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Chapter 14

The Kankapot Creek Coast Guard: Public Service through Monitoring Water Quality of a Stressed Stream

Joy B. Perry

Department of Biological Sciences
University of Wisconsin – Fox Valley
1478 Midway Road
Menasha, WI 54952
(920) 832-2653 (office)
joyperry@uwc.edu

Joy Perry earned a B.S. in General Biology from Purdue University long ago, and an M.S. in Plant Pathology and Integrated Pest Management from the University of Wisconsin – Madison. Her career has included stints as Academic Staff Specialist researching diseases of vegetable and field crops at UW-Madison, being the owner-operator of Savage River Tissue Culture, a commercial micropropagation lab, and a teaching career that began at Allegany College and Frostburg State University in Maryland. Since 1994, she has been a Lecturer in Biological Sciences at UWFox, one of the 13 campuses of the University of Wisconsin Colleges. She teaches courses in general biology, environmental biology, botany, ecology, and in a learning community combining political science, art and environmental science. She has received several campus and institutional awards for excellence in teaching. Mostly, though, she likes to poke around outside and turn over rocks in streams to see who's under there.

Contents

Introduction

Kankapot Creek is a small stream in east-central Wisconsin. It flows through farmland, marshes, and urbanizing areas, including a closed, leaking landfill, before emptying into the Fox River, the single largest tributary of Lake Michigan. Kankapot Creek has been reported to the United States Congress as having "impaired" water quality, meaning that its ability to support aquatic life is not strong.

The *Kankapot Creek Coast Guard* was organized in 2002 as a service project of the University of Wisconsin - Fox Valley, in cooperation with the Wisconsin Department of Natural Resources and City of Kaukauna. As members of the Coast Guard, students in a variety of biology courses conduct water quality monitoring activities each term at different sites on the stream. The purpose of the ongoing monitoring is to develop a database that will provide insight into the sources and nature of factors that degrade water quality in Kankapot Creek, and to determine the diversity and pollution tolerance of organisms living in the stream. The data will provide a more comprehensive view of changes in the habitat and water quality of Kankapot Creek over time. Ultimately, we hope that the collected information will be used to guide projects to restore the stream to a healthier condition.

In the first three years of existence, more than 225 students have participated in monitoring activities annually. Courses in which the Coast Guard is active include general biology, zoology, environmental biology, and ecology. Interdisciplinary collaborations are being explored with courses in chemistry and geography. Students enjoy this rapid water quality assessment field trip, and often mention it as their favorite – and most illuminating – activity of a course.

Student Outline

Water Quality Monitoring

What is trend monitoring?

Trend monitoring is the primary testing method used by our class. To get an accurate picture of a stream's water quality, tests have to be performed on a regular basis, over a period of years. Trend monitoring provides a broad view of the stream allowing the seasonal variations to be sorted out from long-term changes.

What parameters are used to monitor water quality?

Water quality is determined by a variety of factors (See Figure 1). Due to time and resource constraints, we only monitor a fraction of the possible parameters. These are:

Habitat - land use, substrate, flow, depth, riparian vegetation, stream shape, erosion

Chemical - dissolved oxygen, nitrate nitrogen, orthophosphate, turbidity, pH, biochemical oxygen demand (BOD), temperature change

Biological - *E. coli* and other potential pathogens, benthic macroinvertebrates

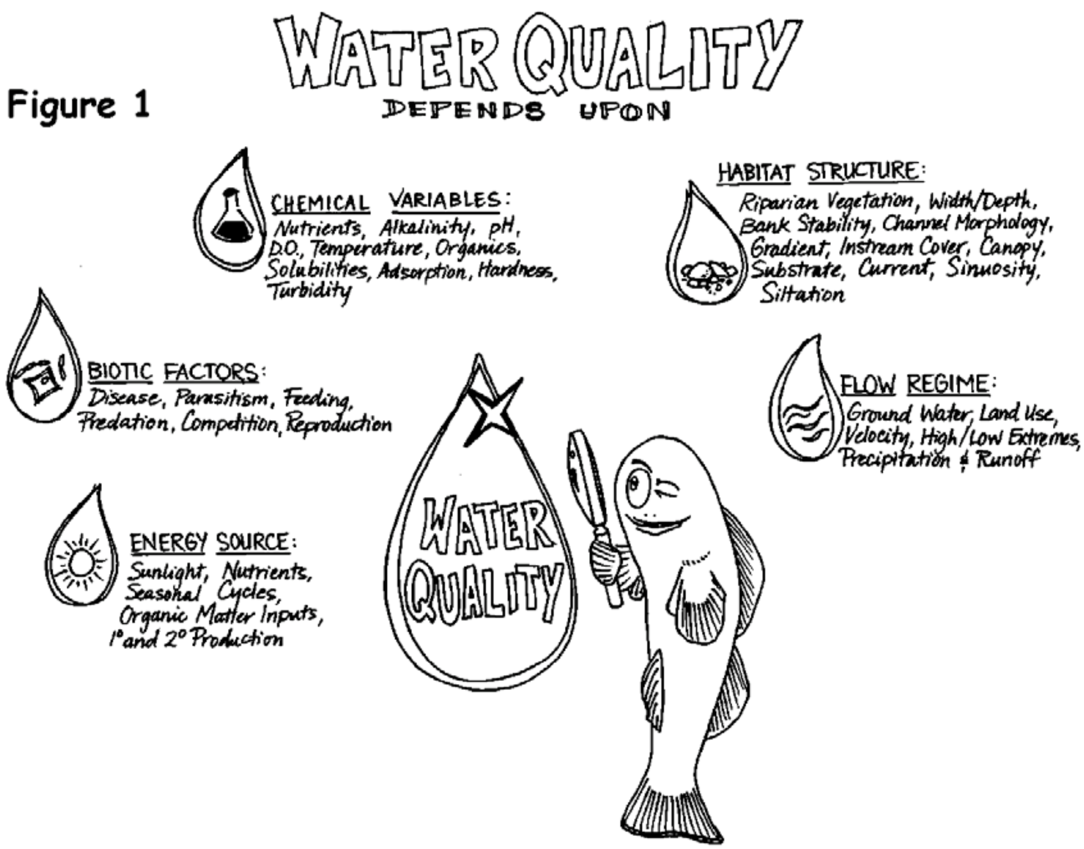


Figure 1. Factors that affect water quality

Safety

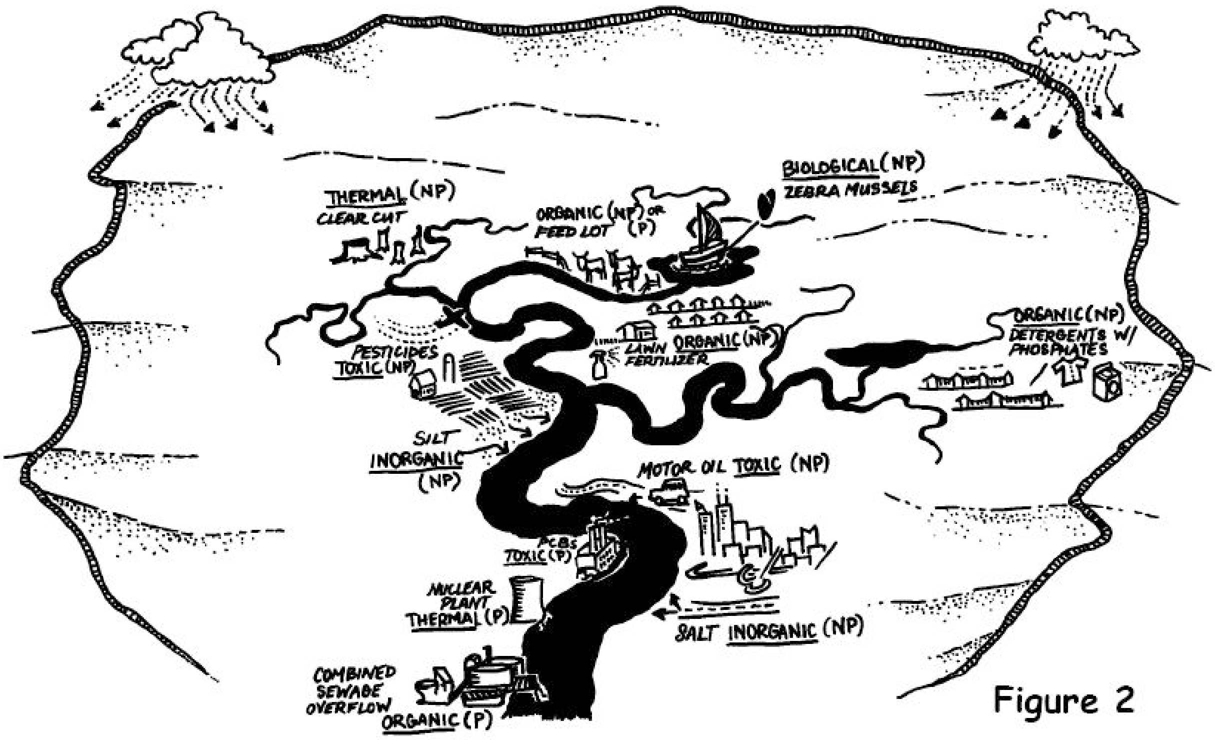
Safety is the critical first step in any stream monitoring program. All volunteers should read the following safety precautions prior to beginning any monitoring activities.

- ✓ **Take a buddy along!** Always monitor with at least one partner. Always let someone else know where you are, when you intend to return, and what to do if you do not return on time.
- ✓ **Honor private property rights.** Never cross a landowner's property without permission.
- ✓ **Never wade in swift or high water.** Do not wade if depth is greater than knee-deep. Do not monitor if the stream is at flood stage. Any stream is dangerous in times of flooding.
- ✓ **Never drink the water in a stream.** Bring water from home to drink. Wash with antibacterial soap and be wary when eating and drinking if your hands have been in contact with stream water.
- ✓ **Beware of polluted streams that are known to be unsafe for handling**. Check with your State or County Health Department or instructor for information on bacterial and/or toxic contamination of local waterways. As a rule, treat every stream as if it were polluted - wear waders, rubber gloves, and protective eyewear when possible. Use hand sanitizer frequently.
- ✓ **Have a first aid kit on hand**.
- ✓ **Develop a safety plan.** Find out the location and telephone number of the nearest telephone and write it down. Locate the nearest medical center and write down directions for traveling there. Have each volunteer monitor complete a medical form that includes emergency contacts, insurance information, and pertinent health information such as allergies, diabetes, epilepsy, etc.
- ✓ **Listen to weather reports.** Never monitor if severe weather is predicted or if a storm occurs.
- ✓ **Be very careful when walking in the stream.** Wear shoes that are in good condition and have traction. Rocky-bottom streams can be very slippery and may contain deep pools. Muddy-bottom streams may also prove dangerous where mud, silt, and sand have accumulated in sinkholes. If you must cross the stream, use a walking stick to steady yourself. Watch for barbed wire fences or sharp, rusty objects (e.g., car bodies, appliances) that may pose a particular hazard.
- ✓ **Do not walk on unstable stream banks**. Disturbing these banks – including the vegetation growing upon them – can accelerate erosion and lead to a collapse.
- ✓ **Beware of potentially dangerous animals.** Watch for irate dogs, farm animals, wildlife (e.g., snakes), and insects such as ticks, mosquitoes, and wasps. Know what to do if you are bitten or stung.
- ✓ **Beware of potentially dangerous plants**. Watch for poison ivy, poison oak, poison sumac, and other skin-irritating vegetation.
- ✓ **If you drive, park in a safe location.** Be sure your car doesn't pose a hazard to other drivers and that you are not trespassing. If you are sampling from a bridge, take special precautions. Watch out for passing traffic and never lean over the bridge unless you are firmly anchored.

What is Water Pollution and Where Does it Come From?

Many people monitor streams because they are concerned about pollution. Monitors check for current pollution and develop a baseline to gauge future pollution. Water pollution can typically be placed in one of two categories: point or non-point source pollution. Point source pollution is easy to identify because it is discharged from the end of a pipe. It accounts for about 25% of all water pollution. Point sources are regulated with permits by state governments.

Nonpoint source pollution originates primarily from runoff and is more difficult to identify. It is a product of land use throughout the entire watershed, and makes up about 75% of water pollution. Different types of pollution are described below and shown in Figure 2.



Point sources are indicated by a "P"; nonpoint sources are "NP."

Figure 2. Sources of water pollution

1. **Organic Pollution** - decomposition of once-living plant and animal materials
2. **Inorganic Pollution** - suspended and dissolved solids (e.g. silt, salt, minerals)
3. **Toxic Pollution** - heavy metals and lethal organic compounds (e.g. iron, mercury, lead, pesticides, PCB's) some of these are transferred via the atmosphere and atmospheric deposition
4. **Thermal Pollution** - heated water from runoff (e.g. streets, parking lots) or point source discharges (e.g. industries, nuclear or other power plant discharges)
5. **Biological Pollution** - introduction of non-native species (e.g. zebra mussels, purple loosestrife, Eurasian water milfoil)

#1 Source of Water Pollution by Volume to Most Streams and Rivers is **Sediment**!

Soil erosion and sediment resulting from poor construction, logging, landscaping, and agricultural practices, as well as eroding stream banks, cause many physical changes in streams that lead to decreased water quality.

Physical Changes in Streams Affected by Sediment	**Resulting Direct and Indirect Effects on Aquatic Organisms**
Heat is absorbed resulting in increased water temperature	Metabolic rates of organisms increases; wasted energy not available for growth and reproduction
Water clarity is decreased; turbidity is increased Increased siltation and embeddedness on stream bottom (Figure 3)	Reduction in visual feeding and visual mating Clogging of gills during breathing and feeding Smothering of nests and eggs Change in habitat, and filling of crevices in bottom gravel
Excess organic debris is carried in with soil; may result in increased biochemical oxygen demand and decreased dissolved oxygen	Oxygen sensitive species are detrimentally affected pH is reduced (water becomes more acidic) resulting in: Phosphorus becoming more available Ammonia becoming more toxic More leaching of heavy metals
Excess phosphorus is attached to soil particles and is carried into streams	Phosphorus acts as a 'fertilizer' Algal growth increases _ higher daytime dissolved oxygen and lower nighttime dissolved oxygen Can upset normal feeding on the aquatic food chain
Heavy metals may be leached from soil → increased toxicity	Developmental deformities, behavioral changes in feeding, mate attraction and activity, and parental care

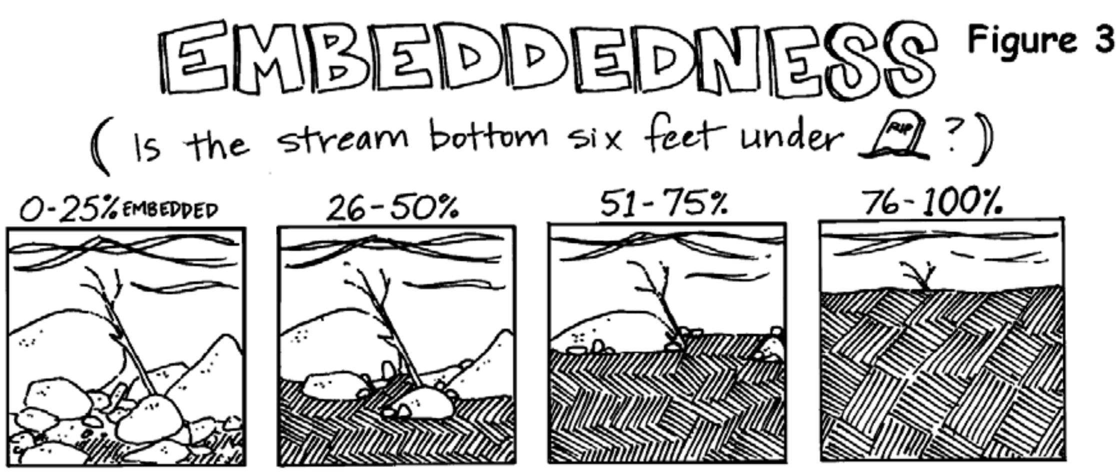


Figure 3. Stream embeddedness

Habitat Assessment

What is a Healthy Stream Habitat?

A natural stream channel provides a variety of habitats for many species of plants and animals. Pools, riffles, undercut banks and snags (fallen limbs or small log piles) all provide different types of habitat. The more types of habitat present in a stream system, the greater the potential for aquatic plant and animal diversity.

A uniformly straight or deep channel provides less potential habitat than a stream with variable flows and depths. Examples of healthy and unhealthy stream habitats are shown in Figure 4.

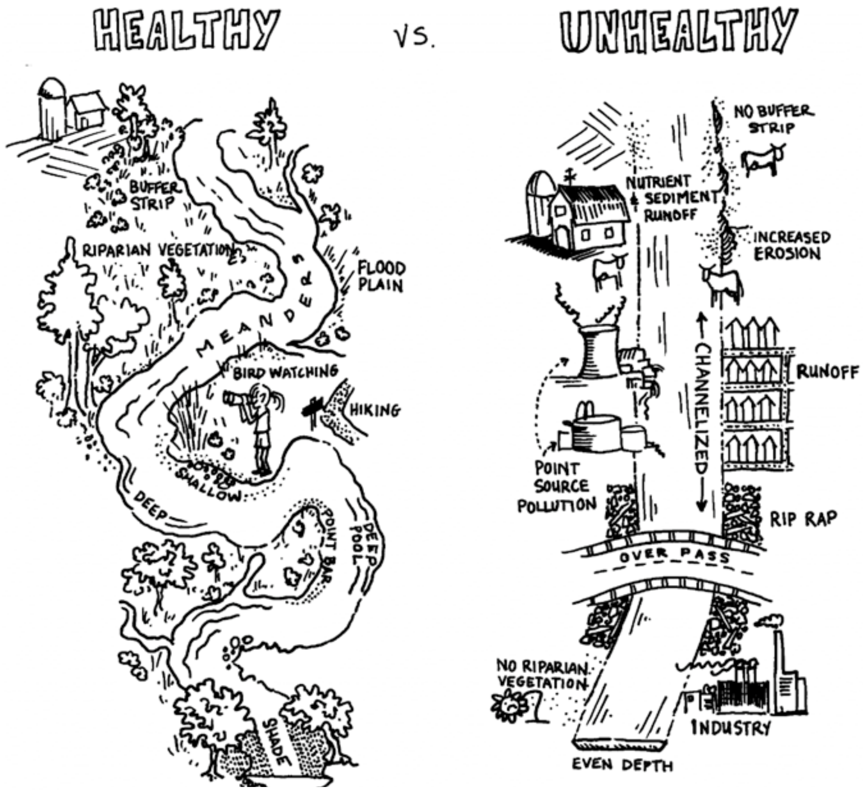


Figure 4. Features of healthy vs. unhealthy streams

Citizens Qualitative Habitat Evaluation Index (CQHEI)

This index was developed in Ohio as a "Citizens" companion to the habitat evaluation method used by the state's professional staff. The index provides a measure of the stream habitat and riparian health that generally corresponds to physical factors affecting fish and other aquatic life (i.e. macroinvertebrates). The CQHEI produces a total score that can be used to compare changes at one site over time or to compare different sites.

NOTE: The CQHEI data sheet was designed to be used primarily in wadeable streams. The index scores do not necessarily reflect the conditions found in intermittent streams or large rivers.

When completing the CQHEI, evaluate your entire stream site (200 foot section).

In each category, choose the most predominant answer. If sections of the stream or stream banks have completely different characteristics, you may check two boxes and average the points to obtain a score for the subsection (a), (b), or (c). See the provided example page in Appendix B.

I. Substrate (Bottom Type) -Max 24 pts

II. Fish Cover (Hiding Places) - Max 20 pts

Select <u>all</u> the cover types that you see using Figure 5 as a guide. <u>Add</u> the points.

III. Stream Shape and Human Alterations - Max 20 pts

IV. Stream Forests and Wetlands (Riparian Areas) & Erosion - Max 20 pts

a) Width of the Riparian Forest or Wetland - **This is not the width of the stream!** Estimate the width of the area containing **trees** or **wetlands** on each side of the stream by answering: "Can you throw a rock to the other side?"

V. Depth & Velocity - Max 15 pts

a) Deepest Pool - If your stream is a consistent depth, select the maximum depth.

b) Select <u>all</u> the flow types that you see and <u>add</u> the points.

VI. Riffles/Runs (where the current is turbulent) - Max 15 pts

Use Figure 6 as a guide.

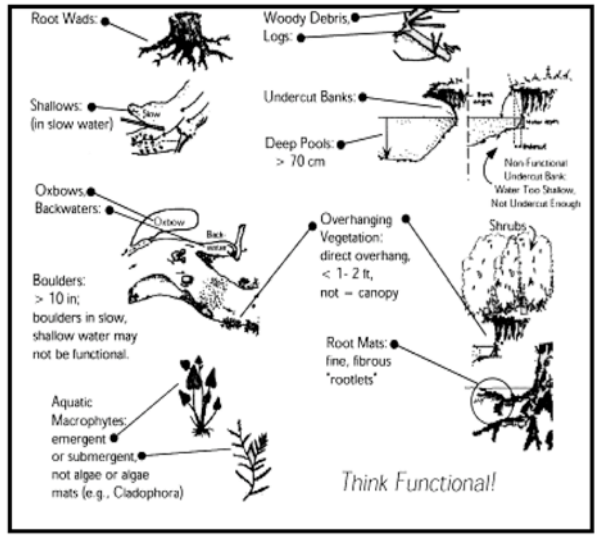
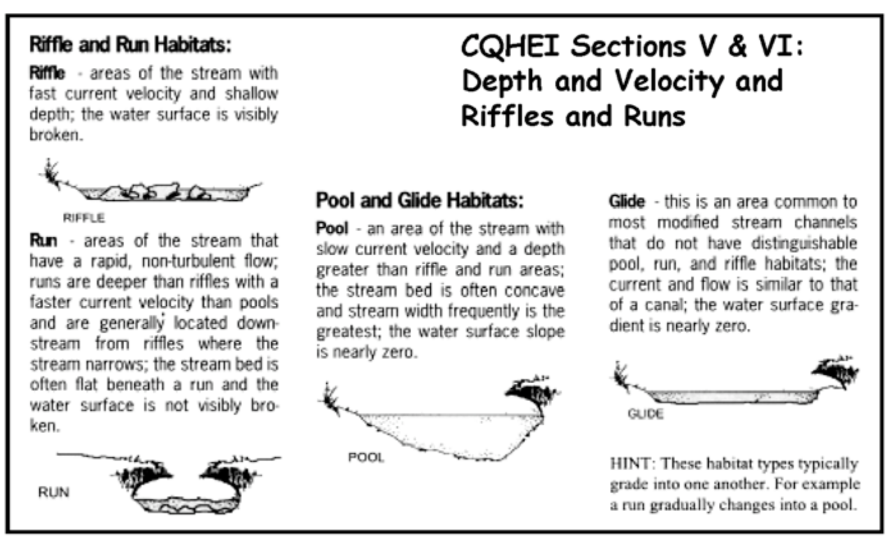


Figure 5. Determining CQHEI section II: Fish Cover (Hiding Places)

MAXIMUM TOTAL POINTS FOR THE CQHEI IS 114.
If the score is over 100, consider it "extra credit." You have an exceptional high-quality stream.
A set of ranges for Excellent, Medium, Poor, Very Poor has not yet been developed for this index – but… QHEI scores > 60 have been found to be "generally conducive to the existence of warmwater fauna."

Figure 6. Determining CQHEI Depth and Velocity, Riffles and Runs

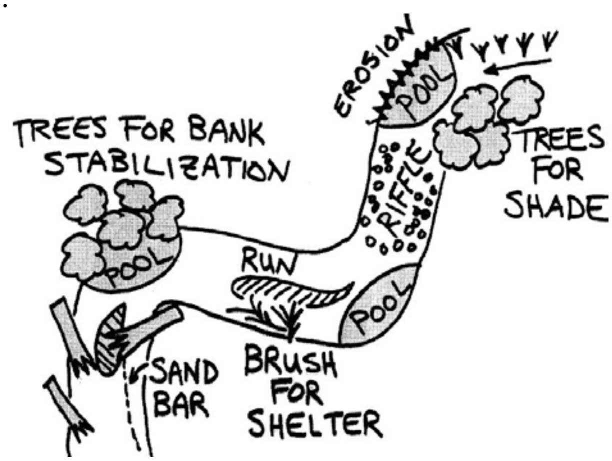


Site Map and Stream Flow

Two components of the Site Survey are not included in the Citizens Qualitative Habitat Evaluation Index (CQHEI): the Stream Site Map and Stream Flow Calculations. These are completed at your site within the same 200-foot stream segment.

Site Map

Drawing a map of your site location on the provided page in Appendix B is an excellent first step in getting to know your 200-foot stream segment. Looking at an aerial photograph before or during your visit may also help with familiarization. Continuing this tradition on an annual basis may also alert you to changes at your site that may not have been obvious during regular sampling visits. An example site map is shown below.



Stream Flow Calculations

A worksheet with diagrams and instructions is provided in Appendix B. Discharge is the amount (volume) of water flowing in the stream per second. This measurement is important because it influences other physical, chemical, and biological factors in the stream (i.e., all of our other tests!). A high discharge rate may indicate recent rainfall or snowmelt events. When a large amount of rain runs off the land, it often carries sediments and nutrients to the stream. Very low discharge rates may indicate drought conditions, which also affect water quality and aquatic life. The discharge rate is obtained by multiplying the average width, depth, and velocity of the stream. In order to be able to compare your measurements with those that other monitor groups may gather, all measurements are taken (or converted) into feet.

Average Width (W) - width of the stream (the water itself) taken from where it touches the stream bank on one side to where it touches the stream bank on the other side - take three width measurements; when possible measure areas that appear most representative of the entire 200 foot stream section

Average Depth (Z) - three depth measurements are taken (using a yardstick) across the stream on three transects - nine total measurements

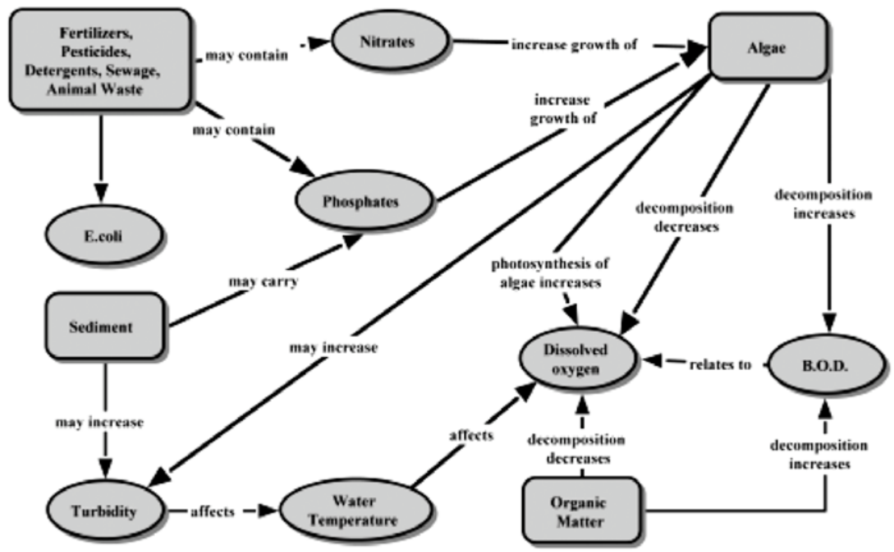
Average Velocity (V) - how fast the water is moving - measure a distance and time how long it takes an orange or fishing bobber to float the distance - repeat three times

Roughness Coefficient (n) - select 0.8 for a gravel or rocky bottom; select 0.9 for sandy, muddy or bedrock bottom.

Chemical Monitoring

Monitoring Parameters are Inter-related

Aquatic chemistry is complex and influenced by many interrelated factors. The simplified concept map (to the right) may help in understanding these relationships in an aquatic environment. The rectangles represent watershed inputs into a river or stream; the circles represent chemical parameters we measure to determine water quality.



ppm vs mg/L

What does parts per million mean? We'll explain with an example: 12 ppm of dissolved oxygen means that there are 12 molecules of oxygen in one million molecules of water. The following examples provide further understanding of these units of concentration.

One part-per-million is equal to:

- one car in bumper-to-bumper traffic from Cleveland to San Francisco
- one inch in 16 miles
- one minute in two years
- one ounce in 32 tons
- one cent in $10,000

So, how can it be that milligram per liter (mg/L) is the same as parts per million (ppm)? Well, a milligram per liter of water is equivalent to 1 ppm (part per million) because a liter of water weighs 1000 grams and a milligram is 1 one-thousandth of a gram. This is true for freshwater since the density of freshwater is 1 g/mL, but it does not hold for salt water because density increases with salinity.

The units **mg/L** and **ppm** are equal in fresh water.

They are used interchangeably throughout this exercise!

Chemical and Bacteriological Monitoring Procedures

Sample at three sites within the designated stretch of stream. Record the average of the three readings on the "Standard Chemical Monitoring Data Sheet" in Appendix B and check the appropriate box.

Temperature: Immerse a thermometer under the water surface and wait until the reading stabilizes before recording, or use other equipment as provided.

Dissolved Oxygen (D.O.): Follow the procedures specified for the equipment provided. Determine the % saturation from the table or graph in Figure 7. Hold a ruler across the graph so that one end lines up with the water temperature, and the other end crosses the bottom line at the measured oxygen content. Read % saturation where the ruler crosses the slanting line.

Supersaturation of water (when water holds much more than 100% of D.O. than it could hold under normal circumstances) for extended periods can be damaging to the respiratory systems of aquatic organisms.

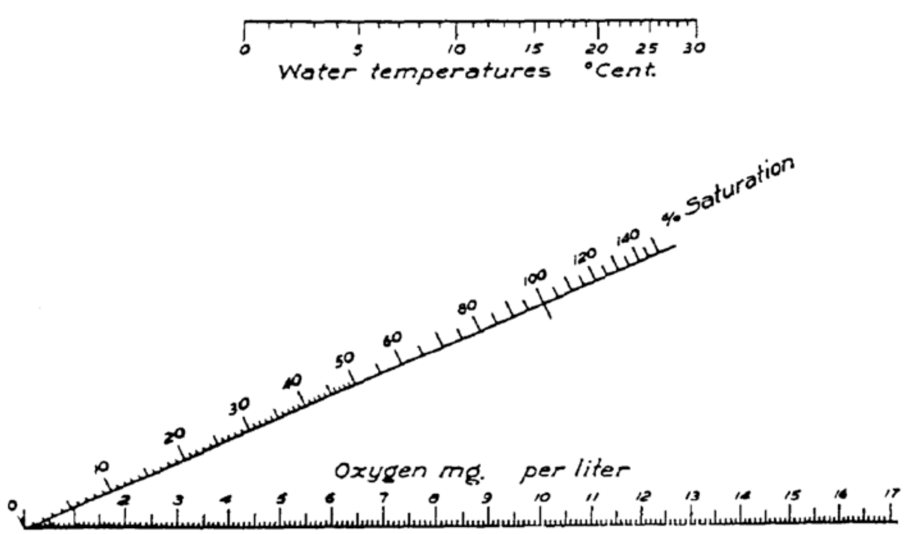
D.O. levels below 3 parts per million (ppm) are stressful to most aquatic organisms. Levels of 5 to 6 ppm are usually required for growth and activity of aquatic life.

Figure 7. Dissolved oxygen determination (Water Action Volunteers, 2003)

To determine the % Saturation of Dissolved Oxygen, use the chart at the right or the graph shown below.

Dissolved Oxygen % Saturation

Temp °C	0ppm	4ppm	8ppm
2	0	29	58
4	0	31	61
6	0	32	64
8	0	34	68
10	0	35	71
12	0	37	74
14	0	39	78
16	0	41	81
18	0	42	84
20	0	44	88
22	0	46	92
24	0	48	95
26	0	49	99
28	0	51	102
30	0	53	106



5-Day Biochemical Oxygen Demand (BOD): Completely fill a dark or foil-covered bottle to overflowing with stream water and stopper it securely. Make sure there are no air spaces at the top. Return the bottle to the lab and store in the dark at room temperature for 5 days. Use the equipment provided to record the dissolved oxygen content of the bottle. Calculate the BOD with the formula:

BOD = ppm D.O. in original sample – ppm D.O. after 5 days

BOD levels of 1-2 mg indicate clean water with little organic waste; levels of 3-5 mg = fairly clean water with some organic waste; 6-9 mg = lots of organic material and bacteria; 10+ mg = very poor water quality with large amounts of organic material in water.

pH: Use pH paper or a calibrated portable pH meter. If using a pH meter, at the stream, turn on the meter and immerse the tip in the stream. Record value when reading stabilizes. Turn the pH meter OFF after each use to lengthen battery life. pH paper is simply immersed in the water and the color that develops compared with that on the standard provided.

The largest diversity of aquatic animals is found between pH 6.5 and 8.2, though some species can tolerate values either lower than this (more acidic) or higher (more basic.)

Orthophosphate: Follow the directions contained in the kit provided.

Orthophosphate levels greater than 0.1 ppm indicate phosphorous pollution.

Nitrate nitrogen: Follow the directions for the equipment provided.

Nitrate levels greater than 2 ppm indicate water that is overenriched with nitrogen from organic or nutrient sources.

Turbidity: is the measurement of the cloudiness of the water.

1. Collect sample water in a bucket from halfway down from the water surface and upstream from where you've been walking. Do not stir up bottom sediments when collecting the sample. Return to shore.
2. Do not allow the sample to settle. Slowly pour the sample water into a turbidity tube while looking vertically down into it. When the water level reaches the point at which you can barely see the "X" or other black and white pattern on the bottom of the tube, stop pouring. Record the water level from the scale on the side of the tube.
3. Stir up the sample and repeat. Average the two readings at each of three different points in the stream.
4. Convert the average readings to NTU, a measure of the amount of light scattered by suspended material in the sample, using the table to the right.

Inches	NTU
2.5 - 2.75	240
2.76 - 3.25	185
3.26 - 3.75	150
3.76 - 4.25	120
4.26 - 4.75	100
4.76 - 5.5	90
5.6 - 6.5	65
6.6 - 7.5	50
7.6 - 8.5	40
8.6 - 9.5	35
9.6 - 10.5	30
10.6 - 11.5	27
11.6 - 12.5	24
12.6 - 13.5	21
13.6 - 14.5	19
14.6 - 15.5	17
15.6 - 16.5	15
16.6 - 17.5	14
17.6 - 18.5	13
18.6 - 19.5	12
19.6 - 20.5	11
20.6 - 21.5	10
>21.6	<10

Biological Monitoring

Coliscan Easygel Test for Detection of E. coli and other fecal coliform bacteria

Fecal coliform bacteria, including *E. coli*, are potentially pathogenic (disease-causing). This test for fecal coliforms requires that petri plates remain undisturbed for up to an hour. If this can't be assured in the field, you will need to collect a water sample from the stream and keep it on ice until you can get back to the lab and complete the test setup. Adjust the following procedure accordingly.

1. Use a marker to label the edge of a Coliscan dish with identifying information.
2. Collect a water sample from beneath the surface of the stream.
3. Use a sterile pipet and transfer 1 mL of the water into the Easygel bottle. Be careful not to touch the inside of the bottle or cap with anything in order to maintain sterile conditions.
4. Swirl the bottle to mix, then pour into the labeled Petri dish. Place lid back on dish and gently swirl until the entire dish is covered with liquid. Be careful not to splash over the side or on the lid.
5. Place dishes right-side-up on a level spot, preferably warm, until solid (up to an hour).
6. Incubate at 35°C for 24 hours or at room temperature for 48 hours.
7. Inspect the dishes and count the purple colonies (not light blue, blue-green, white, or pink). Multiply that number by 100 to determine the number of fecal coliform bacterial colonies per 100 mL of water. Record on the "Standard Chemical Monitoring Data Sheet."

Fecal coliform bacteria in excess of 200 per 100 mL (2 colonies per plate) water are unsafe for human contact and indicate contamination of water with animal or human wastes.

Benthic Macroinvertebrates

Benthic macroinvertebrates are animals that are big enough (macro) to be seen with the naked eye. They lack backbones (invertebrate) and live at least part of their lives in or on the bottom (benthos) of a body of water.

Macroinvertebrates include aquatic insects (such as mayflies, stoneflies, caddisflies, midges, beetles), snails, worms, freshwater clams, mussels, and crayfish. Some benthic macroinvertebrates, such as midges, are small and grow no larger than 1/2 inch in length. Others, like the three ridge mussel, can be over ten inches long.

Why Do We Monitor Them?

Biological monitoring focuses on the aquatic organisms that live in streams and rivers. Scientists observe changes that occur in the number of types of organisms present in a stream system to determine the richness of the biological community. They also observe the total number of organisms in an area, or the density of the community. If community richness and community density change over time, it may indicate the effects of human activity on the stream.

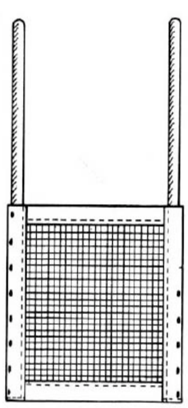
Biological stream monitoring is based on the fact that different species react to pollution in different ways. Pollution-sensitive organisms such as mayflies, stoneflies, and caddisflies are more susceptible to the effects of physical or chemical changes in a stream than other organisms. These organisms act as indicators of the absence of pollutants. Pollution-tolerant organisms such as midges and worms are less susceptible to changes in physical and chemical parameters in a stream. 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; pollution-tolerant organisms increase in variety and number.

In addition to being sensitive to changes in the stream's overall ecological integrity, benthic macroinvertebrates offer other advantages to scientists looking for indications of stream pollution:

- Benthic macroinvertebrates are relatively easy to sample. They are abundant and can be easily collected and identified by students with relatively little training.
- They are relatively immobile. Fish can escape toxic spills or degraded habitats by swimming away. Migratory animals may spend only a small portion of their life cycles in a particular stream before moving to larger rivers, wetlands, or other streams. However, most macroinvertebrates spend a large part of their life cycle in the same part of a stream, clinging to objects so they are not swept away with the water's current.
- Benthic macroinvertebrates are continuous indicators of environmental quality. The composition of a macroinvertebrate community in a stream reflects that stream's physical and chemical conditions over time. Monitoring for certain water quality parameters (such as the amount of dissolved oxygen) only describes the condition of the water at the moment in time the samples were collected.
- Benthic macroinvertebrates are a critical part of the aquatic food web. They form a vital link in the food chain connecting aquatic plants, algae, and leaf litter to the fish species in streams. The condition of the benthic macroinvertebrate community reflects the stability and diversity of the larger aquatic food web.

How Do We Collect Them?

Kick Seine or D-frame Net Riffle Sampling Method



The kick seine method is a simple procedure for collecting stream-dwelling macroinvertebrates. It is used in riffle areas where the majority of the organisms live. This method can be quite effective in determining relative stream health; *however, it is only as good as the sampling technique.* Two to three people work together to perform the method properly. Follow the procedures as closely as possible.

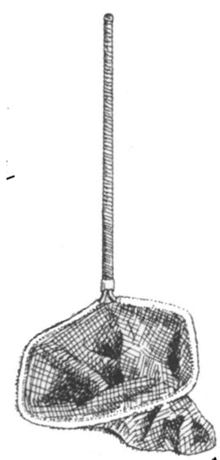
1. Locate a "typical riffle." Such a riffle is a shallow, faster moving mud-free section of stream with a streambed composed of material ranging in size from ten-inch cobbles to one-quarter inch gravel or sand. The water ranges in depth from approximately two inches to a foot, with a moderately swift flow. Avoid riffles located in an area of a stream that has been recently disturbed by anything, including construction of a pipeline crossing or roadway.
2. Once the riffle has been located, select an area measuring 3 feet by 3 feet that is typical of the riffle as a whole. Avoid disturbing the streambed upstream from this area.
3. Examine the net closely and remove any organisms remaining from the last time it was used.
4. *Approach the sampling area from downstream!*
5. Have one person place the net at the downstream edge of the sampling area. (It may take two

people to hold it in place.) The net should be held perpendicular to the flow, but at a slight downstream angle. Stretch the net approximately 3 feet, being certain that the bottom edge is lying firmly against the bed. If water washes beneath or over the net, you will lose organisms.

6. Another person comes upstream of the net. *Stand beside, not within the sampling area.* Remove all stones and other objects two inches or more in diameter from the sampling area. Hold each one below the water as you brush all organisms from the rock into the net. You can also place rocks on the bottom edge of the net to help hold it down against the stream bottom.
7. When all materials two inches or larger have been brushed, step into the upstream edge of the sampling area 3 feet from the net and kick the stream bed vigorously until you have disturbed the entire sampling area. Kick from the upstream edge toward the net. Try to disturb the bed to a depth of at least two inches. You can also use a small shovel to disturb the bed. Kick for three minutes.
8. Carefully remove the net with a forward upstream scooping motion. DO NOT allow water to flow over the top of the net or you may lose organisms.
9. Carry the seine to a flat area on the stream bank. Place it on a large white sheet, plastic tablecloth, garbage bag, or shower curtain. Remove leaves, rocks, and other debris - examine them for any attached organisms. Using fingers or forceps, remove organisms from the net and place in another container with water for later identification. If nothing appears to be on the net, leave it alone for a few minutes, and the organisms will begin to move around because they are out of the water. Be sure to check your white ground cover for any creatures attempting to escape.
10. Perform steps 1-9 a total of 3 times at different locations in riffles within your site.
11. Follow the procedures on the "Recording Form for the Citizen Monitoring Biotic Index" in Appendix B and use Figure 8 to sort all the organisms collected according to body shape. Place those that are visibly different from each other into separate cells of water-filled ice cube trays or petri dishes. Record the presence of each type of organism and calculate the Biotic Index Score.

Dip Net Sampling Method

If there are no riffles at your stream site to perform the kick seine sampling method, then you should use the dip net to perform your biological monitoring. Take a total of 20 jabs in a variety of habitats. One dip net "jab" involves forcing the dip net against the stream bottom repeatedly, starting close to your body and finishing with arms fully outstretched. However, sampling technique differs depending on habitat conditions.



- **Leaf Pack**: Shake the leaf pack in the water to release organisms, and then quickly scoop up the net, capturing both the organisms and the leaves.
- **Tree Roots, Snags (accumulations of debris), and Submerged Logs:** Select an area approximately 3 by 3 feet in size. Scrape the surface of roots, logs, or debris with the net, a large stick, or your hand or foot. Be sure the net is positioned downstream from the snag, root, or log, so that dislodged material floats into it.
- **Undercut Banks:** Place the net below the overhanging vegetation. Move the net in a bottom-up motion, jabbing at the bank several times to loosen organisms.
- **Sediments** (sand or mud): If there is not much flow, jab the net into the bottom with a sweeping motion. If stream flow is good, stand upstream of the net holding the net against the bottom of

the stream and kick in front of the net so that the flow washes organisms into the net. Finally, keeping the opening of the net at least an inch or two above the surface of the water, wash sediment out of the net by moving it back and forth in the water.

After two or three jabs with one net, dump the collected materials into a shallow white container or bin (a dishpan works well). The materials in the bin may be quite muddy and turbid (depending upon your stream habitat). Once you find macroinvertebrates in your sample, place them into another clean container (white pan, petri dish, ice cube tray) with a small amount of water for easier identification and follow the procedures described previously.

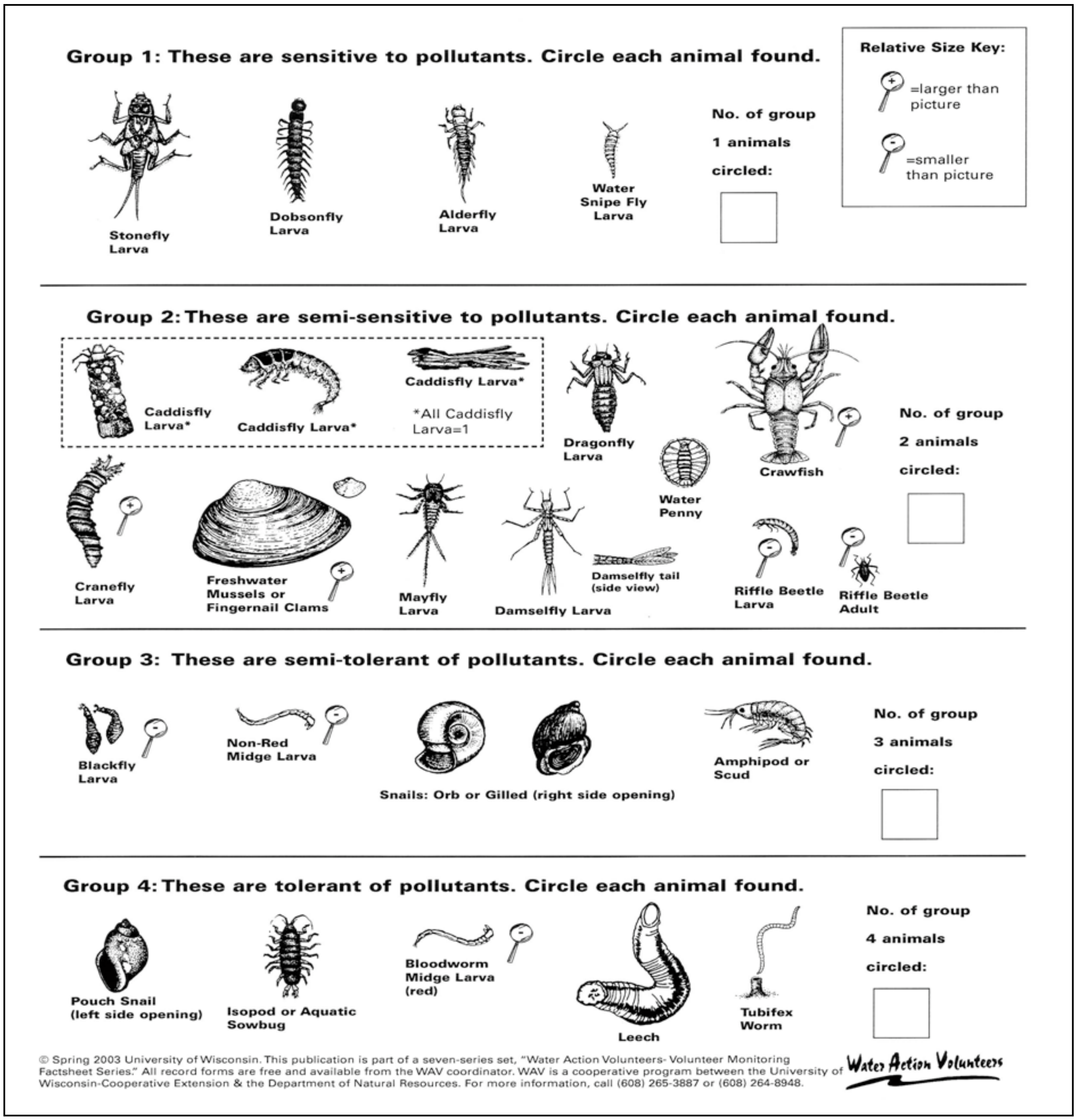


Figure 8. Stream macroinvertebrates sorted by pollution tolerance groups

Water Quality Monitoring: Post-Lab Questions

1. Human sewage is rich in plant nutrients. Why is it important for wastewater treatment plants to remove most nitrates and phosphates from sewage before discharging it into a river? What problems/damage can excess nutrients cause in a river?

2. Trout are fish that require relatively low-temperature water. Suppose a shaded trout stream has its overhanging streambank trees removed. Explain the possible effects of this action on the trout population over the course of a summer.

3. Distinguish between point and non-point sources of pollution. Provide several specific examples of each.

4. What is dissolved oxygen? Why is it important in a stream? What chemical and/or biological parameters influence the amount of dissolved oxygen in a stream?

5. Why is excess turbidity in stream water a problem? List several ways that sediment pollution might be decreased in a stream.

6. What is BOD? What problems result from high BOD? What other chemical conditions generally are associated with high BOD levels?

7. Thinking about the monitoring activity you undertook…
   A. Which of the parameters measured in your stream indicate poorer water quality?
   B. Which of the parameters measured in your stream indicate better water quality?
   C. What are some factors (chemical or other) that might impact water quality, but that weren't assessed in this exercise?
   D. Which of the tests performed, and measurements taken, do you think are the most reliable indicators of overall water quality? Why?
   E. What are the strengths and limitations of the methods used in this rapid assessment of water quality?
   F. How would you improve information gathering to produce more reliable and informative stream condition results?

Materials

(per section, unless otherwise noted)

Citizens Qualitative Habitat Evaluation Index (CQHEI)
- tape measure, 200 ft. long if possible
- loggers' flagging or two stakes to mark stream segment boundaries

Site Map and Stream Flow
- tape measure
- yardstick
- fishing bobber or orange
- stopwatch
- calculator

Chemical and Bacteriological Monitoring
- plastic collection jars for water samples (3 or more)
- thermometer or electronic temperature sensor
- dissolved oxygen test kit or electronic sensor
- ruler
- BOD bottle or foil-wrapped bottle with air-excluding stopper
- dissolved oxygen test kit or sensor
- electronic pH meter or pH paper
- phosphate test kit
- nitrate test kit or test strips
- turbidity tube
- bucket

Biological Monitoring
E. coli and other fecal coliforms:
Coliscan Easygel Test (one treated Petri dish plus one bottle of medium per test)
benthic macroinvertebrates:
- kick seines and/or d-frame nets (3)
- forceps (1 per student)
- large bore plastic dropping pipets (1 per student)
- plastic spoons (1 per student)
- dishpans, preferably white (3 or more)
- buckets (3 or more)
- ice cube trays, preferably white (6 or more)
- magnifying lenses (several)

General supplies
- plastic shower curtains for work surface, preferably white (2-3)
- hand sanitizer
- paper towels
- trashbag for debris
- bottle of distilled water for rinsing test kit materials
- Sharpie or other marker (2-3)
- first aid kit
- plastic gloves (avoid latex)
- clipboards (1 per student, optional)
- boots and/or waders (1 pair per student, optional)
- towels (optional)
- plastic ponchos (optional)

Notes for the Instructor

This field lab works best when students are divided into a number of small teams to collaborate and carry out the habitat analysis, stream flow determination, site map, chemical tests, and collection of samples for biological monitoring. We then involve all students in the sorting and identification of the collected macroinvertebrates and calculation of the biotic index. While we have successfully carried out this activity with classes as large as 28, we have also had classes as small as 12.

There is an initial period of chaos upon arrival at the stream site as students volunteer for, or are assigned to, their tasks and receive their equipment. As a group, we select the appropriate stream segment for sampling. Two students measure off the segment; one or two will collect the three water samples for chemical testing from upstream, midstream, and downstream areas within that segment, below riffles if possible. Then all students begin work to collect their data and specimens.

It is inevitable that there will be students in your class whose footwear is not suitable for being in the stream. You might assign them to carry out the chemical tests on collected water samples, to assess the habitat, or to draw the site map.

The student instructions for performing chemical tests are deliberately silent on specific procedures in order to accommodate the materials and equipment available. We have successfully used, and recommend, both Hach test kits and test strips and PASCO electronic sensors.

I recommend that plastic "glassware" be used whenever possible. For example, screw-cap peanut butter jars make excellent containers for collecting water samples. They are lightweight, won't break if dropped, and cheap! I also recommend storing and transporting all equipment for this activity in one or two plastic storage containers and 5-gallon buckets.

This entire activity can be completed by novice students within approximately two hours, not including travel time to/from the site. The methods are adapted from programs developed for volunteer citizen monitors and require no special expertise. This activity is adaptable to students of all levels, however, by extending the analyses (see "Water Quality Analysis for Fun and (Educational) Profit.")

Acknowledgements

My thanks to Lyn Hartman and the other staff and volunteers of Hoosier Riverwatch, one of the nation's preeminent volunteer water quality monitoring organizations, for permission to use portions of their 2004 Volunteer Stream Monitoring Training Manual, including some of their excellent graphics. My thanks also to the International Papers Foundation for grants which partially funded purchase of PASCO data acquisition hardware and software for the Kankapot Creek Coast Guard project.

Literature Cited

Hartman, L. and J. Hosier. 2004. Volunteer Stream Monitoring Training Manual. Hoosier Riverwatch, Indianapolis, IN 46126-1066. [posted 2004 www.state.in.us/dnr/soilcons/riverwatch]

Water Action Volunteers. 2003. Dissolved Oxygen: Aquatic Life Depends on It. University of Wisconsin, Madison, WI 53703.

Water Action Volunteers. 2001. Citizen Monitoring Biotic Index. University of Wisconsin, Madison, WI 53703.

Appendix A: Sources of equipment and supplies

- Hach Test Kit, Dissolved Oxygen OX-2P, Drop Count Titration, Fisher Scientific cat. no. NC9596139, Hach Company No. 146900
- BOD bottle, black plastic coated, with stopper and opaque cap, Fisher cat. no. 02-926-89, Wheaton No. 227667; clear glass bottle with stopper, Forestry Suppliers cat. no. 53868
- Hach Test Kit, Orthophosphate model PO-19, Hach Company cat. no. 2248-00
- Hach AquaCheck Test Strips, Phosphate, Hach Company cat. no. 27571-50
- Hach AquaCheck Test Strips, Nitrate Nitrite, Hach Company cat. no. 27454-25
- pHep 4, portable pH and temperature meter, Fisher Scientific cat no. S66103
- Coliscan Easygel, 10 tests/set, Micrology Laboratories item no. 25001, $18.50 U.S. list
- Turbidity Tube, 120 cm, Forestry Suppliers cat. no. 77096, $53.50 U.S. list
- LaMotte Student Grade Kick Net, Forestry Suppliers cat. no. 78012, $27 U.S. list
- LaMotte D-Net, Forestry Suppliers cat. no. 53788, $45 U.S. list
- PASCO Xplorer data logger, PS-2000, $149 U.S. list price, in conjunction with:
    - Temperature sensor, PS-2101, $49 U.S. list
    - pH sensor, PS-2102, $109 U.S. list
    - Dissolved oxygen sensor, PS-2108, $219 U.S. list
    - USB link for connection to computer, PS-2100, $59 U.S. list

Fisher Scientific, www.fisherscientific.com
Hach Company, www.hach.com
PASCO, www.pasco.com
Forestry Suppliers, www.forestry-suppliers.com
Micrology Labs, P.O. Box 340, Goshen, IN 46527-0340, phone 888-327-9435 (for first purchase, ask for inclusion of Colony Color Guide in addition to Coliscan Easygel materials)

Appendix B: Student data sheets and samples

Example

Date: 04-16-03

Citizens Qualitative Habitat Evaluation Index

85.5 CQHEI Total

Vol ID: 0001 Site ID: 0001 River and Watershed: White River - upper white #05120201

I. Substrate (Bottom Type) Score: 20

a) Size

- [ ] Mostly Large (Fist Size or Bigger) 14 pt
- [ ] Mostly Small (Smaller Than Fingernail, but Still Coarse, or Bedrock) 6 pt
- [x] Mostly Medium (Smaller than Fist, but Bigger than Fingernail) 10 pt
- [ ] Mostly Very Fine (Not Coarse, Sometimes Greasy or Mucky) 0 pt

b) "Smothering"

Are Fist Size and Larger Pieces Smothered By Sands/Silts?

- [x] NO 5 pt
- [ ] YES 0 pt

Symptoms: Hard to Move Large Pieces, Often Black on Bottom with Few Insects

c) "Silting"

Are Silts and Clays Distributed Throughout Stream?

- [x] NO 5 pt
- [ ] YES 0 pt

Symptoms: Light Kicking of Bottom Results in Substantial Clouding of Stream for More than a Minute or Two

II. Fish Cover (Hiding Places) - Add 2 Points For Each One Present Score: 14

- [x] Underwater Tree Roots (Large) 2 pt
- [ ] Boulders 2 pt
- [x] Downed Trees, Logs, Branches 2 pt
- [ ] Water Plants 2 pt
- [ ] Undercut Banks 2 pt
- [x] Underwater Tree Rootlets (Fine) 2 pt
- [x] Backwaters, Oxbows or Side Channels 2 pt
- [x] Shallow, Slow Areas for Small Fish 2 pt
- [x] Deep Areas (Chest Deep) 2 pt
- [x] Shrubs, Small Trees that Hang Close Over the Bank 2 pt

III. Stream Shape and Human Alterations Score: 15

a) "Curviness" or "Sinuousity" of Channel

- [ ] 2 or More Good Bends 8 pt
- [x] 1 or 2 Good Bends 6 pt
- [ ] Mostly Straight Some "Wiggle" 3 pt
- [ ] Very Straight 0 pt

b) How Natural Is The Site?

- [ ] Mostly Natural 12 pt
- [ ] Many Man-made Changes, but still some natural conditions left (e.g., trees, meanders) 6 pt
- [x] A Few Minor Man-made Changes (e.g., a bridge, some streambank changes) 9 pt
- [ ] Heavy, Man-made Changes (e.g., leveed or channelized) 0 pt

IV. Stream Forests & Wetlands (Riparian Area) & Erosion Score: 13.5

a) Width of Riparian Forest & Wetland - Mostly: (Avg 4 pts.)

- [x] Wide (Can't Throw A Rock Through/ Across It) 8 pt
- [ ] Narrow (Can Throw A Rock Through/ Across It) 5 pt
- [x] None 0 pt

b) Land Use - Mostly: (Avg 3.5 pts)

- [x] Forest/Wetland 5 pt
- [ ] Conservation Tillage 2 pt
- [ ] Shrubs 4 pt
- [ ] Suburban 1 pt
- [ ] Overgrown Fields 3 pt
- [ ] Row Crop 1 pt
- [ ] Fenced Pasture 2 pt
- [ ] Open Pasture 0 pt
- [x] Park (Grass) 2 pt
- [ ] Urban/ Industrial 0 pt

c) Bank Erosion - Typically:

- [x] Stable Hard or Well-Vegetated Banks 4 pt
- [ ] Combination of Stable and Eroding Banks 2 pt
- [ ] Raw, Collapsing Banks 0 pt

d) How Much of Stream is Shaded?

- [ ] Mostly 3 pt
- [x] Partly 2 pt
- [ ] None 0 pt

V. Depth & Velocity Score: 13

a) Deepest Pool is At Least:

- [x] Chest Deep 8 pt
- [ ] Knee Deep 4 pt
- [ ] Waist Deep 6 pt
- [ ] Ankle Deep 0 pt

b) Check ALL The Flow Types That You See (Add Points):

- [ ] Very Fast: Hard to Stand in the Current 2 pt
- [x] Moderate: Slowly Takes Objects Downstream 1 pt
- [x] None 0 pt
- [x] Fast: Quickly Takes Objects Downstream 3 pt
- [x] Slow: Flow Nearly Absent 1 pt

IV. Riffles/Runs (Areas Where Current is Fast/Turbulent, Surface May Be Broken) Score: 10

a) Riffles/Runs Are:

- [ ] Knee Deep or Deeper & Fast 8 pt
- [ ] Ankle Deep or Less & Slow 4 pt
- [x] Ankle/Calf Deep & Fast 6 pt
- [ ] Do Not Exist 0 pt

b) Riffle/Run Substrates Are:

- [ ] Fist Size or Larger 7 pt
- [ ] Smaller Than Your Fingernails or Do Not Exist 0 pt
- [x] Smaller Than Fist Size, but Larger Than Fingernail 4 pt

24

www.HoosierRiverwatch.com

Date: ______

Citizens Qualitative Habitat Evaluation Index

CQHEI Total ______

Vol ID: ______ Site ID: ______ River and Watershed: ______

I. Substrate (Bottom Type) Score: ______

a) Size

- ☐ 14 pt — Mostly Large (Fist Size or Bigger)
- ☐ 6 pt — Mostly Small (Smaller Than Fingernail, but Still Coarse, or Bedrock)
- ☐ 10 pt — Mostly Medium (Smaller than Fist, but Bigger than Fingernail)
- ☐ 0 pt — Mostly Very Fine (Not Coarse, Sometimes Greasy or Mucky)

b) "Smothering"

Are Fist Size and Larger Pieces Smothered By Sands/Silts?

- ☐ NO 5 pt
- ☐ YES 0 pt

Symptoms: Hard to Move Large Pieces, Often Black on Bottom with Few Insects

c) "Silting"

Are Silts and Clays Distributed Throughout Stream?

- ☐ NO 5 pt
- ☐ YES 0 pt

Symptoms: Light Kicking of Bottom Results in Substantial Clouding of Stream for More than a Minute or Two

II. Fish Cover (Hiding Places) - Add 2 Points For Each One Present Score: ______

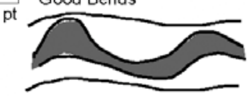
- ☐ 2 pt — Underwater Tree Roots (Large)
- ☐ 2 pt — Boulders
- ☐ 2 pt — Downed Trees, Logs, Branches
- ☐ 2 pt — Water Plants
- ☐ 2 pt — Undercut Banks
- ☐ 2 pt — Underwater Tree Rootlets (Fine)
- ☐ 2 pt — Backwaters, Oxbows or Side Channels
- ☐ 2 pt — Shallow, Slow Areas for Small Fish
- ☐ 2 pt — Deep Areas (Chest Deep)
- ☐ 2 pt — Shrubs, Small Trees that Hang Close Over the Bank

III. Stream Shape and Human Alterations Score: ______

a) "Curviness" or "Sinuousity" of Channel

- ☐ 8 pt — 2 or More Good Bends

- ☐ 6 pt — 1 or 2 Good Bends



- ☐ 3 pt — Mostly Straight Some "Wiggle"

- ☐ 0 pt — Very Straight

b) How Natural Is The Site?

- ☐ 12 pt — Mostly Natural
- ☐ 6 pt — Many Man-made Changes, but still some natural conditions left (e.g., trees, meanders)
- ☐ 9 pt — A Few Minor Man-made Changes (e.g., a bridge, some streambank changes)
- ☐ 0 pt — Heavy, Man-made Changes (e.g., leveed or channelized)

IV. Stream Forests & Wetlands (Riparian Area) & Erosion Score: ______

a) Width of Riparian Forest & Wetland - Mostly:

- ☐ 8 pt — Wide (Can't Throw A Rock Through/ Across It)
- ☐ 5 pt — Narrow (Can Throw A Rock Through/ Across It)
- ☐ 0 pt — None

b) Land Use - Mostly:

- ☐ 5 pt — Forest/Wetland
- ☐ 2 pt — Conservation Tillage
- ☐ 4 pt — Shrubs
- ☐ 1 pt — Suburban
- ☐ 3 pt — Overgrown Fields
- ☐ 1 pt — Row Crop
- ☐ 2 pt — Fenced Pasture
- ☐ 0 pt — Open Pasture
- ☐ 2 pt — Park (Grass)
- ☐ 0 pt — Urban/ Industrial

c) Bank Erosion - Typically:

- ☐ 4 pt — Stable Hard or Well-Vegetated Banks
- ☐ 2 pt — Combination of Stable and Eroding Banks
- ☐ 0 pt — Raw, Collapsing Banks

d) How Much of Stream is Shaded?

- ☐ 3 pt — Mostly
- ☐ 2 pt — Partly
- ☐ 0 pt — None

V. Depth & Velocity Score: ______

a) Deepest Pool is At Least:

- ☐ 8 pt — Chest Deep
- ☐ 4 pt — Knee Deep
- ☐ 6 pt — Waist Deep
- ☐ 0 pt — Ankle Deep

b) Check ALL The Flow Types That You See (Add Points):

- ☐ 2 pt — Very Fast: Hard to Stand in the Current
- ☐ 1 pt — Moderate: Slowly Takes Objects Downstream
- ☐ 0 pt — None
- ☐ 3 pt — Fast: Quickly Takes Objects Downstream
- ☐ 1 pt — Slow: Flow Nearly Absent

VI. Riffles/Runs (Areas Where Current is Fast/Turbulent, Surface May Be Broken) Score: ______

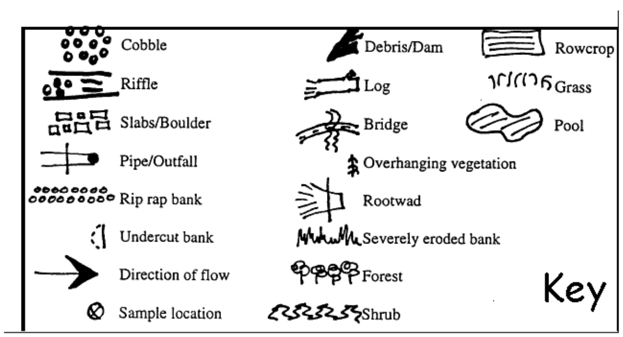
a) Riffles/Runs Are:

- ☐ 8 pt — Knee Deep or Deeper & Fast
- ☐ 4 pt — Ankle Deep or Less & Slow
- ☐ 6 pt — Ankle/Calf Deep & Fast
- ☐ 0 pt — Do Not Exist

b) Riffle/Run Substrates Are:

- ☐ 7 pt — Fist Size or Larger
- ☐ 0 pt — Smaller Than Your Fingernails or Do Not Exist
- ☐ 4 pt — Smaller Than Fist Size, but Larger Than Fingernail

Stream Site Map



Hoosier Riverwatch Stream Flow Calculation Worksheet

Example

1. River Width (W)

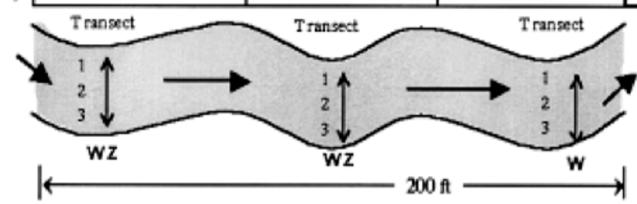
(One measurement at each transect.)

Transect #	Width (ft)	
(1)	10.33	(10ft 4in)
(2)	9.67	(9ft 8in)
(3)	11.0	(11 ft)
Average Width (W)	10.33 ft	

2. River Depth (Z)

(Three measurements along each transect.)

	Transect 1 (ft)	Transect 2 (ft)	Transect 3 (ft)	
(1)	.83 (10in)	1 ft	1.22 (1ft 6.5in)	
(2)	1.42 (1ft 5in)	1.58 (1ft 7in)	1.11 (1ft 1/3in)	
(3)	1.08 (1ft 1in)	.58 (7in)	1.33 (1ft 4in)	
Average Depth (Z)	1.39 ft	1.05 ft	1.22 ft	1.22 ft



3. Surface Velocity(V) = Length/Time

(Allow the object to attain velocity before timing it.)

	Length (ft)	Time (sec)	Velocity ft/sec
(1)	10	25	.4
(2)	10	28	.36
(3)	10	26	.38
		Average Velocity (V)	.38

Unit Conversions
1 in = 0.0833 ft 1 m = 3.281 ft

4. Stream Flow = Discharge (D)

Avg. Width (W)	10.33	feet
Avg. Depth (Z)	1.22	feet
Avg. Velocity (V)	.38	feet/sec
*(n) = 0.9 or 0.8	.8	none
Discharge (D)	3.83	ft^3/s = (cfs)

Multiply W x Z x V x n = D

*n is a constant indicating roughness of substrate - use 0.9 for sandy, muddy bottom or bedrock; use 0.8 for gravel or rocky bottom

Convert measurements of feet + inches to 10ths of feet. **Example: 10 ft + 4 in = 10.33 ft.** (Multiply 4 inches x 0.0833 feet/inch = 0.3332 ft. Add this to 10 feet → 10.33 feet.)

Stream Flow Calculation Worksheet

1. River Width (W)

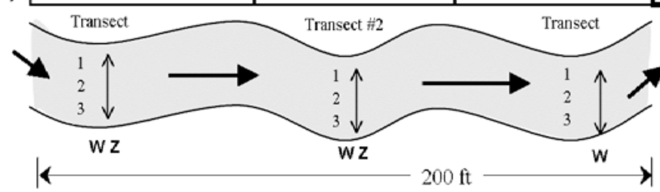
(One measurement at each transect.)

Transect #	Width (ft)
(1)	
(2)	
(3)	
Average Width (W)	

2. River Depth (Z)

(Three measurements along each transect.)

	Transect 1 (ft)	Transect 2 (ft)	Transect 3 (ft)	
(1)				
(2)				
(3)				
Average Depth (Z)				



3. Surface Velocity(V) = Length/Time

(Allow the object to attain velocity before timing it.)

	Length (ft)	Time (sec)	Velocity ft/sec
(1)			
(2)			
(3)			
		Average Velocity (V)	

Unit Conversions
1 in = 0.0833 ft 1 m = 3.281 ft

4. Stream Flow = Discharge (D)

Avg. Width (W)		feet
Avg. Depth (Z)		feet
Avg. Velocity (V)		feet/sec
*(n) = 0.9 or 0.8		none
Discharge (D)		ft^3/s = (cfs)

Multiply W x Z x V x n = D

*n is a constant indicating roughness of substrate - use 0.9 for sandy, muddy bottom or bedrock; use 0.8 for gravel or rocky bottom

Convert measurements of feet + inches to 10ths of feet. **Example: 10 ft + 4 in = 10.33 ft.** (Multiply 4 inches x 0.0833 feet/inch = 0.3332 ft. Add this to 10 feet 10.33 feet.)

Recording Form for the Citizen Monitoring Biotic Index

Name:______________________________ Date:______________

Watershed and Stream Names:______________________________ Time:______________

Location:______________________________ Site ID:______________
(County, Township, Range, Section, Road, Intersection, Other)

At this point, you should have collected a wide variety of aquatic macroinvertebrates from your three sites. You will now categorize your sample, using the chart (other side) to help you identify the macroinvertebrates found. The number of animals found is not important; rather, the variety of species and how they are categorized tells us the biotic index score. Before you begin, check off the sites from which you collected your sample (see right).

- ☐ Riffle Sampling
- ☐ Snag Areas, Tree Roots, Submerged Logs
- ☐ Leaf Packs
- ☐ Undercut Banks

1. Check the basin with the debris to see if any aquatic macroinvertebrates crawled out. Add these animals to your prepared sample.
2. Fill the ice cube tray half-full with water.
3. Using plastic spoons or tweezers, (be careful not to kill the critters -- ideally, you want to put them back in their habitat after you're finished) sort out the macroinvertebrates and place same species together in their own ice cube tray compartments. Sorting and placing same species together will help insure that you find all varieties of species in the sample.
4. Refer to the "Key to Macroinvertebrate Life in the River" and the Citizen Monitoring Biotic Index to identify the macroinvertebrates:

   A. On the back of this page, circle the animals on the index that match those found in your sample.

   B. Count the number of circled animals in each category and write that number in the box provided.

   C. Enter each boxed number in work area below.

   D. Multiply the entered number from each category by the category value.

   E. Do this for all categories.

   F. Total the number of animals circled.

   G. Total the values for each category.

   H. Divide the total values by the total number of animals: total values (b) / total animals (a).

   I. Record this number.

   SHOW ALL MATH (Use space below to do your math computations)

No. of animals from group 1 _________ x 4=_________

Return form to:

No. of animals from group 2 _________ x 3=_________

No. of animals from group 3 _________ x 2=_________

No. of animals from group 4 _________ x 1=_________

TOTAL ANIMALS(a)______ TOTAL VALUE(b)________

Divide totaled value (b)______by total no. of animals (a) ______for index score:

Index score:

Call your local Monitoring Coordinator if you have questions about sampling or determining the Biotic Index Score.

How Healthy is the Stream?

Excellent-------3.6+
Good----------2.6 - 3.5
Fair-----------2.1 - 2.5
Poor-----------1.0 - 2.0