthic macroinvertebrates have a range of behavioral adaptations critical to their survival as well. When water gets too warm and oxygen levels decrease, stoneflies will do “push-ups” to increase the amount of water flowing over their gills to increase oxygen. The net-building caddisfly larva attaches a funnel-shaped net to a rock, and then periodically creeps out of its crevice to harvest the tiny plants and animals caught in the mesh.

**Human Adaptation:**

What physical characteristics do humans have to survive and reproduce? The human body readily responds to changing environmental stresses in a variety of biological and cultural ways. We can acclimatize to a wide range of temperature and humidity. When traveling to high altitudes, the level of oxygen is the same, but at a couple of miles above sea level, the pressure is lower, so the oxygen molecules are farther apart. Over time, our bodies adjust to the lower pressure and adapt to a less dense atmosphere. We also are constantly responding in physiological ways to internal and external stresses such as bacterial and viral infections, pollution, and dietary imbalances. To understand structural adaptations, try to zip a zipper without using your thumbs.

## PROCEDURE: MAKE-A-MACRO STEP-BY-STEP

1. **PREPARATION: Create Cards**
    a. Copy the body part card masters onto cardstock, one set for each group of students.



### Goal:

To apply understanding of macroinvertebrate adaptations to design the ultimate macroinvertebrate.

### Class Time:

One class period; two class periods for students needing more background instruction time

### Group Size:

3-4 students per group

### Materials List:

- 1 set of macroinvertebrate adaptation cards per group
- Scissors for cutting out the macroinvertebrate body parts
- Glue
- Copies of assessment rubric (one per group)
- Flip chart, chalkboard, or whiteboard for recording definitions/answers
- Choice of crayons/colored pencils/markers/paint

   b. Cut the cards apart. Have them create a new macroinvertebrate from the cards. Based on what they learned in the macroinvertebrate PowerPoint or online activity, have them describe the conditions under which their macroinvertebrate will thrive.

2. PRESENTATIONS

   a. Each group will present its macroinvertebrate to the class.

   b. Each group should identify and explain its macro, including its name, what adaptations are present, how it has adapted to its environment, and what adaptations are important to its survival.

3. EXTENSION/HOMEWORK

   a. Ask students to research the life history of a specific macroinvertebrate of their choice. Many of them are juvenile forms of insects.

   b. How are they adapted for where they live and what they eat? How would a sudden change of habitat affect them?

   c. Investigate how some macroinvertebrates got their names. For example, why is a dragonfly larvae called a "dragon" fly? Explore the scientific names of various macroinvertebrates.

### SUGGESTED ADAPTATIONS:

- Have more physically active students pantomime and verbally explain the adaptations of their invented macroinvertebrate instead of drawing and writing.

  For students who need extra instruction split this into two class periods. Students can create their own macroinvertebrate in the first period and then describe its adaptations during the second class period.

- If students are having difficulty grasping the concept of adaptations, show them pictures of animals which have obvious adaptations:

  Giraffe → long neck → allows it to eat leaves from tall trees

  Zebra → stripes → camouflages in tall grasses

  Owl → large eyes → helps it to see prey at night

# Make-A-Macro

## EXPLORATION

Group Members/Name: ______________________________________________

Date:________________

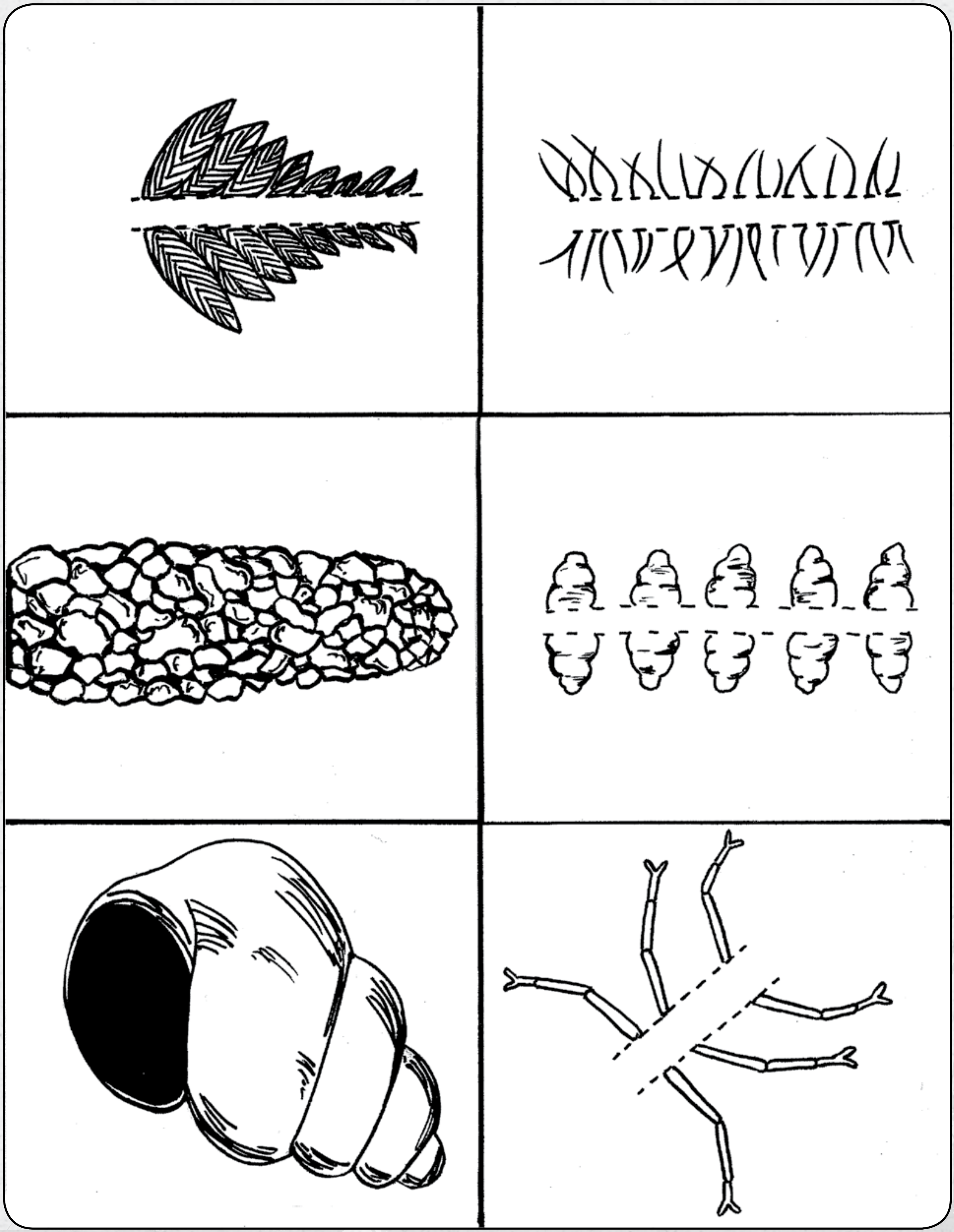
Your group is to create an original, fictitious macroinvertebrate that has all of the body parts on the cards you randomly selected. You'll need to select parts to complete your macro, and then provide an explanation that includes where your macro lives, what it needs in its habitat to survive, and how its various body parts help it to compete. Your group will be assessed based upon the criteria in the following rubric.

### RUBRIC FOR MAKE-A-MACRO

| CRITERIA | 3 | 2 | 1 | 0 |
|---|---|---|---|---|
| **Adaptations are present and explained in picture.** | All adaptations and explanations are present in picture. | Missing one or two adaptations and/ or explanations in picture. | Missing more than 2 adaptations and/ or explanations in picture. | Adaptations and/ or explanations are absent in picture. |
| **Name of macroinvertebrate and reasoning for name.** | Name and reasoning for name are present and well-explained. | Name and reasoning for a name is present but not well-explained. | Just name is present; reasoning for name is absent. | Name and reasoning for name are absent. |
| **How has the macroinvertebrate adapted to the environment?** | Description for adaptation is detailed and supported with reason. | Description for adaptation is fair and somewhat supported. | Description for adaptation is weak and not well-supported. | Description for adaptation to environment is absent. |
| **How are the adaptations important to their survival?** | Importance of adaptation is detailed and supported with reason. | Importance of adaptation is fair and somewhat supported. | Importance of adaptation is weak and not well-supported. | Importance of adaptation is absent. |

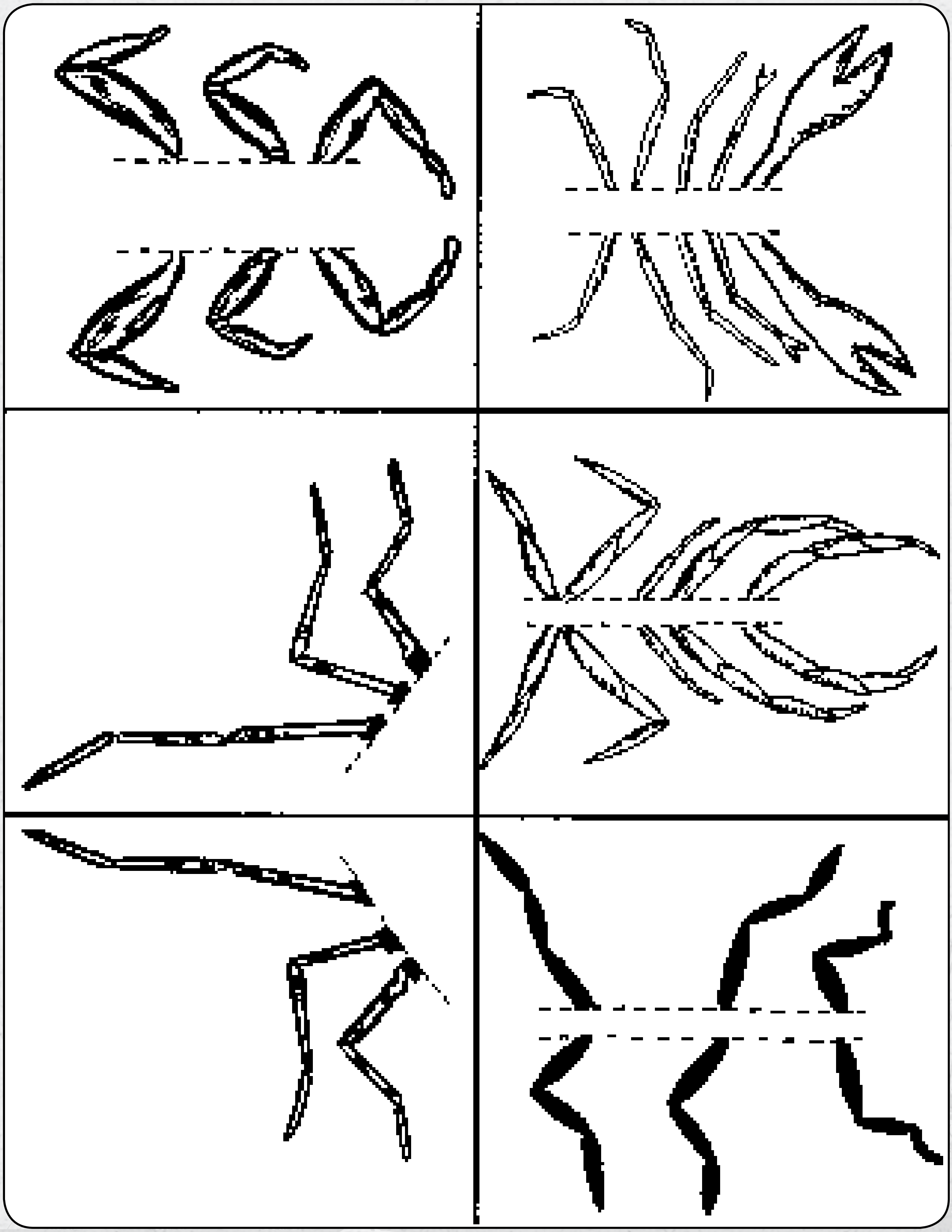
# Make-A-Macro

## EXPLORATION



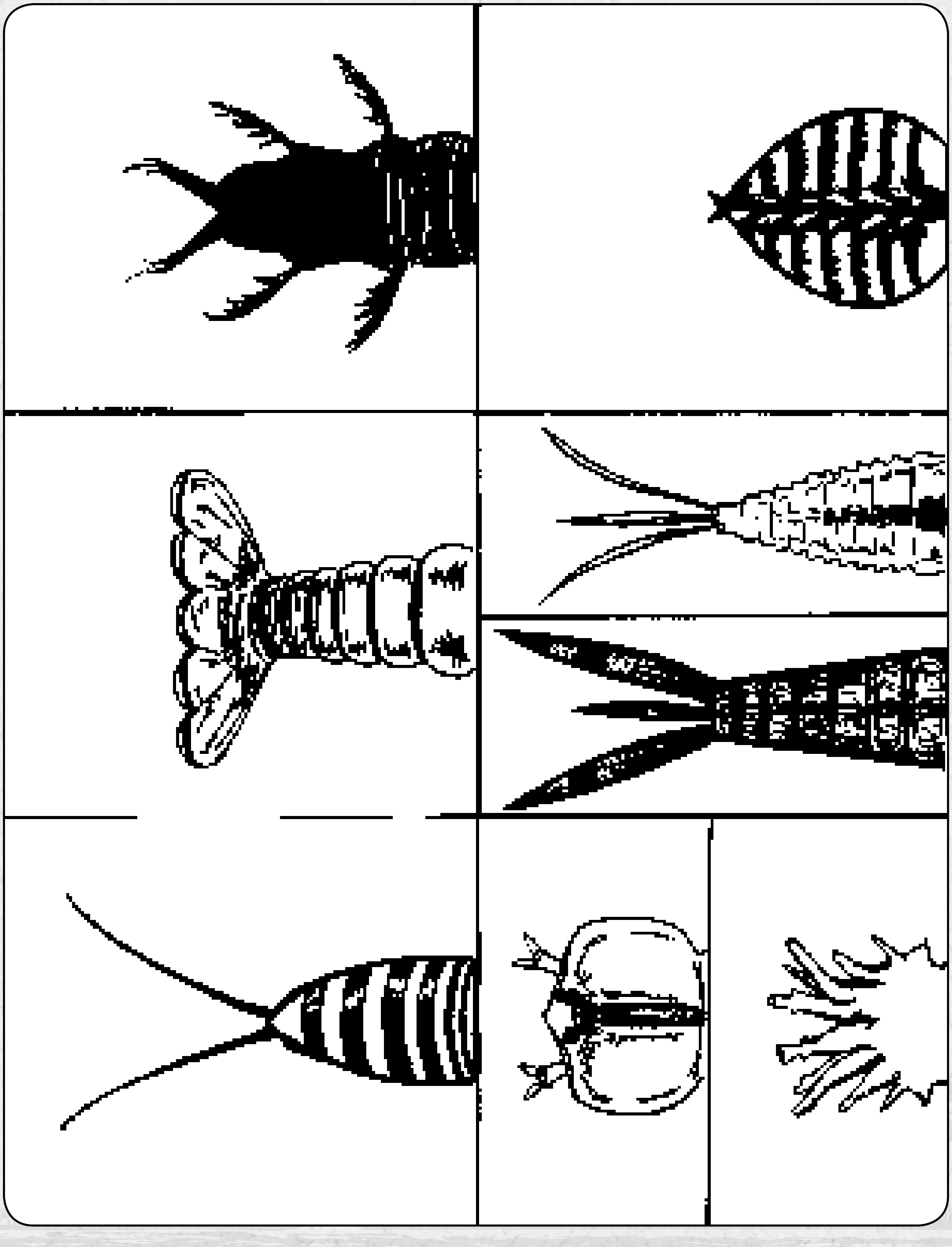
# Make-A-Macro

## EXPLORATION



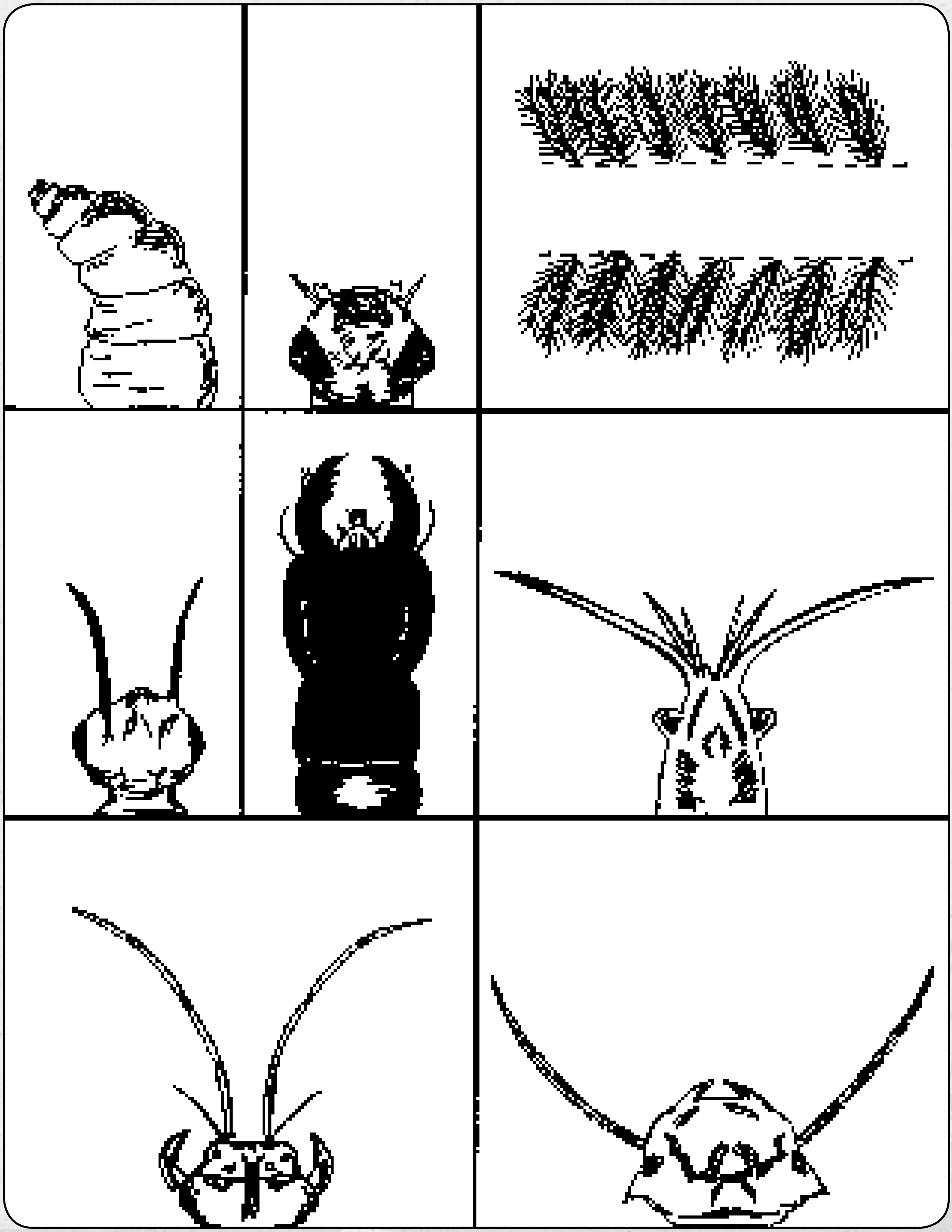
# Make-A-Macro

## EXPLORATION



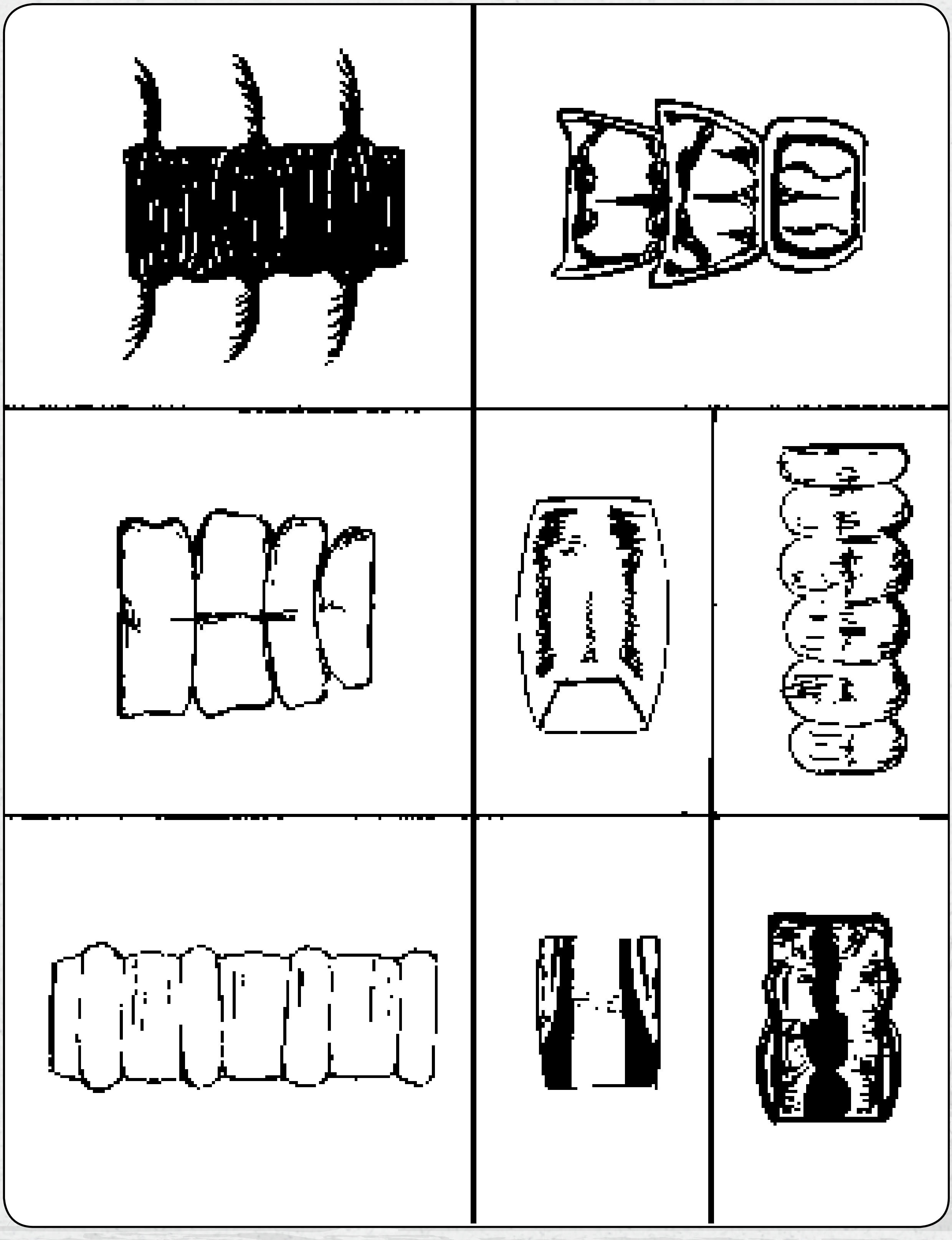
# Make-A-Macro

EXPLORATION



# Make-A-Macro

EXPLORATION



# Macroinvertebrate Mayhem

EXPLORATION

# Macroinvertebrate Mayhem

**Grade Level:**
Upper Elementary, Middle School

**Subject Areas:**
Ecology, Environmental Science, Mathematics

**Duration:**
Preparation time:
Part I: 20 minutes
Part II: 50 minutes

Activity time:
Part I: 50 minutes
Part II: 50 minutes

**Setting:**
Large playing field

**Skills:**
Gathering information (researching); Organizing (categorizing); Interpreting (relating, drawing conclusions)

**Charting the Course**
Orient students to stream ecology prior to this activity. The Extension of "Stream Sense" provides a variety of streamside investigations. Students can learn how nonpoint source pollutants accumulate in a stream in "Sum of the Parts." Treating polluted water is addressed in "Sparkling Water" and "Reaching Your Limits."

**Vocabulary**
macroinvertebrate, biodiversity

How does the phrase "appearances can be deceiving" apply to the water quality of a sparkling, crystal-blue stream?

### Summary

Students play a game of tag to simulate the effects of environmental stressors on macroinvertebrate populations.

## Objectives

Students will:

- illustrate how tolerance to water quality conditions varies among macroinvertebrate organisms.
- explain how population diversity provides insight into the health of an ecosystem.

## Materials

- Samples of macroinvertebrate organisms (optional)
- Resources(texts, field guides, encyclopedia)
- Identification labels for macroinvertebrate groups, one per student(Divide the number of students by 7 and make that number of copies of each macroinvertebrate picture. One side of each label should have a picture of one of the seven macroinvertebrates. The other side of each label [except those for midge larvae and rat-tailed maggots] should have a picture of either the midge larva or rat-tailed maggot. For durability, the cards may be laminated. Use clothespins or paper clips to attach labels to students' clothing.)
- Pillowcases or burlap bags
- Chart paper or a chalkboard

NOTE : To adapt this activity for your area, call the state Department of Land and Natural Resources or Fish and Wildlife Service for information.

## Making Connections

People may be able to assess the water quality of a stream by its appearance and smell. Sometimes, however, a polluted stream looks and smells clean. Students may have already learned certain ways to test water quality and may have conducted macroinvertebrate stream studies. Simulating how environmental stressors affect macroinvertebrate populations helps students relate the concept of biodiversity to the health of aquatic ecosystems.

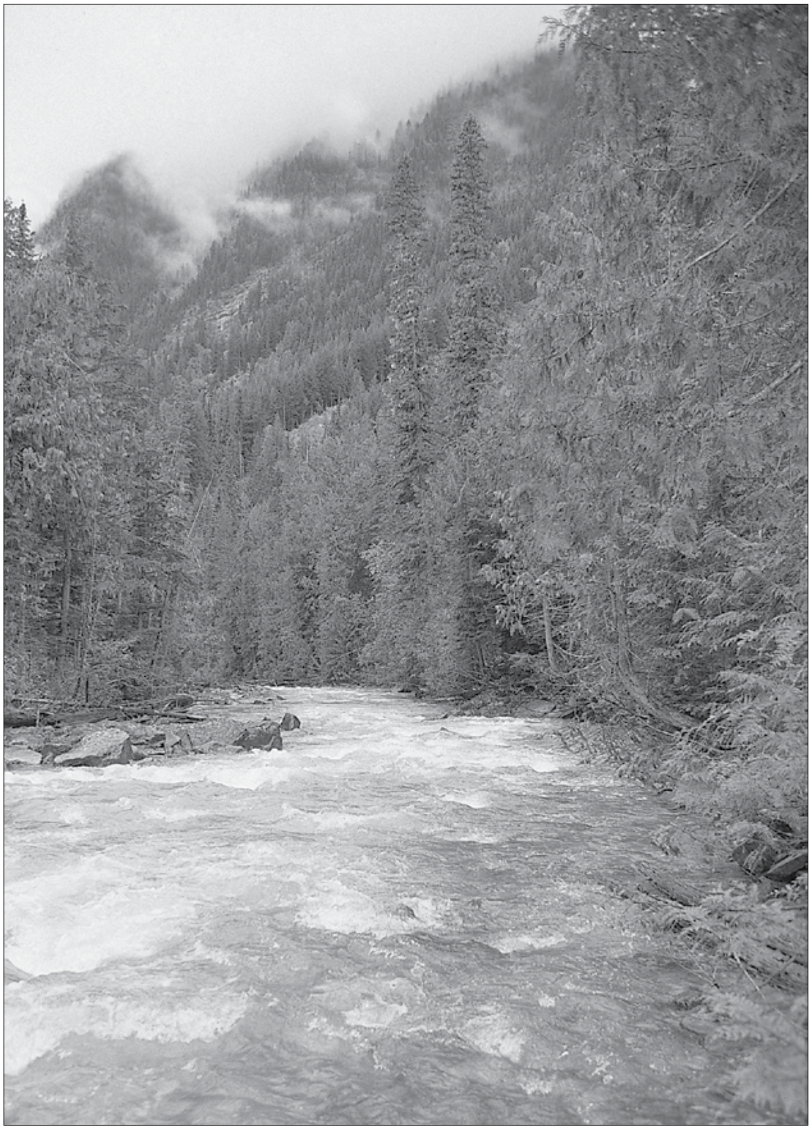
## Background

Macroinvertebrates (organisms that lack an internal skeleton and are large enough to be seen with the naked eye) are an integral part of wetland and stream ecosystems. Examples of macroinvertebrates include mayflies, stoneflies, dragonflies, rat-tailed maggots, scuds, snails, and leeches. These organisms may spend all or part of their lives in water; usually their immature phases (larvae and nymphs) are spent entirely in water. Larvae do not show wing buds and are usually very different in appearance from the adult versions of the insects. (Maggot is the term used for the larva of some flies.) Nymphs generally resemble adults, but have no developed wings and are usually smaller.

A variety of environmental stressors can impact macroinvertebrate populations. Urban and/or agricultural runoff can produce conditions that some macroinvertebrates cannot tolerate. Sewage and fertilizers added to streams induce the growth of algae and bacteria that consume oxygen and make it unavailable for macroinvertebrates. Changes in land use from natural vegetation to a construction site or to poorly protected cropland may add sediment to the water. Sedimentation destroys habitats by smothering the rocky areas of the stream where macroinvertebrates live. The removal of trees along the banks of a river and alteration along the banks of a river and alteration of stream velocity can both alter normal water temperature patterns in the stream. Some organisms depend on certain temperature patterns to regulate changes in their life cycles. Other stressors include the introduction of alien species and stream channelization.

Some macroinvertebrates, such as the mayfly and stonefly nymphs and caddisfly larvae, are sensitive (intolerant) to changes in stream conditions brought about by pollutants. Some of these organisms will leave to find more favorable habitats, but others will be killed or will be unable to reproduce. Macroinvertebrates (e.g., rat-tailed maggots and midge larvae) that may thrive in polluted conditions are called tolerant organisms. Other organisms, called facultative organisms (e.g., dragonfly and damselfly nymphs) prefer good stream quality but can survive polluted conditions.

Water quality researchers often sample macroinvertebrate populations to monitor changes in stream conditions over time and to assess the cumulative effects of environmental stressors. Environmental degradation will likely decrease the diversity of a community by eliminating intolerant organisms and increasing the number of tolerant organisms. If the environmental stress is severe enough, species of intolerant macroinvertebrates may disappear altogether. For example, if a sample of macroinvertebrates in a stream consists of rat-tailed maggots, snails, and dragonfly nymphs, the water-quality conditions of that stream are probably poor (i.e., low oxygen level, increased sediment, contaminants). If, on the other hand, the sample contains a diversity of organisms, the stream conditions are likely good.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Unimpaired streams host a wide variety of aquatic macroinvertebrates.

However, baseline data is essential because some healthy streams may contain only a few macroinvertebrate species. A variety of food sources, adequate oxygen levels, and temperatures conducive to growth all characterize a healthy stream.

## Procedure

### ☒ Warm Up

Review the conditions that are necessary for a healthy ecosystem. Ask students to describe what could happen to an ecosystem if these conditions were altered or eliminated. What clues would students look for to determine if an ecosystem was healthy or not?

Remind students that a stream is a type of ecosystem. Ask them how they would assess the health of a stream. Students may suggest conducting a visual survey of the surrounding area and answering the following questions: What land use practices are visible in the area? How might these practices affect the stream? Is there plant cover on the banks of the stream or are the banks eroded? What color is the water? What is living in the stream?

Identify several environmental stressors (e.g., urban and agricultural runoff, sedimentation, introduction of alien species) and discuss how they can affect the health of a stream. Review the many types of plants and animals, including insects, that live in streams. How might environmental stressors affect these organisms? Would all organisms be impacted in the same way? Why or why not?

### ☒ The Activity

#### Part I

1. Introduce the practice of sampling macroinvertebrate populations to monitor stream quality. Show students pictures or samples of macroinvertebrates used to monitor stream quality.

2. Divide the class into seven groups and assign one macro-invertebrate (from Macroinvertebrate Groups) to each group. Have group members conduct library research to prepare a report for the class about their organism. The report should include the conditions (e.g., clean water, abundant oxygen supplies, cool water) the organism must have to survive.

**Macroinvertebrate Groups**

Caddisfly larva
Mayfly nymph
Stonefly nymph
Dragonfly nymph
Damselfly nymph
Midge larva
Rat-tailed maggot

3. Have students present their reports to the class and compare each organism's tolerance of different stream conditions.

#### Part II

1. Tell students they are going to play a game that simulates changes in a stream when an environmental stressor, such as a pollutant, is introduced. Show students the playing field and indicate the boundaries.

2. Have one student volunteer to be an environmental stressor (e.g., sedimentation, sewage, or fertilizer). Discuss the ways that a stream can become polluted and how this can alter stream conditions. With a large class or playing field, more students will need to be stressors.

3. Divide the rest of the class into seven groups to play the game. Each group represents one type of macroinvertebrate species listed in Macroinvertebrate Groups. Record the number of members in each group, using a table similar to A Sample of Data From Macroinvertebrate Mayhem.

NOTE: Try to have at least four students in each group. For smaller classes, reduce the number of groups. For example, eliminate the stonefly nymph and the damselfly nymph groups.

**Intolerant Macroinvertebrates and Hindrances**

| ORGANISM | HINDRANCE | RATIONAL FOR HINDRANCE |
|---|---|---|
| Caddisfly | Must place both feet in a bag* and hop across field, stopping to gasp for breath every five hops. | Caddisflies are intolerant of low oxygen levels. |
| Stonefly | Must do a push-up every ten steps. | When oxygen levels drop, stoneflies undulate their abdomens to increase the flow of water over their bodies. |
| Mayfly | Must flap arms and spin in circles when crossing field. | Mayflies often increase oxygen absorption by moving gills. |

*Caddisfly larvae build cases and attach themselves to rocks for protection and stabilization.

# Macroinvertebrate Mayhem

## EXPLORATION

### A Sample of Data From Macroinvertebrate Mayhem:

| ORGANISM | TOLERANCE | NUMBERS (AT START AND AFTER EACH ROUND) | | | |
|---|---|---|---|---|---|
| | | START | ROUND ONE | ROUND TWO | ROUND THREE |
| Caddisfly larva | Intolerant | 5 | 2 | 2 | 2 |
| Mayfly nymph | Intolerant | 5 | 4 | 1 | 0 |
| Stonefly nymph | Intolerant | 4 | 4 | 4 | 2 |
| Dragonfly nymph | Facultative | 5 | 5 | 4 | 4 |
| Damselfly nymph | Facultative | 4 | 4 | 4 | 3 |
| Midge larva | Tolerant | 4 | 6 | 7 | 9 |
| Rat-tailed maggot | Tolerant | 4 | 6 | 9 | 11 |
| TOTAL | | 31 | 31 | 31 | 31 |

4. Distribute appropriate identification labels to all group members. The picture of each group's macroinvertebrate should face outward when labels are attached.

5. Inform students that some macroinvertebrates have hindrances to crossing the field. (See Intolerant Macroinvertebrates and Hindrances) These obstacles symbolize sensitive organisms' intolerance to pollutants. Have students practice their motions.

6. Assemble the macroinvertebrate groups at one end of the playing field and the environmental stressor(s) at midfield. When a round starts, macroinvertebrates will move toward the opposite end of the field and the stressor will try to tag them. To "survive," the macroinvertebrates must reach the opposite end of the field without being tagged by the environmental stressor. The environmental stressor can try to tag any of the macroinvertebrates, but will find it easier to catch those with hindered movements.

7. Begin the first round of the game. Tagged macroinvertebrates must go to the sideline and flip their identification labels to display the more tolerant species (i.e., rat-tailed maggot or midge larva). Tagged players who are already in a tolerant species group do not flip their labels.

8. The round ends when all of the macroinvertebrates have either been tagged or have reached the opposite end of the playing field. Record the new number of members in each species.

9. Complete two more rounds, with all tagged players rejoining the macroinvertebrates who successfully survived the previous round. Record the number of members in each species of macroinvertebrates at the conclusion of each round. Because some players will have flipped their identification labels, there will be a larger number of tolerant species in each successive round.

### ☒ Wrap Up and Action

The game is completed after three rounds. Discuss the outcome with students. Emphasize the changes in the distribution of organisms among groups. Have students compare population sizes of groups at the beginning and end of the game and provide reasons for the changes. Review why some organisms are more tolerant of poor environmental conditions than others. Have students compare the stream environment at the beginning of the game to the environment at the end.

Have students investigate a nearby stream. What types of macroinvertebrates live there? How would students describe the diversity of organisms? Do students' findings provide insight into the quality of the stream? What other observations can students make to determine stream quality? They may want to report their findings to local watershed managers or water quality inspectors.

# Macroinvertebrate Mayhem

EXPLORATION

## Assessment

Have students:

- analyze a stream based on a visual assessment ( Warm Up ).
- describe macroinvertebrate organisms and identify what stream conditions they need to survive (Part I , steps 2 and 3, and Wrap Up).
- explain how some organisms indicate stream quality ( Wrap Up ).
- interpret stream quality based on the diversity and types of organisms found there ( Wrap Up ).

Upon completing the activity, for further assessment have students:

- develop a matching game in which pictures of streams in varying conditions are matched with organisms that might live there.

## Extensions

Supplement the students' macroinvertebrate survey of a stream with chemical tests and analyses. (See **Resources**.)

Have students design their own caddisfly case.

Have students study aspects of biodiversity by adding another round to the game. For example, add a fourth round in which all organisms are caddisflies. This round will demonstrate how a few intolerant species or a single species can be quickly eliminated.

## Resources

🍎 Ancona, George. 1990. River Keeper. New York, N.Y.: Macmillan.

Cromwell, Mare. 1992. Investigating Streams and Rivers. Ann Arbor, Mich.: Global Rivers Environmental Education Network (GREEN).

Delta Labs. 1987. Adopt-A-Stream Teacher's Handbook. Rochester, N.Y.: Delta Laboratories, Inc.

Edelstein, Karen. 1993. Pond and Stream Safari: A Guide to the Ecology of Aquatic Invertebrates. Ithaca, N.Y.: Cornell University.

Ellet, K. K. 1988. An Introduction to Water Quality Monitoring Using Volunteers. Baltimore, Md.: Citizens for the Chesapeake Bay, Inc.

Mitchell, M. K., and W.B. Stapp. 1986. Field Manual for Water Quality Monitoring: An Environmental Education Program for Schools. Dexter, Mich.: Thompson-Shore Printers.

Project WILD. 1992. Activity "Water Canaries." From Aquatic Project WILD . Bethesda, Md.: Western Regional Environmental Education Council.

Save Our Streams. Contact: Izaak Walton League of America, 1401 Wilson Blvd., Level B, Arlington, VA 22209.

The Stream Scene: Watersheds, Wildlife and People. 1990. Portland, Oreg.: Oregon Department of Fish & Wildlife.

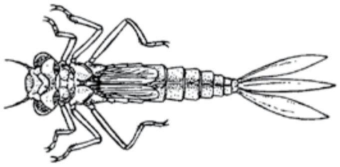
© Susan Denson, Project WET International Foundation

Students 'become' macroinvertebrates during "Macroinvertebrate Mayhem."

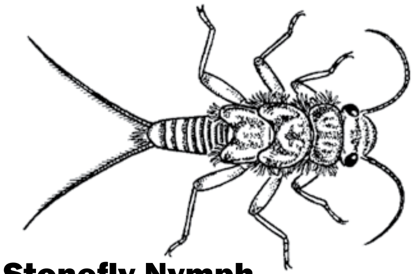
## Identification Labels

**Dragonfly Nymph**

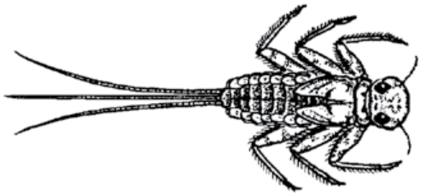
**Caddisfly Larva**



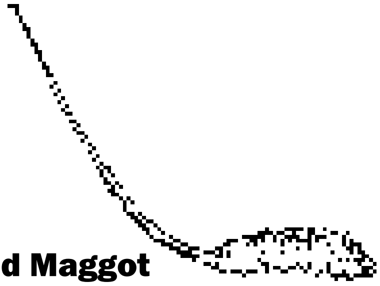
**Damselfly Nymph**



**Stonefly Nymph**



**Mayfly Nymph**



**Rat-tailed Maggot**

**Midge Larva**

**Environmental Stressor**

IllustRation of macroinvertebrates used with permission of the artist, Tamara Sayre.

# Plan Wisely for Your Students' Field Study

ENGAGEMENT

## BACKGROUND INFORMATION:

It is crucial that all students be prepared for the field study in the park. For many students, working outdoors will be an unusual and challenging experience. You should review the information in this section carefully with your students to help them prepare mentally for the field study, and to ensure that they have the appropriate dress and supplies to be comfortable in the park. You may have to review this information several times before the park field study to be sure all students understand the required preparations and plan well for their visit. Listening to the weather and developing a what-to-wear list for the day is a great homework assignment or class discussion in advance of the field study. Some teachers do a dry run a few days in advance of the field study by having their students come to school wearing their field study clothes with their backpacks packed as if for the field study.

Before the site visit, review the Data Sheet in the Student Pages to ensure your students understand what data they will be required to obtain. Pay particular attention to the questions each group must answer in addition to the data they collect. Students can read the resource information to learn about the observations they will be required to make in the park.

The AFF educator and National Park ranger will have all the supplies for the field study activities.

## PARK INFORMATION:

Students can review information about the park and its history on the Bridging the Watershed website at fergusonfoundation.org.

## THINGS TO BRING:

- There won't be a place to buy food. Students must bring a bag lunch and plenty to drink, preferably water. For students on a school lunch plan, let the cafeteria manager know about the field trip a few days in advance to ensure that a bagged lunch will be available.
- The hotter the weather, the more students should bring to drink. Have students pack their lunch and drinks in a backpack or bag that they can easily carry into and out of the park study site.
- Keeping in the ecology-minded spirit, suggest that students make their lunch as trash free as possible. Some areas and parks do not have trash cans. What is packed in must be packed out.
- Make sure that students bring sunscreen and insect repellent if desired.

**Goal:**

To help students plan and prepare for their field study in a local national park.

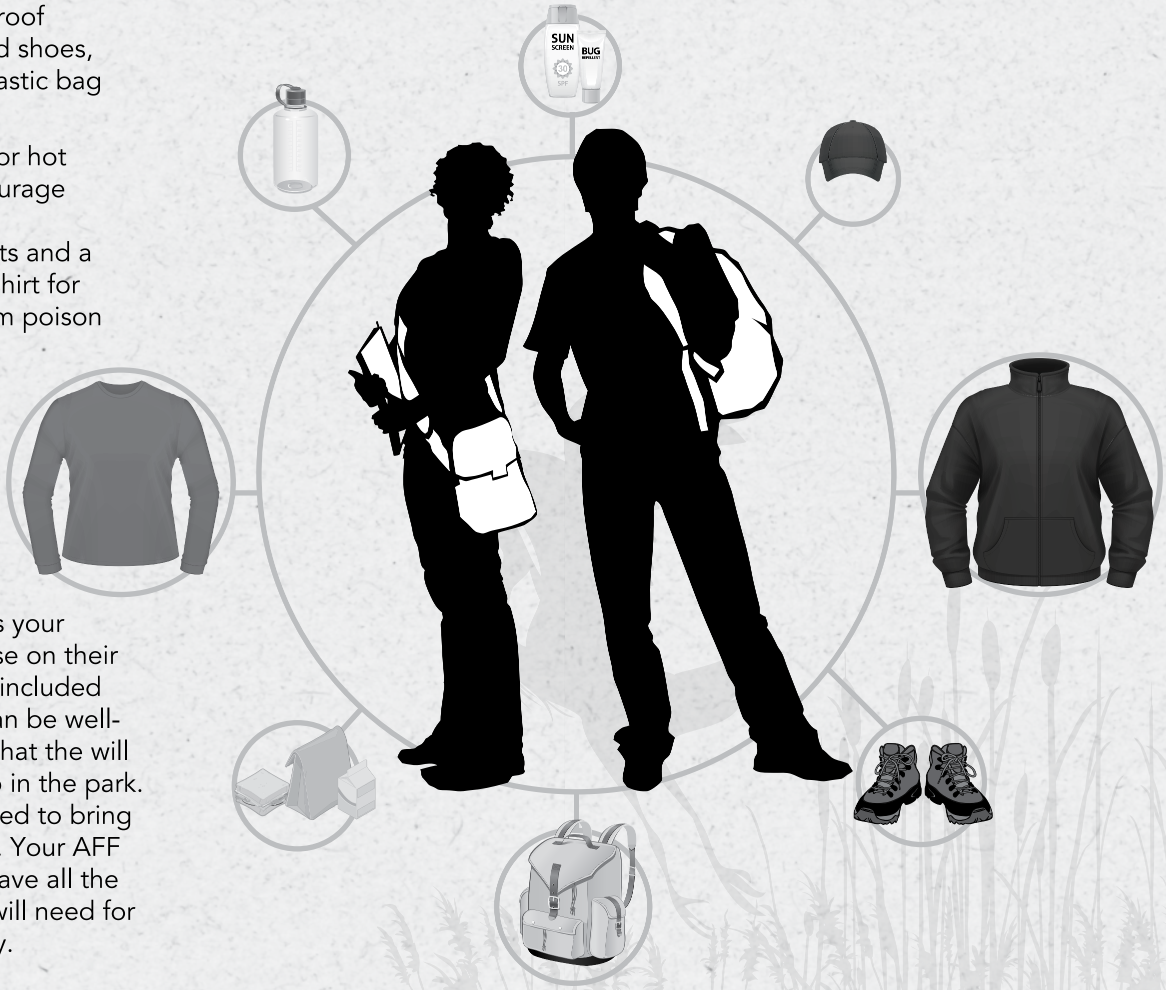
# Plan Wisely for Your Students' Field Study

## PARK STEWARDSHIP:

- Remind students that collecting of any type is not permitted.
- Remind students to take only photographs and leave only footprints.

## TIPS ABOUT CLOTHING:

- Students should wear comfortable clothing that allows them to easily move, hike, bend, and climb. Students may have to gather data in a wet and muddy environment, so they should choose clothes they don't mind getting wet and dirty. With the Water Canaries module, some students will be going into the water to collect organisms. We suggest that students bring an extra pair of socks in their backpacks.
- Dress for the weather. In cool weather, encourage students to wear layers of clothing to keep them warm in the early morning, but that they can remove later in the day or while working. If the forecast calls for possible rain, students should wear a waterproof jacket, hat, and shoes, and bring a plastic bag for materials.
- Even in warm or hot weather, encourage students to wear long pants and a long-sleeved shirt for protection from poison ivy and briars. Students may be in a wooded area or may walk through tall grass.
- The datasheets your students will use on their field study are included here so they can be well-prepared for what the will be asked to do in the park. You will not need to bring these with you. Your AFF educator will have all the materials you will need for your field study.



# Plan Wisely for Your Students' Field Study

## Bridging the Watershed

### Water Canaries Datasheet

Date:

Teacher:

Park:

Study Site:

Park Rangers & Educators: (one per row)

Group Members: (one per row)

Latitude: North ________________________ °

Longitude: West ____________________ °

Why is it important to know the latitude and longitude?

|  | Yesterday |  |  | Today |  |  |
|---|---|---|---|---|---|---|
| Air Temperature | ˚ C |  |  | ˚ C |  |  |
| Cloud Cover | ☐ Clear | ☐ Partly Cloudy | ☐ Cloudy | ☐ Clear | ☐ Partly Cloudy | ☐ Cloudy |
| Precipitation | ☐ None | ☐ Rain | ☐ Other | ☐ None | ☐ Rain | ☐ Other |

How could weather affect today's field study?

Water Color

Water Odor

Water Temperature ˚C

Stream Bottom: ☐ Rocky ☐ Sandy/Gravel ☐ Silty

Stream Canopy: ☐ Full Shade ☐ Partial Shade ☐ Sun

How are water temperature, stream bottom, and canopy related?

Stream Speed:

Trial 1 Seconds

Trial 2 Seconds

Trial 3 Seconds

Average Seconds (Add all 3 Trials and divide by 3)

Stream Speed measured with digital probe: ft/s

Use the average time from above in the calculation below to determine average stream speed

10m / ____ [average time]= meters/second

Because we test speed only at the surface of the stream, we use a 'fudge factor' of 0.8 to adjust for an overall stream speed. Use the average speed from above to find the overall stream speed:

Average Speed x 0.8 (fudge factor) = meters/second

# Plan Wisely for Your Students' Field Study

ENGAGEMENT

Sketch the study site, showing all details that affect your field study:

## Macroinvertebrate Collection (Write in numbers only)

| | |
|---|---|
| Alderfly, Fishfly, Hellgrammite | |
| Aquatic Sowbug | |
| Aquatic Worms | |
| Beetle & Water Penny | |
| Blackfly | |
| Clam | |
| Cranefly (Truefly) | |
| Crayfish | |
| Common Netspinner Caddisfly | |
| Damselfly & Dragonfly | |

| | |
|---|---|
| Flatworm | |
| Gilled Snail | |
| Leech | |
| Lunged Snail | |
| Mayfly | |
| Midge | |
| Most Caddisflies | |
| Scud | |
| Stonefly | |

Other/Notes:

Bridging the Watershed • www.fergusonfoundation.org

# Macroinvertebrates: Collect, Classify and Count

## EXPLORATION

### BACKGROUND INFORMATION:

Benthic macroinvertebrates (organisms that live in or on the bottom of a water body) vary in their sensitivity to stress in their habitat. Students will collect, classify, and count macroinvertebrates to help determine the health of a stream. Because stream benthic macroinvertebrates are classified into categories according to their tolerance to pollution, the relative number of each species gives an indication of the environmental stress the stream is under. Your AFF educator will direct park activities with assistance from the classroom teacher when appropriate.

### Goal:

To assess water quality by collecting, classifying and counting macroinvertebrates found in a stream.

### Class Time:

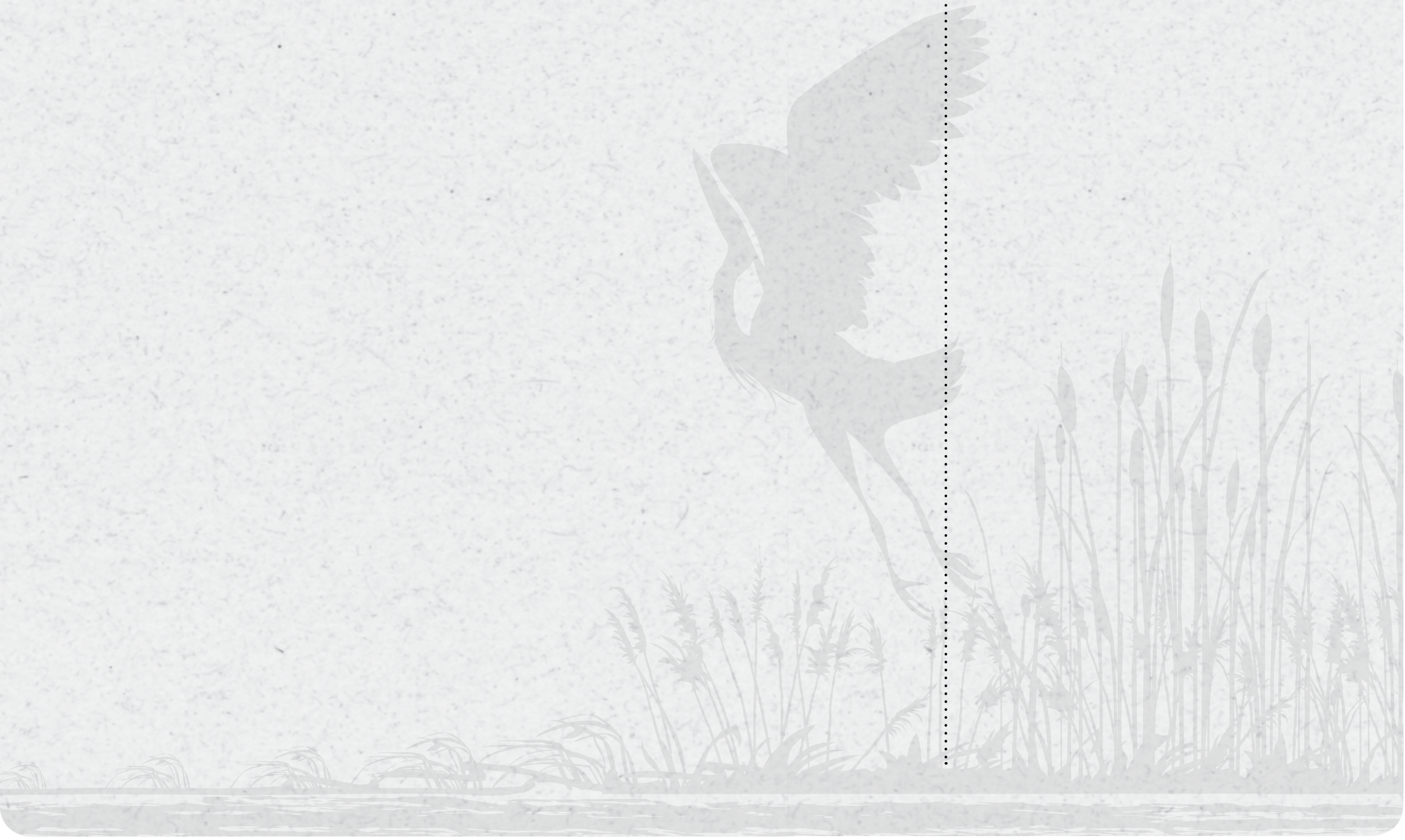
This field study will be completed in a single, minimum four-hour visit to a national park.

### Group Size:

3 to 4 students

### Materials List:

Your AFF educator will have everything your students will need for their **field** study.



# Data Analysis – Determine Stream Health Using Macroinvertebrate Counts

## PROCEDURE:

1. Refer to the Macroinvertebrate Survey Data Sheet. Determine the number collected for each species and record in the "Number Collected" column in Table V: Total Index Value for Stream.
2. Enter "Number Collected" for each species in the block(s) under the headings "Sub-Categories A-F" to the right of the species name. Because of the pollution tolerance level of each category of species used in computing the water quality, you will need to copy the "Number Collected" two or three times for certain species.
3. Total the numbers in all columns and write the totals in line 3.
4. Compute the percentage of the total number of organisms for each column and write in line 4.
5. Use the percentages computed in step 4 to determine an index value for each sub-category. Consult Table IV: Index Values assigned to Sub-Categories. Determine an index value of 2, 1, or 0 by finding where the percentage of each sub-category best fits. Record index values in line 5.
6. Add all index values to obtain a total index value for the stream and write the value in line 6.
7. Mark an "X" on the scale below Table V, corresponding to your total index value, to determine your stream's health.

### TABLE IV: INDEX VALUES (%)

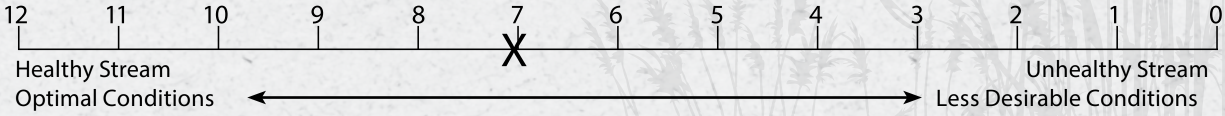
| Sub-Categories | 2 | 1 | 0 |
|---|---|---|---|
| A | > 32.2 | 16.1 – 32.2 | < 16.1 |
| B | > 6.4 | 3.2 – 6.4 | < 3.2 |
| C | < 19.7 | 19.7 – 34.5 | > 34.5 |
| D | < 0.3 | 0.3 – 1.5 | > 1.5 |
| E | < 46.7 | 46.7 – 61.5 | > 61.5 |
| F | < 5.4 | 5.4 – 20.8 | > 20.8 |

> greater than
< less than

# Data Analysis – Determine Stream Health Using Macroinvertebrate Counts

### TABLE V: TOTAL INDEX VALUE FOR STREAM

| | Species | 1. Number Collected | 2. Sub-Categories | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | A | B | C | D | E | F |
| Sensitive | Mayfly larvae | 12 | 12 | | | | | |
| | Stone Fly larvae | 8 | 8 | | | | | |
| | Most Caddisfly larvae | 3 | 3 | | | | | |
| | Beetles (adults & larvae) | 2 | | 2 | | | | |
| Somewhat Sensitive | Dragonfly larvae<br>Damselfly larvae | 11 | | | | | 11 | |
| | Common Netspinner larvae | 3 | | | 3 | | | |
| | Crayfish | 5 | | | | | | 5 |
| | Gilled Snails | 0 | | | | | | 0 |
| | Aquatic Sowbugs | 0 | | | | | 0 | 0 |
| | Scuds | 2 | | | | | 2 | 2 |
| | Clams | 0 | | | | | 0 | 0 |
| | True Fly larvae | 6 | | | | | | |
| | Hellgramites, Fishfly larvae, Alderfly larvae | 4 | | | | | | |
| Tolerant | Lunged Snails | 1 | | | | 1 | 1 | 1 |
| | Black Fly larvae | 2 | | | | | 2 | |
| | Midge larvae | 15 | | | | | 15 | |
| | Aquatic worms | 1 | | | | | 1 | 1 |
| | Flatworms | 0 | | | | | 0 | 0 |
| | Leeches | 0 | | | | | 0 | 0 |
| | 3. Sum of numbers in each column | 75 | 23 | 2 | 3 | 1 | 32 | 9 |
| | 4. Percentage of total number of macroinvertebrates in each sub-category | 100% | 31% | 3% | 4% | 1% | 43% | 12% |
| | 5. Index value for each sub-category | | 1 | 0 | 2 | 1 | 2 | 1 |
| | 6. Total index value for stream | | | | | | | 7 |

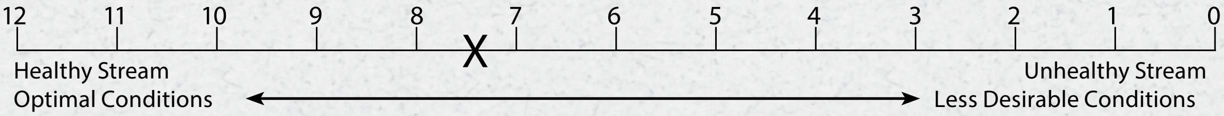


# Data Analysis – Determine Stream Health Using Macroinvertebrate Counts

### TABLE VI: CLASS TOTAL INDEX VALUE FOR STREAM

| Sub-Category | Class Groups | | | | | Class Average |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | |
| A | 1 | 1 | | | | 1.0 |
| B | 0 | 1 | | | | .5 |
| C | 2 | 1 | | | | 1.5 |
| D | 1 | 2 | | | | 1.5 |
| E | 2 | 1 | | | | 1.5 |
| F | 1 | 2 | | | | 1.5 |
| | Total index value for stream | | | | | 7.5 |

Hint: Class total index value for stream is the sum of class averages.



# Performance List

## ELABORATION

Group Members________________________________________ Date____________________

| Performance Criteria | Assessment | | |
|---|---|---|---|
| | Points | Group | Teacher |
| 1 All group data are entered, and an average total index value for the group is accurately determined. | | | |
| 2 All class data are entered, and an average total index value for the class is accurately determined. | | | |
| 3 The summary report begins with a detailed description of the study area and weather conditions. | | | |
| 4 Along with the summary of class data and total index value, a descriptive assessment of the health of the stream is included. | | | |
| 5 Individual water quality parameters that exceeded significant levels are noted, and possible reasons are proposed. | | | |
| 6 The summary is clear and concise, and accurately reflects the findings of the study. | | | |
| 7 Scientific terminology and concepts are accurately explained and applied to illustrate major points of the report. | | | |
| 8 Visual aids (photographs, charts, graphs, and drawings, etc.) enhance understanding of the text. | | | |
| 9 Visuals are clearly titled, labeled, and referenced within the text. | | | |
| 10 Language used in the report is purposeful, descriptive, and appropriate for the intended audience. | | | |
| Total | | | |

Teacher Comments:

# Potomac Confidential

## ELABORATION

### BACKGROUND INFORMATION:

"Potomac Confidential" is a graphic novel that introduces students to the topic of benthic macroinvertebrates (see Resources section for complete description). The characters represent different organisms in a stream's benthic environment. Some are tolerant of environmental disruptions, including changes in dissolved oxygen levels and nutrients, while others are more sensitive. The graphic novel also describes physical characteristics of some of the benthic organisms, giving students a foundation from which they will begin to learn identification techniques.

Instruct students to read Potomac Confidential, or lead a group reading of the graphic novel (to help this, include a list of characters with speaking parts).

### DISCUSSION QUESTIONS:

1. What happened to the stream to make conditions unfavorable for the macroinvertebrates?
2. What do you think we'd find if we sampled for macroinvertebrates in both streams?

   Many teachers like to re-read "Potomac Confidential" later in their unit so students can re-check their understanding of the material.

**POTOMAC CONFIDENTIAL:**
**The Case Of The Missing Macroinvertebrates**

**Authors:**
Katrina Fauss, BTW educator
Rebecca Fordham, BTW educator
Will Sheppard, BTW educator
Anna Wadhams, BTW educator

**Graphic Designer:** Emily Wright
**Artist:** Jessica Miller

### Goal:

To understand how the presence of certain organisms can give us information about the health of the environment.

### Class time:

One class period

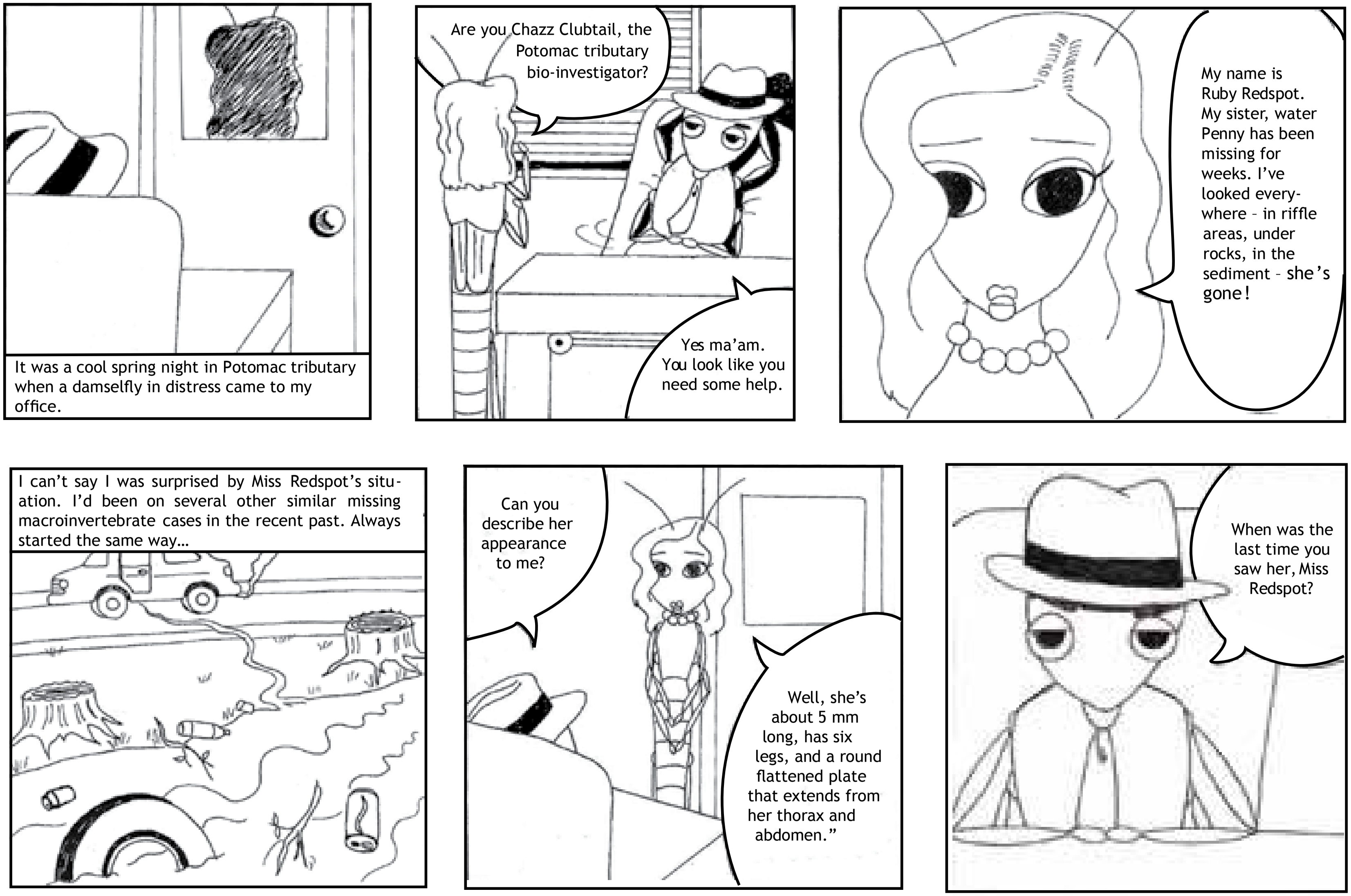
### Group Size:

No groups. Provide each student with a copy of the graphic novel.

# Potomac Confidential

Bridging the Watershed

Alice Ferguson Foundation



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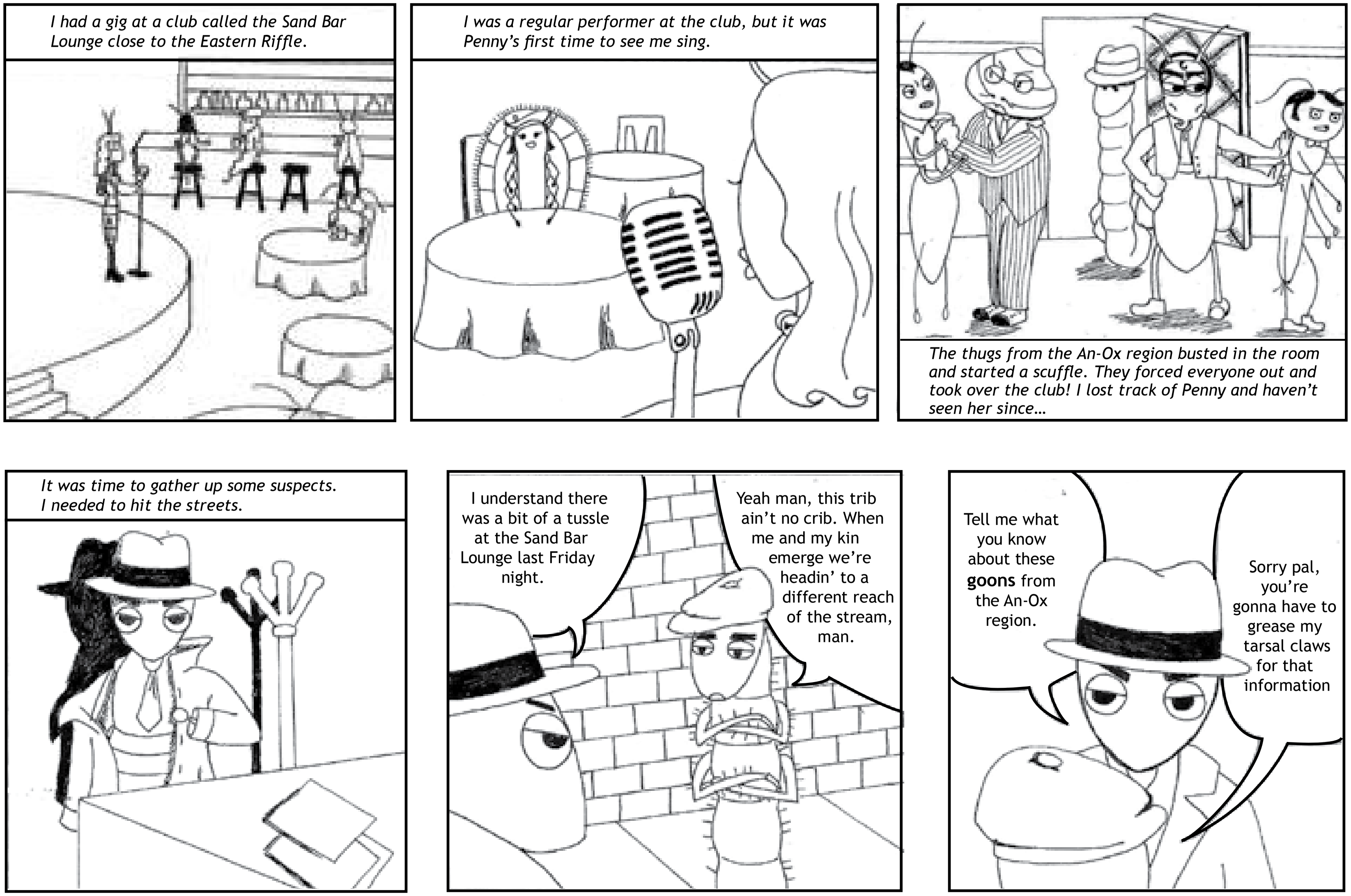
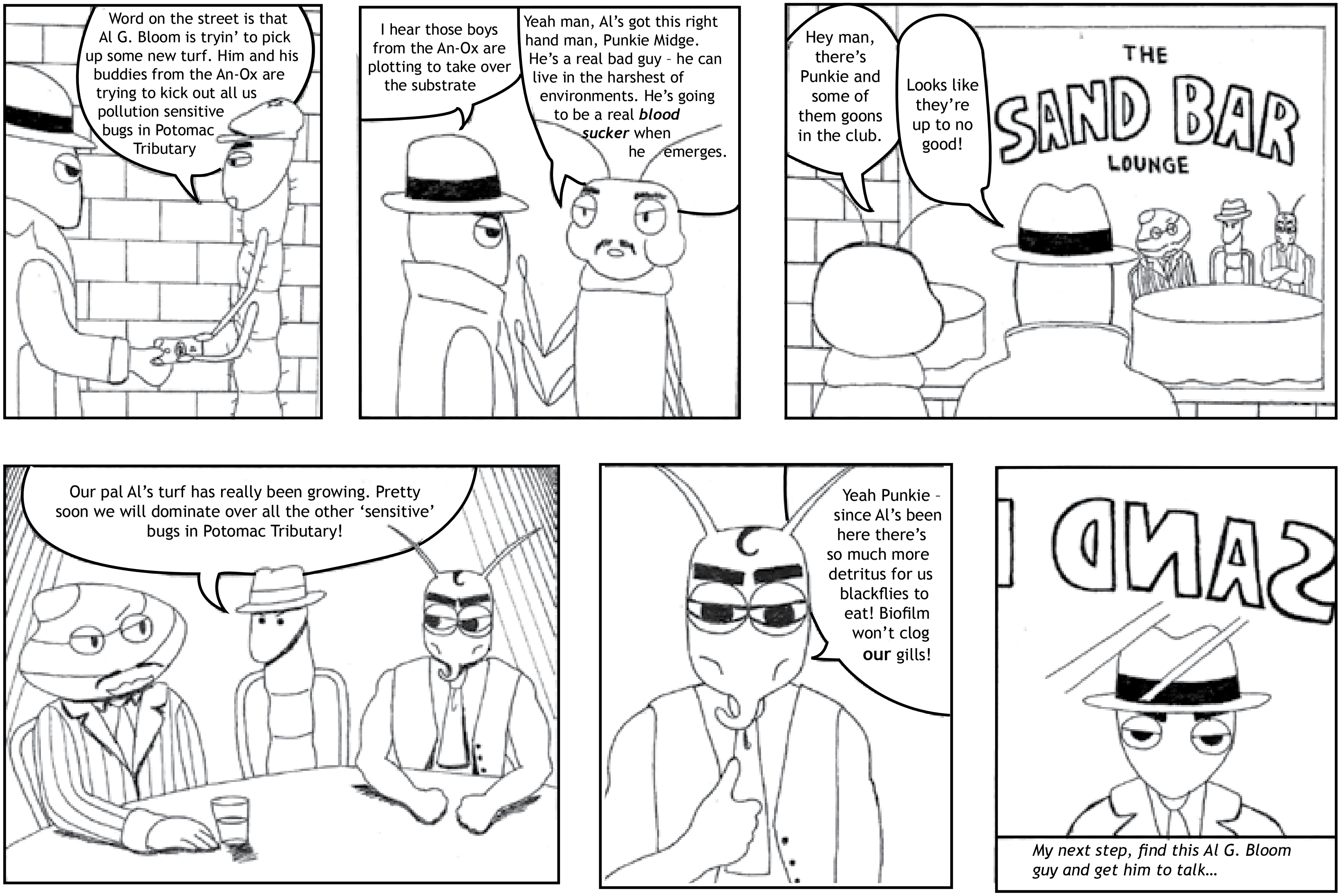
# Potomac Confidential

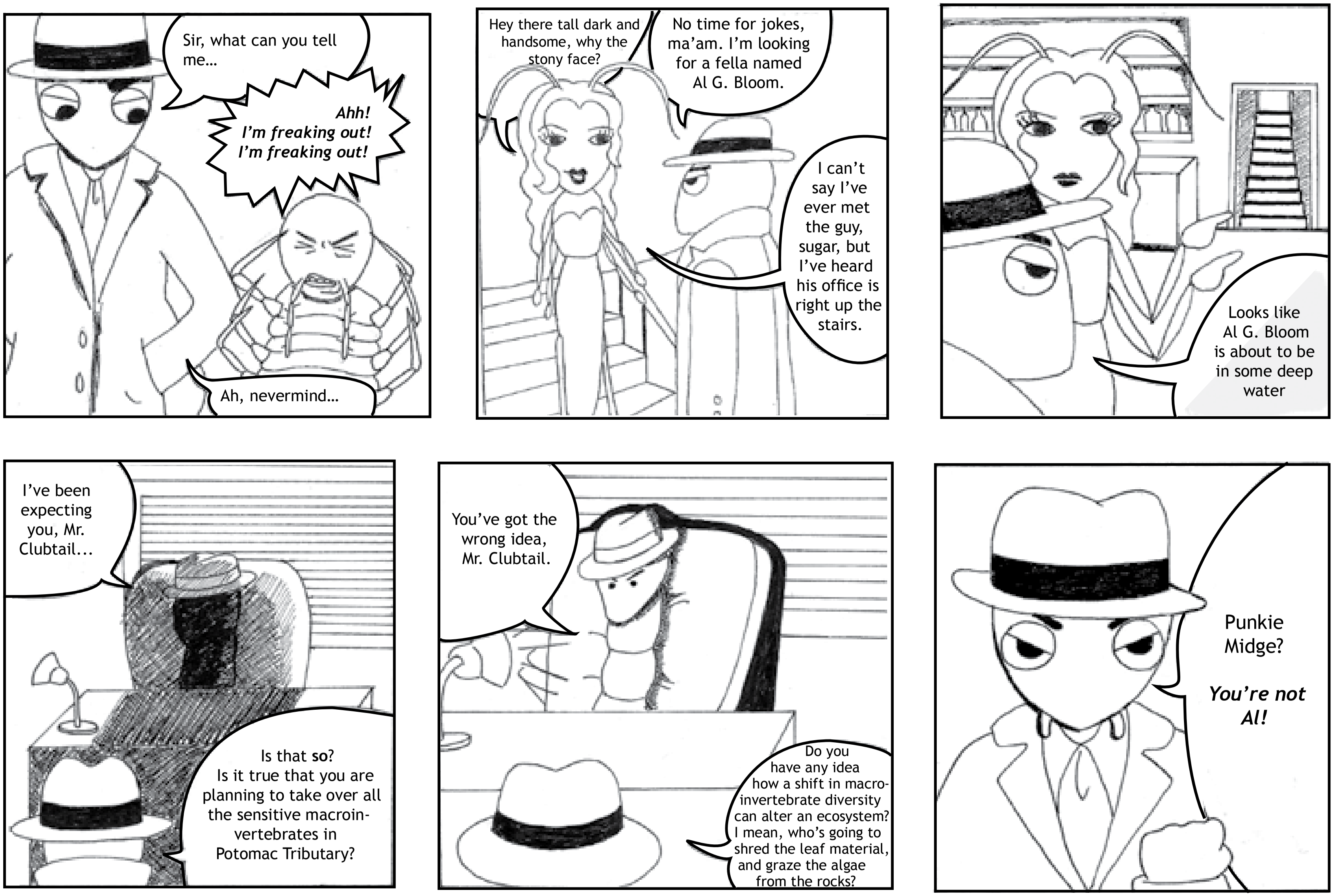


# Potomac Confidential



Bridging the Watershed

Alice Ferguson Foundation



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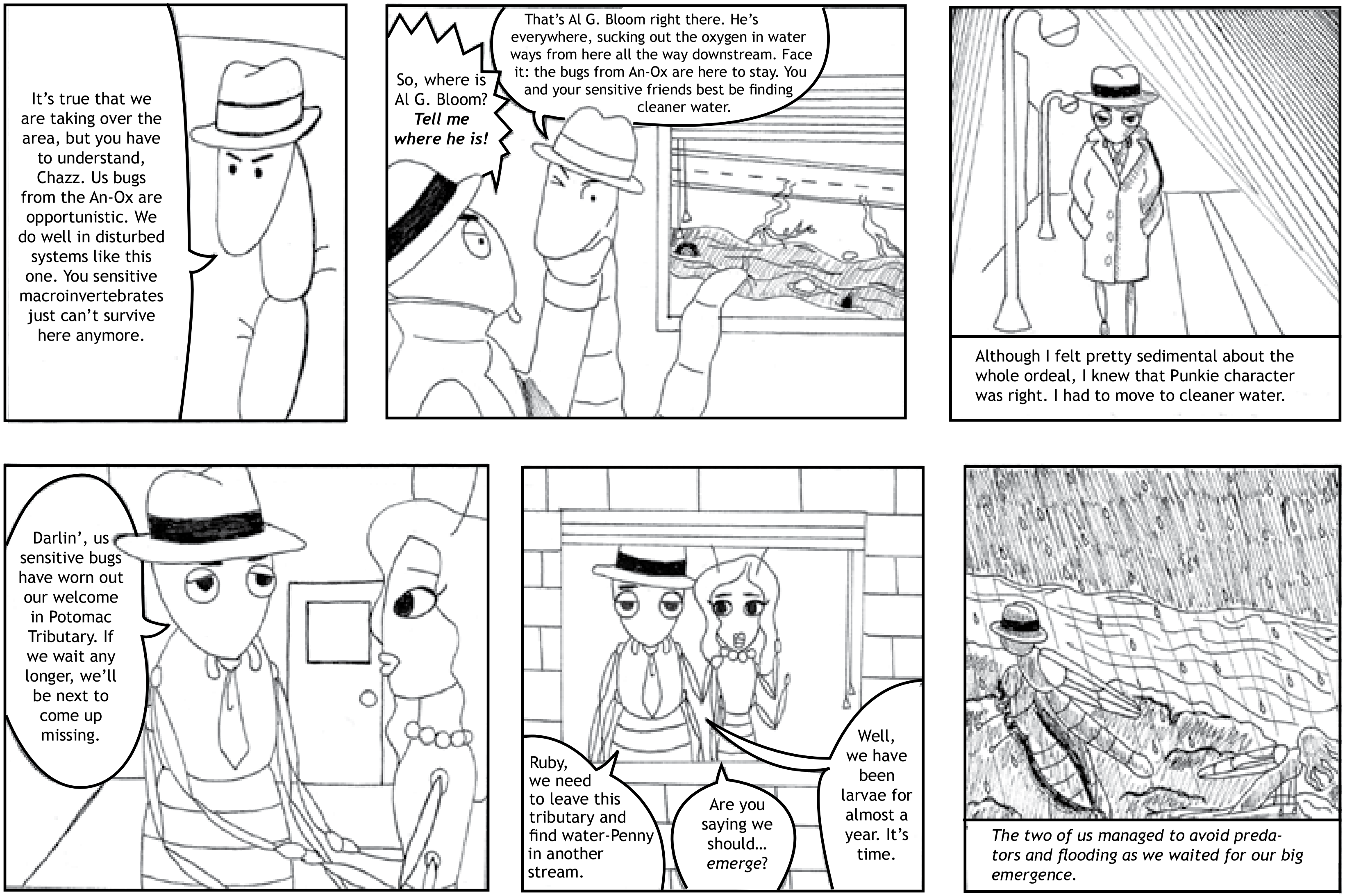
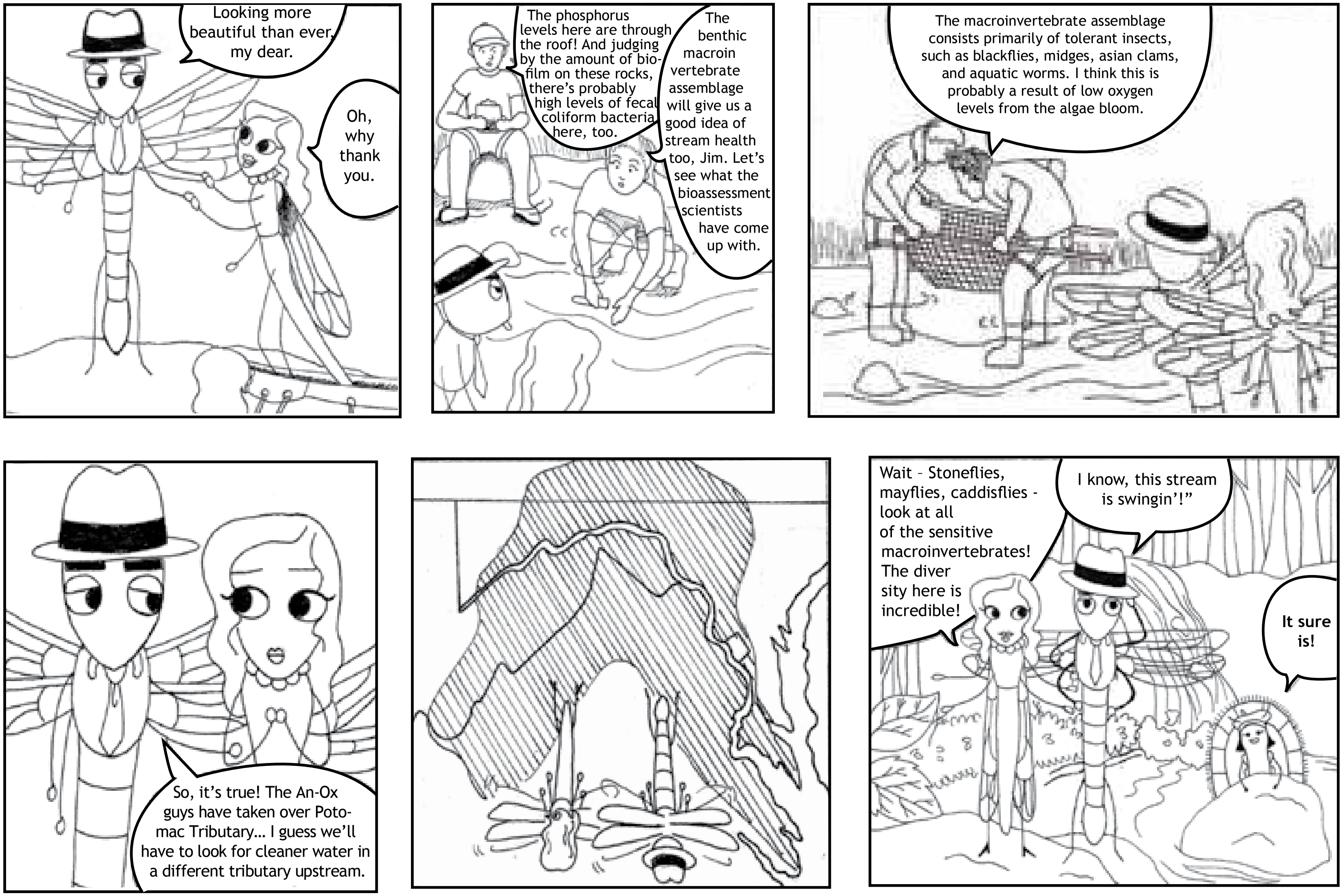
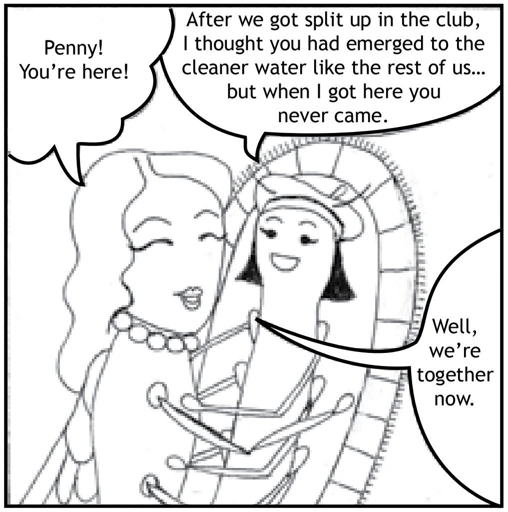
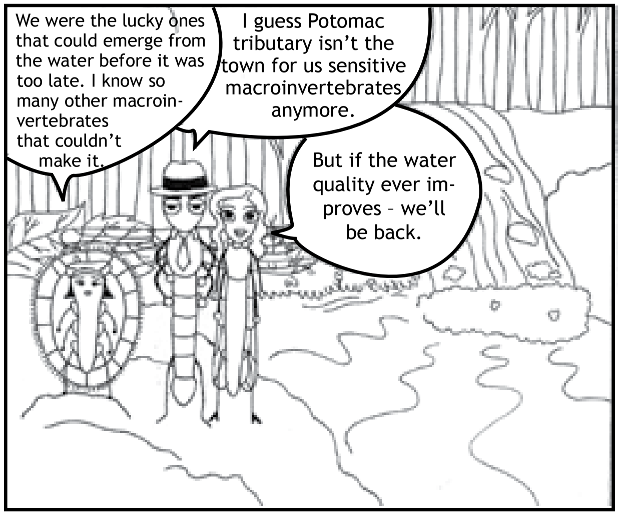
# Potomac Confidential



# Potomac Confidential




Penny! You're here!
After we got split up in the club, I thought you had emerged to the cleaner water like the rest of us… but when I got here you never came.
Well, we're together now.


We were the lucky ones that could emerge from the water before it was too late. I know so many other macroinvertebrates that couldn't make it.
I guess Potomac tributary isn't the town for us sensitive macroinvertebrates anymore.
But if the water quality ever improves – we'll be back.

# Now You See Them; Now You Don't

## ELABORATION

### BACKGROUND INFORMATION:

Students have examined the macroinvertebrate population of a stream that is part of the Potomac River watershed. The stream they sampled will eventually drain into the Chesapeake Bay, along with any pollution it contains. The health of that stream will ultimately affect the health of the Bay. In this activity, students will complete a data table and analyze a graph from macroinvertebrate sampling in the Potomac River watershed.

When they have finished this exercise, students can use a Geographic Information System developed by National Geographic (FieldScope) to examine land cover around three separate stream sites to address the following scenario:

There has been a major chemical spill from a coal plant located near the headwaters of the Potomac River in West Virginia. You will be sampling three downstream sites to determine the short-term effects of the spill on the benthic macroinvertebrate population. Before you go out in the field, you want to study the surrounding land cover and land-use types to make hypotheses about how each stream site will be affected.

### PROCEDURE, QUESTIONS, AND POSSIBLE RESPONSES:

1. **Look at the map from the watershed address activity. Find and label the Potomac River.**

2. **Macroinvertebrates in the Potomac River tributaries are monitored on a continuing basis. Refer to Table VII: Macroinvertebrate Species Count - Potomac River 2008. The data was compiled from three different tributaries along the Potomac River.**

3. **For each of the three sites calculate the percent of total number and determine the index value for each sub-category. Add all sub-categories at each site to determine the total index value.**

4. **Place an "X" on the scale below Table VII marked 0 to 12 to get an idea of stream health at each site.**

5. **At the time of the sampling, one of the sites was under environmental stress from wastewater runoff. Which site do you think it was? Use the data from the three sites to support your answer.**

   *Site 3 – Total Index Value is low. Even though there is a higher total number of organisms, there are more species of organisms that are pollution tolerant and fewer species that are sensitive or somewhat sensitive.*

#### Goals:

- To assess the health of three sites on the Potomac River.
- To relate macroinvertebrate populations to the degradation of benthic habitat in the Potomac River watershed.
- Using the Geographic Information System tool Fieldscope, consider implications of a chemical spill and its impact on macroinvertebrates in the Potomac River watershed.

#### Class Time:

45 minutes

#### Group Size:

2–4 students

#### Materials:

- Internet access with latest version of Adobe Flash Player

#### Special Considerations:

- Some familiarity with geographic information systems is helpful

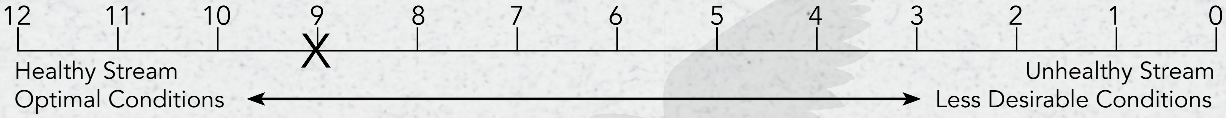
# Now You See Them; Now You Don't

## ELABORATION

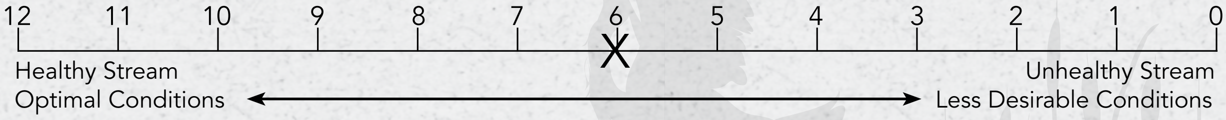
### TABLE VII: MACROINVERTEBRATES SPECIES COUNT — POTOMAC RIVER 2008

| | Site 1 | | | Site 2 | | | Site 3 | | |
|---|---|---|---|---|---|---|---|---|---|
| **Sub-Category** | **Number Collected** | **Percent of Total Number** | **Index Value** | **Number Collected** | **Percent of Total Number** | **Index Value** | **Number Collected** | **Percent of Total Number** | **Index Value** |
| **A** | 39 | 37.5 | 2 | 30 | 28 | 1 | 2 | 1 | 0 |
| **B** | 9 | 8.6 | 2 | 4 | 3.7 | 1 | 1 | .49 | 0 |
| **C** | 26 | 25 | 1 | 6 | 5.6 | 2 | 5 | 2.5 | 2 |
| **D** | 1 | 0.96 | 1 | 7 | 6.5 | 0 | 7 | 3.5 | 0 |
| **E** | 15 | 14.4 | 2 | 27 | 25.2 | 2 | 88 | 43.7 | 0 |
| **F** | 14 | 13.5 | 1 | 33 | 30.8 | 0 | 98 | 48.7 | 0 |
| **Total (all sub-categories)** | 104 | 100% | | 107 | 100% | | 201 | 100% | |
| | **Total Index Value for Site 1** | | **9** | **Total Index Value for Site 2** | | **6** | **Total Index Value for Site 3** | | **2** |

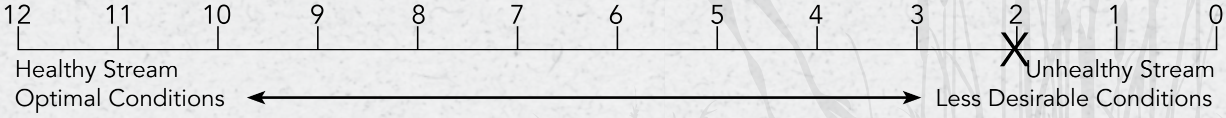
**Site 1**



**Site 2**



**Site 3**



6. **Does the total number of macroinvertebrates found at a site give an indication of the water quality?**

   Explain your answer.

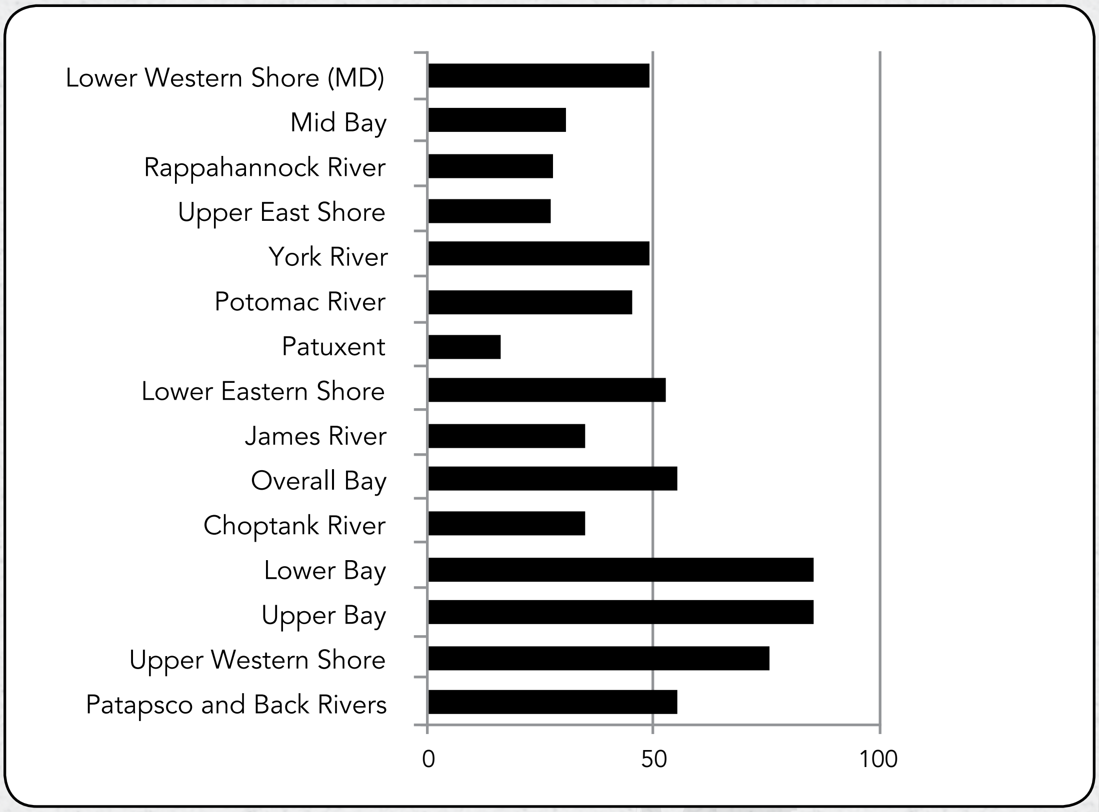
   *Site 1 – 104, site 2 – 107, site 3 – 201. No – the total number of organisms found is not as important as the type of species found.*

# Now You See Them; Now You Don't

## ELABORATION

7. **Below is the Benthic Index of Biotic Integrity, with data collected by VERSAR under an agreement with the Chesapeake Bay Program's Chesapeake Information Management System (CIMS). This Benthic IBI evaluates the health of the benthic community in the tributaries of the Chesapeake, and reflects information from 2009. A score of "100" represents a very healthy tributary; "0" indicates a severely impacted tributary. Examine this graph and answer question 8.**

8. **Which major river in the Chesapeake Bay watershed had the most severely degraded benthic habitat? What do you think contributed to its poor health?**



Benthic Index of Biotic Integrity by Chesapeake EcoCheck

# Student Action Project: Take Action!

ELABORATION

## BACKGROUND INFORMATION:

Students have looked at the problems caused by pollution in the Potomac River watershed. Recognizing a problem is the first step to solving it. The next step is to take what they've learned and apply that knowledge at the local level in the community.

During the field study in the park, students investigated a portion of their local watershed. This module and the field experience in the park were designed to heighten students' awareness and help them understand the important role they play in the health of their watershed. The choices they make about how to interact with their environment make a long-term difference, not only to the area in which they live, but also to the watershed as a whole.

## TAKE ACTION!

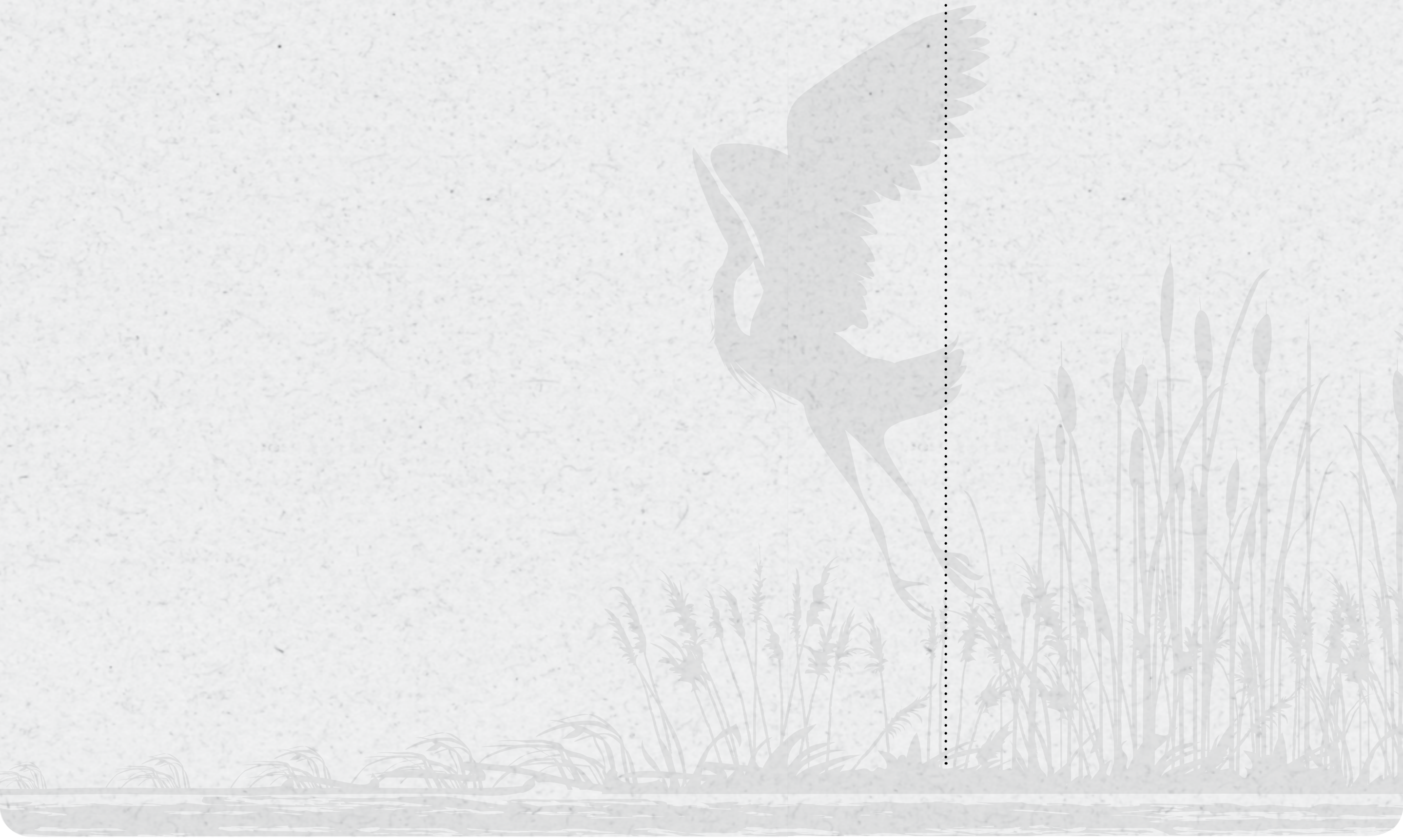
Visit the BTW page of the Ferguson Foundation website to find information on how to take on a watershed action project. We provide some step-by-step instructions, but students provide the inspiration and execution.

### Goals:

- To increase awareness of the need for individual environmental action.
- To act locally and get involved in a service project.

### What Your Class Can Do:

When students are ready to take the challenge, there are many great ways they can get involved. The **first** step is to head to the BTW website and check out our detailed guide on organizing a student-led conservation project.



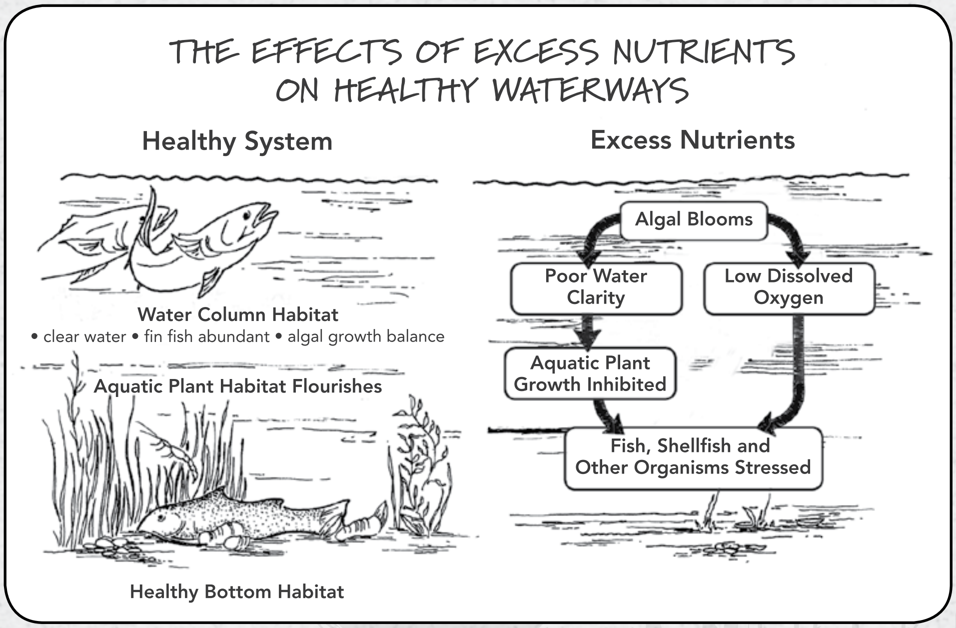
# Resources

# Nitrates and Phosphates: The Effects of These Pollutants on Aquatic Ecosystems

**Nitrates** and **phosphates** are two nutrients essential for aquatic organisms. Both occur naturally in soil, water, and air. There are also many nitrates and phosphates in human sewage and farm animal manure. Plant fertilizers used on lawns and farm fields contain large amounts of these substances. High-temperature burning of fossil fuels also adds nitrogen to the atmosphere.

Nitrates and phosphates can be pollutants in a waterway. In fact, they are the two major pollutants in the waters of the Potomac watershed. An aquatic ecosystem quickly gets out of balance when an excess of either one is washed in, and then **eutrophication** may occur. The literal meaning of eutrophication is "well-nourished." Eutrophication used in the context of an ecosystem means that the water is over-enriched with nutrients like nitrates and phosphates. This excess of nutrients causes accelerated growth of algae and higher forms of plant life. Thus, eutrophication describes an aquatic ecosystem that is out of balance due to natural aging or human influences.

A eutrophic body of water is rich in the nutrients that support abundant growth of aquatic plants at the surface. Microscopic producers, called algae, are an essential first link in the aquatic food web. When a waterway receives excess nutrients, an algal "bloom," or population explosion occurs. Because there are so many algae, the water turns a brownish or greenish color. This causes two major problems for other aquatic life. First, these algal blooms block sunlight from reaching beds of **submerged aquatic vegetation** (SAV). These are benthic plants that grow entirely under water, providing habitat, food, and oxygen for many aquatic animals. SAVs can die when light is reduced. Secondly, when these large masses of algae die, they sink to the bottom, where bacteria break them down. The bacteria use up large amounts of oxygen in this process. With less oxygen in the water, fish, crabs, and other aquatic life forms are harmed or killed. Eutrophication can have both temporary and more permanent effects on aquatic ecosystems. Eutrophication reduces biodiversity by encouraging the growth of nutrient-tolerant plants and algal species that tend to displace more sensitive species. Any decrease in biodiversity makes a food web more vulnerable to collapse.



THE EFFECTS OF EXCESS NUTRIENTS ON HEALTHY WATERWAYS

Nitrate and phosphate pollutants can come from two types of pollution based on the origin of the pollutants: **point source pollution** and **nonpoint source pollution**. Point source pollution can be traced to one certain point such as a pipe from a sewage treatment plant, a factory, or a power plant. Wastewater from these sources can contain toxic chemicals, phosphates, nitrates and other pollutants. Because of stricter regulations and better pollution-removal technology, point source pollution is much more easily controlled than nonpoint source pollution, which is pollution discharged over a wide land area that may be washed into a body of water.

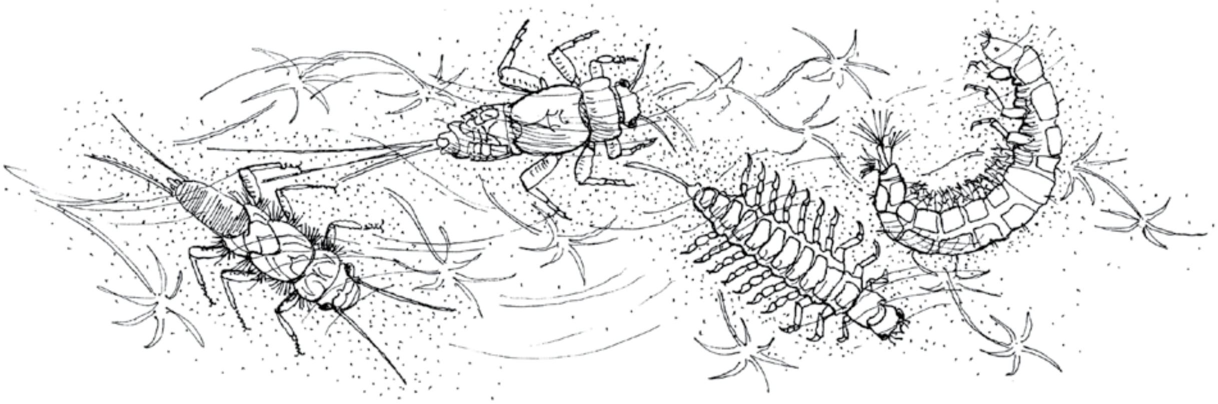
Nonpoint source pollution originates from a source that is not easy to identify or from multiple sources, so these pollutants are very difficult to control. Nonpoint source pollution is sometimes called "runoff " because much of it is washed off the land by rain. Runoff includes fertilizers and toxic chemicals such as pesticides washing off lawns and farmland, oil, grease, litter from streets and parking lots, soil eroding off construction sites, and air pollutants washed into streams during rain events..

Most people fail to realize the great threat posed by nonpoint source pollution. Nonpoint source pollutants currently tend to have a much greater impact on life in streams and rivers than point source pollutants do.

# Benthic Macroinvertebrates

Living things interact with their physical environment. When the physical environment changes, organisms must adapt or die. Therefore, the variety of organisms living in a stream provides the best indicator of a stream's overall ecological health. Organisms in the benthic zone, the area at the bottom of a body of water, filter plankton and organic particles from the water. Benthic macroinvertebrates are excellent indicator species because many are sensitive to pollution and low dissolved oxygen levels. A low level of dissolved oxygen, often caused by excess nutrients such as nitrates and phosphates, is the primary cause of benthic degradation, or loss of populations.

The benthic community includes a wide variety of organisms with diverse body shapes and adaptations for survival. Flowing water places great demands on the organisms living in it and the faster the water moves, the more difficult the living conditions. In fast streams, organisms must keep from being swept away by the current. Adaptations to help them hold on include having very flattened bodies (mayflies), having claws or hooks to hold on to the substrate (riffle beetles, sow bugs), or being able to build nests to anchor them to the substrate (caddisflies). Slower streams have more sediment, so organisms must be able to move to keep from being buried. These organisms often have the ability to burrow into the silt or mud (nematodes, annelids, and some species of mayfly and dragonfly larvae). The slower water also makes for easier swimming, so such creatures as freshwater shrimp and daphnia are able to swim freely.



# Stream Study

Aquatic ecosystems cannot be studied in isolation but must be viewed in relation to the surrounding area. The physical characteristics, or abiotic factors, of a stream are important in determining which organisms live there. One of the most important characteristics of any stream is its speed. A fast-moving stream is usually cold, has good light penetration, lower nutrient concentration, less organism diversity and lower overall productivity. Speed will vary in different portions of the stream such as rapids, riffles, pools, or on the inner or outer edges of a bend.

Overall biological characteristics of the stream are also significant because plants and animals living near the stream may alter the stream environment. The runoff from a nearby barnyard may increase the nutrients in a stream. Trees on the stream bank may shade the stream and lower the temperature during the day. Leaves and branches that fall from bank vegetation into the water may serve as food for aquatic organisms. These three examples illustrate just a few of the biological influences that may affect the stream you are studying.

As you begin your study, locate your stream on a topographical map. Determine the stream's source and where it joins with a larger body of water. Sketch the study site as it appears from overhead and make notes to describe the area. The sketch and description will help you understand how land around the stream is used and may include such things as evidence of runoff, the amount and variety of plant life present, types of animals present, human impact on the area, and any evidence of pollution.

# Apparent Color and Odor

The apparent color of water is the result of dissolved substances and suspended materials. Thus, color provides useful information about the water's source and content. Pure water absorbs various wavelengths of light at different rates. Blue light and blue-green light are the wavelengths best transmitted through water, so a white surface under pure water appears blue. Natural metallic ions, algae and other forms of plankton, industrial pollution, and plant pigments from humus and peat may all produce color in water.

Determine the apparent color of water by lowering a white disc far enough below the water surface to produce a distinct color. Use the table of colors below to determine the source of the water color.

| Color | Source |
|---|---|
| Blue | Low accumulation of dissolved materials and particulate matter (indicating low productivity) |
| Yellow or brown | Organic materials: humus, peat, decaying plants |
| Reddish or deep yellow | Algae |
| Green | Phytoplankton or algae |
| Yellow, red, brown, or gray | Soil runoff |

The odor (smell or scent) of a water body is an indication of water content. Odor can be caused by the natural presence of algae and dissolved minerals. Odor can also come from municipal or industrial waste discharges, natural sources such as decomposing plants, or microbial activity. Odor affects the acceptability of drinking water, the aesthetics of water used for recreational purposes, and the taste of fish and other aquatic food.

Your nose is an excellent odor-detecting device. Collect a water sample in a wide-mouthed jar. Waft the air above the water sample toward you with your hand. Use the table of odors below to describe the nature of what you smell.

| Odor | Nature of Odor |
|---|---|
| Aromatic (spicy) | Cloves, lavender, lemon |
| Flowery | Geranium, violet, vanilla |
| Chemical | Industrial wastes, chlorine, oil refinery wastes, medicinal, sulfur (rotten eggs) |
| Disagreeable/unpleasant | Fishy, pigpen, septic (stale sewage) |
| Earthy | Damp earth |
| Grassy | Crushed grass |
| Musty | Decomposing straw, mold |

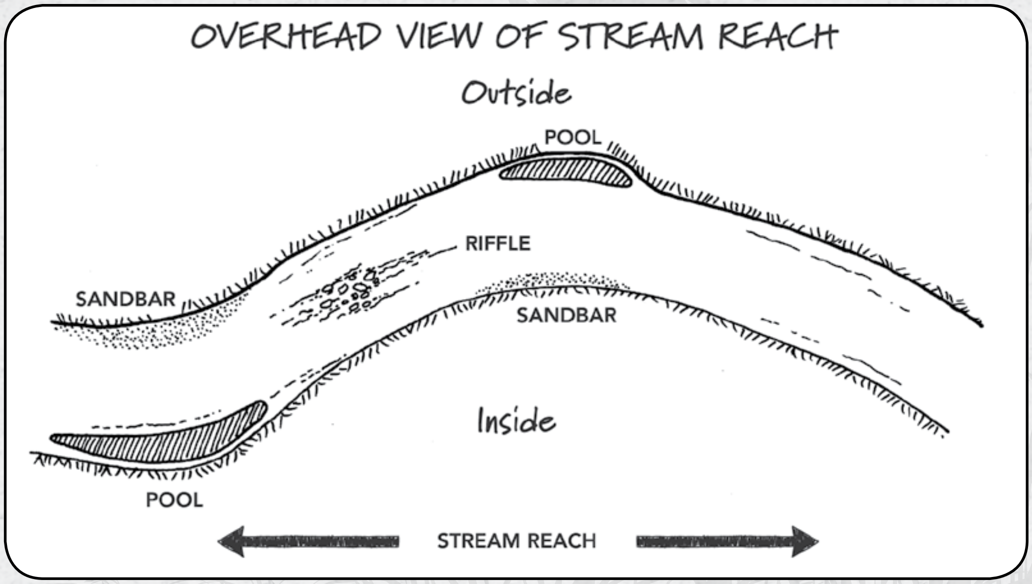
# Riffles, Pools, and Bends

Rocks and debris in a stream may create shallow areas. Water rushes over these shallow areas to form an area of rapids with turbulent flow called a **riffle**. Riffles aerate (add oxygen to) the water and provide habitat for many invertebrates.

A **pool** is a deeper area of water that is quiet and often has no visible flow. Pools provide deeper areas for fish and other larger aquatic organisms. Streams that have many pools and riffles are able to support more life and a greater variety of species than streams that do not.

A **bend** is a change in the direction of the stream channel and the flow of water. Larger, slow-flowing rivers usually have more bends that can provide different habitats. The cutting action of the water at bends provides regions of varying depth and water velocity. Frequently, there is erosion of the bank on the outside of a bend and sediment deposition on the inside of the bend.

Resources

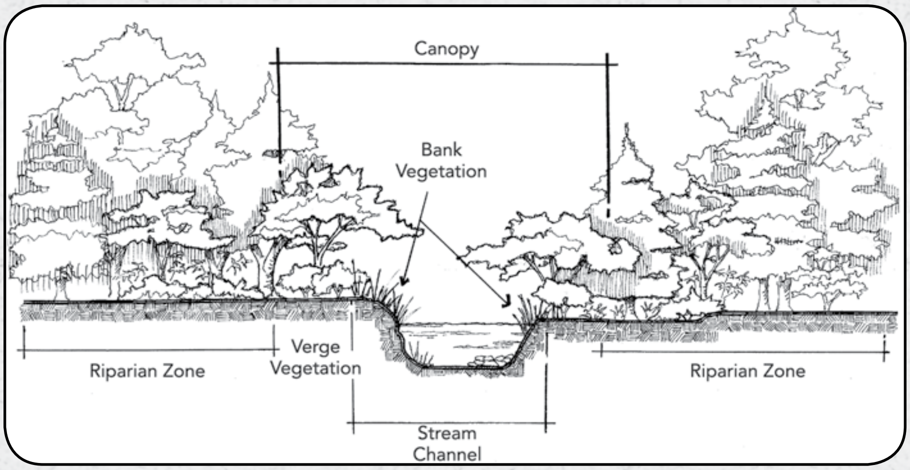


# Land Vegetation

The condition and composition of **vegetation** (e.g., trees, shrubs, grasses) around a stream is a good indication of the health of the aquatic environment. Vegetation provides a natural buffer against erosion and prevents transport of sediments into streams. When vegetation around a stream is degraded or absent, there is less protection for the stream. Deterioration of water quality and habitat for aquatic plants and animals may occur.

A **riparian** area refers to land adjacent to streams, rivers, or water bodies that directly affects and is affected by the water. Trees, shrubs, and other types of vegetation make up the riparian area along waterways. These plants prefer moist to very wet soil and can withstand the disturbance of water flowing over and around them. Riparian vegetation along riverbanks provides a unique habitat in mutual balance with the river channel.

The riparian area includes bank vegetation and verge vegetation. **Bank vegetation** refers to trees, shrubs, grasses, and other vegetation actually growing on the stream bank (sides of the stream channel). The trees from this area overhanging the stream form the stream **canopy**. Bank vegetation provides food and shelter for aquatic organisms in the form of fallen twigs, leaves, fruits, flowers, and branches.



**Verge vegetation** starts at the top of the bank and extends to the next major line of vegetation or to the point of a change in land use. Excellent verge vegetation is a wide corridor of undisturbed native vegetation. As verge vegetation deteriorates the corridor of vegetation narrows and exotic (non-native) plants replace native vegetation. In areas of very poor verge vegetation, there is no native tree or shrub layer, resulting in patchy growth or bare soil.

The vegetation in the riparian area affects many features of the waterway ecology such as light, temperature, and bank stability. It acts as a physical buffer to reduce runoff, and is especially effective as a sediment trap. It forms habitats for birds and small mammals, provides overhanging shelter for fish, serves as a place for emergent insects to rest, feed, and lay eggs, improves water quality by filtering runoff before it reaches the water, and promotes sediment deposition on the land. Riparian vegetation slows floodwaters and reduces the total volume of water entering the stream through root absorption. It provides opportunities for recreational activities such as fishing, hiking, bird watching, picnicking, and camping. Riparian vegetation is vulnerable to destruction by natural change and careless human management. It is as important to protect as the river channel itself.

# Stream Speed

The physical characteristics, or abiotic factors, of a stream are most important in determining which organisms live there. Stream speed is one of the most important characteristics of any stream. A fast-moving stream is usually cold, has good light penetration, lower nutrient concentration, less organism diversity, and lower overall productivity than slow-moving streams. A slow-moving stream is warmer, has less light penetration, a higher nutrient concentration, and more organism diversity. Speed will vary in different portions of the stream moving faster over riffles and the outer edges of a bend, and slower through pools and the inner edges of a bend. During the following investigation, you will determine the overall speed of the stream.

## MATERIALS LIST FOR EACH GROUP:

- Orange, rubber ducky or ping pong ball
- Watch with a second hand
- Flash tape
- 10-meter length of rope

## PROCEDURE:

1. **Measure a 10-meter section of stream. String flashing tape across the stream at each end of the 10-meter segment.**

2. **Drop the orange into the middle of the stream above the beginning of your 10-meter segment.**

3. **Start timing when the orange crosses the “start” line of your 10-meter segment.**

4. **Record the time in seconds that it takes the orange to travel the length of your stream segment.**

5. **Repeat Step 2 for a total of 3 trials. Average your results.**

6. **Divide 10 meters by your average time to get the midstream speed in meters/sec. Overall stream speed is approximately 0.8 (m/s) of the midstream speed. (Water in the middle of the stream channel moves more quickly than water on the sides and bottom.) Use the following formula to calculate overall stream speed.**

   Overall stream speed (meters/sec) = midstream speed (meters/sec) X 0.8

7. **Record the overall stream speed on your data sheet.**

# Student Pages

# Bridging the Watershed

## Water Canaries Datasheet

Date:

Teacher:

Park:

Study Site:

Park Rangers & Educators: (one per row)

Group Members: (one per row)

Latitude: North ______________________°

Longitude: West ____________________°

Why is it important to know the latitude and longitude?

| | Yesterday | | | Today | | |
|---|---|---|---|---|---|---|
| Air Temperature | ˚C | | | ˚C | | |
| Cloud Cover | ☐ Clear | ☐ Partly Cloudy | ☐ Cloudy | ☐ Clear | ☐ Partly Cloudy | ☐ Cloudy |
| Precipitation | ☐ None | ☐ Rain | ☐ Other | ☐ None | ☐ Rain | ☐ Other |

How could weather affect today's field study?

Water Color

Water Odor

Water Temperature ˚C

Stream Bottom: ☐ Rocky ☐ Sandy/Gravel ☐ Silty

Stream Canopy: ☐ Full Shade ☐ Partial Shade ☐ Sun

How are water temperature, stream bottom, and canopy related?

Stream Speed:

Trial 1 Seconds

Trial 2 Seconds

Trial 3 Seconds

Average Seconds (Add all 3 Trials and divide by 3)

Stream Speed measured with digital probe: ft/s

Use the average time from above in the calculation below to determine average stream speed

10m / ____ [average time]= meters/second

Because we test speed only at the surface of the stream, we use a 'fudge factor' of 0.8 to adjust for an overall stream speed. Use the average speed from above to find the overall stream speed:

Average Speed x 0.8 (fudge factor) = meters/second

Sketch the study site, showing all details that affect your field study:

## Macroinvertebrate Collection (Write in numbers only)

| | |
|---|---|
| Alderfly, Fishfly, Hellgrammite | |
| Aquatic Sowbug | |
| Aquatic Worms | |
| Beetle & Water Penny | |
| Blackfly | |
| Clam | |
| Cranefly (Truefly) | |
| Crayfish | |
| Common Netspinner Caddisfly | |
| Damselfly & Dragonfly | |

| | |
|---|---|
| Flatworm | |
| Gilled Snail | |
| Leech | |
| Lunged Snail | |
| Mayfly | |
| Midge | |
| Most Caddisflies | |
| Scud | |
| Stonefly | |

Other/Notes:

# Procedure and Tables for Data Analysis

1. **Refer to the Macroinvertebrate Survey Data Sheet. Determine the number collected for each species and record in the "Number Collected" column in Table V: Total Index Value for Stream.**

2. **Enter "Number Collected" for each species in the block(s) under the headings "Sub-Categories A-F" to the right of the species name. Because of the pollution tolerance level of each category of species used in computing the water quality, you will need to copy the "Number Collected" two or three times for certain species.**

3. **Total the numbers in all columns and write the totals in line 3.**

4. **Compute the percentage of the total number of organisms for each column and write in line 4.**

5. **Use the percentages computed in step 4 to determine an index value for each sub-category. Consult Table IV: Index Values assigned to Sub-Categories. Determine an index value of 2, 1, or 0 by finding where the percentage of each sub-category best fits. Record index values in line 5.**

### TABLE IV: INDEX VALUES (%)

| Sub-Categories | 2 | 1 | 0 |
|---|---|---|---|
| A | > 32.2 | 16.1 – 32.2 | < 16.1 |
| B | > 6.4 | 3.2 – 6.4 | < 3.2 |
| C | < 19.7 | 19.7 – 34.5 | > 34.5 |
| D | < 0.3 | 0.3 – 1.5 | > 1.5 |
| E | < 46.7 | 46.7 – 61.5 | > 61.5 |
| F | < 5.4 | 5.4 – 20.8 | > 20.8 |

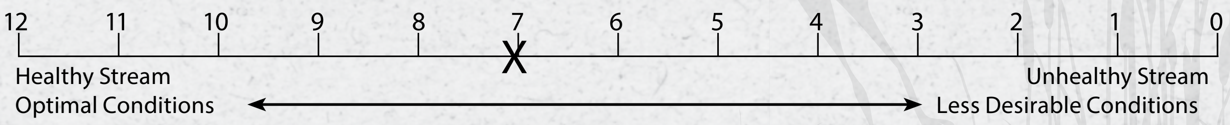
> greater than
< less than

6. **Add all index values to obtain a total index value for the stream and write the value in line 6.**

7. **Mark an "X" on the scale below Table V, corresponding to your total index value, to determine your stream's health.**

# TABLE V: TOTAL INDEX VALUE FOR STREAM

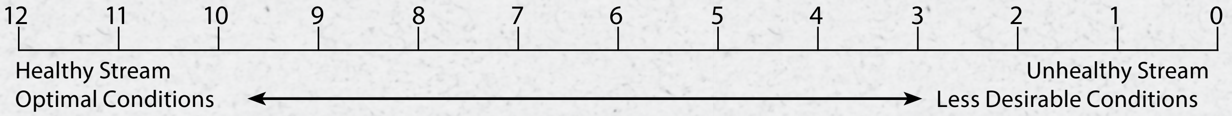
| | Species | 1. Number Collected | 2. Sub-Categories | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | A | B | C | D | E | F |
| Sensitive | Mayfly larvae | | | ▨ | ▨ | ▨ | ▨ | ▨ |
| | Stone Fly larvae | | | ▨ | ▨ | ▨ | ▨ | ▨ |
| | Most Caddisfly larvae | | | ▨ | ▨ | ▨ | ▨ | ▨ |
| | Beetles (adults & larvae) | | ▨ | | ▨ | ▨ | ▨ | ▨ |
| Somewhat Sensitive | Dragonfly larvae<br>Damselfly larvae | | ▨ | ▨ | ▨ | ▨ | | ▨ |
| | Common Netspinner larvae | | ▨ | ▨ | | ▨ | ▨ | ▨ |
| | Crayfish | | ▨ | ▨ | ▨ | ▨ | ▨ | |
| | Gilled Snails | | ▨ | ▨ | ▨ | ▨ | ▨ | |
| | Aquatic Sowbugs | | ▨ | ▨ | ▨ | ▨ | | |
| | Scuds | | ▨ | ▨ | ▨ | ▨ | | |
| | Clams | | ▨ | ▨ | ▨ | ▨ | | |
| | True Fly larvae | | ▨ | ▨ | ▨ | ▨ | ▨ | ▨ |
| | Hellgramites, Fishfly larvae, Alderfly larvae | | ▨ | ▨ | ▨ | ▨ | ▨ | ▨ |
| Tolerant | Lunged Snails | | ▨ | ▨ | ▨ | | | |
| | Black Fly larvae | | ▨ | ▨ | ▨ | ▨ | | ▨ |
| | Midge larvae | | ▨ | ▨ | ▨ | ▨ | | ▨ |
| | Aquatic worms | | ▨ | ▨ | ▨ | ▨ | | |
| | Flatworms | | ▨ | ▨ | ▨ | ▨ | | |
| | Leeches | | ▨ | ▨ | ▨ | ▨ | | |
| 3. Sum of numbers in each column | | | | | | | | |
| 4. Percentage of total number of macroinvertebrates in each sub-category | | | | | | | | |
| 5. Index value for each sub-category | | | | | | | | |
| 6. Total index value for stream | | | | | | | | |



## TABLE VI: CLASS TOTAL INDEX VALUE FOR STREAM

| Sub-Category | Class Groups | | | | | Class Average |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | |
| A | | | | | | |
| B | | | | | | |
| C | | | | | | |
| D | | | | | | |
| E | | | | | | |
| F | | | | | | |
| | | | | | Total index value for stream | |

Hint: Class total index value for stream is the sum of class averages.



Group Members________________________________________ Date ______________________

| Performance Criteria | Assessment | | |
|---|---|---|---|
| | Points | Group | Teacher |
| 1 All group data are entered, and an average total index value for the group is accurately determined. | | | |
| 2 All class data are entered, and an average total index value for the class is accurately determined. | | | |
| 3 The summary report begins with a detailed description of the study area and weather conditions. | | | |
| 4 Along with the summary of class data and total index value, a descriptive assessment of the health of the stream is included. | | | |
| 5 Individual water quality parameters that exceeded significant levels are noted, and possible reasons are proposed. | | | |
| 6 The summary is clear and concise, and accurately reflects the findings of the study. | | | |
| 7 Scientific terminology and concepts are accurately explained and applied to illustrate major points of the report. | | | |
| 8 Visual aids (photographs, charts, graphs, and drawings, etc.) enhance understanding of the text. | | | |
| 9 Visuals are clearly titled, labeled, and referenced within the text. | | | |
| 10 Language used in the report is purposeful, descriptive, and appropriate for the intended audience. | | | |
| Total | | | |

Teacher Comments:

# Now You See Them; Now You Don't Tables and Procedures

## PROCEDURE AND QUESTIONS

1. **Look at the map from the watershed address activity. Find and label the Potomac River.**

2. **Macroinvertebrates in the Potomac River tributaries are monitored on a continuing basis. Refer to Table VII: Macroinvertebrate Species Count - Potomac River 2008. The data was compiled from three different tributaries along the Potomac River.**

3. **For each of the three sites calculate the percent of total number and determine the index value for each sub-category. Add all sub-categories at each site to determine the total index value.**

4. **Place an "X" on the scale below Table VII marked 0 to 12 to get an idea of stream health at each site.**

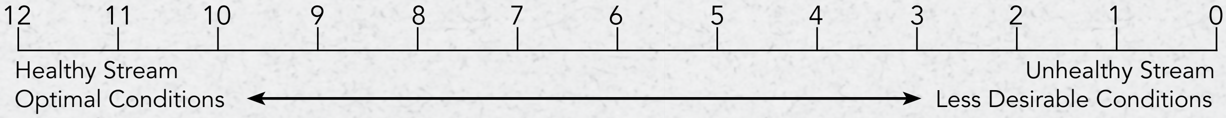
5. **At the time of the sampling, one of the sites was under environmental stress from wastewater runoff. Which site do you think it was? Use the data from the three sites to support your answer.**

6. **Does the total number of macroinvertebrates found at a site give an indication of the water quality?** Explain your answer.

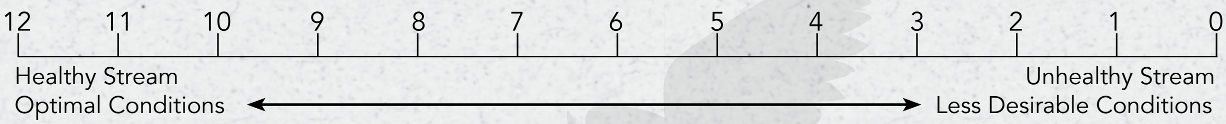
# TABLE VII: MACROINVERTEBRATES SPECIES COUNT – POTOMAC RIVER 2008

| | Site 1 | | | Site 2 | | | Site 3 | | |
|---|---|---|---|---|---|---|---|---|---|
| **Sub-Category** | **Number Collected** | **Percent of Total Number** | **Index Value** | **Number Collected** | **Percent of Total Number** | **Index Value** | **Number Collected** | **Percent of Total Number** | **Index Value** |
| **A** | 39 | | | 30 | | | 2 | | |
| **B** | 9 | | | 4 | | | 1 | | |
| **C** | 26 | | | 6 | | | 5 | | |
| **D** | 1 | | | 7 | | | 7 | | |
| **E** | 15 | | | 27 | | | 88 | | |
| **F** | 14 | | | 33 | | | 98 | | |
| **Total (all sub-categories)** | 104 | | | 107 | | | 201 | | |
| | **Total Index Value for Site 1** | | | **Total Index Value for Site 2** | | | **Total Index Value for Site 3** | | |

**Site 1**



**Site 2**



**Site 3**