Volunteer Stream Monitoring
Training Manual
2022

HOOSIER
RIVERWATCH

Education
Monitoring
Preservation
Improvement

INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

Indiana Department of Environmental Management

www.idem.IN.gov/riverwatch

www.HoosierRiverwatch.com

The original training manual was developed by Hoosier Riverwatch staff in 1997. This manual represents many revisions and updates, and is the tenth edition. Special thanks to Lyn Crighton, Lisa Ritter-McMahan, Katie Hodgdon, Jan Sneddon, Mandy Burk, Jeff Muse, Gwen White, and Sarah Hippensteel for their contributions through the years. The beautiful large-scale graphics were created by Sarah Beth Lauterbach, unless otherwise indicated.

Password: ______________________________

Volunteer ID: ______________________________

Site ID: ______________________________

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Org ID: ______________________________

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Welcome to Hoosier Riverwatch

About the Program

Hoosier Riverwatch is a program of the Indiana Department of Environmental Management (IDEM), Office of Water Quality. The program began in Indiana in 1996 to increase public awareness of water quality issues and concerns by training volunteers to monitor stream water quality. The State of Indiana has a surface area of approximately 36,532 square miles. There are over 100,000 miles of rivers, streams, ditches and drainage ways in Indiana. In addition, there are approximately 35,673 miles of surface waterways in Indiana greater than one mile in length.

The mission of Hoosier Riverwatch is: "To involve the citizens of Indiana in becoming active stewards of Indiana's water resources through watershed education, water monitoring, and clean-up activities."

We accomplish this mission through the following goals:

- Educate citizens on watersheds and the relationship between land use and water quality.
- Train citizens on the basic principles of water quality monitoring.
- Promote opportunities for involvement in water quality issues.
- Provide water quality information to individuals or groups working to protect water resources.
- Support volunteer efforts through technical assistance, and providing monitoring equipment, networking opportunities, and educational materials.

Hoosier Riverwatch staff will assist you and your organization in understanding the importance of protecting local streams. Voluntary participation is the key to success of any statewide stream monitoring and education program. This manual provides information to help you begin a successful water quality monitoring program.

For more information about Hoosier Riverwatch, a schedule of upcoming workshops, or to sign up for an electronic subscription to our ***Riffles & Pools*** newsletter, go to: www.idem.IN.gov/riverwatch or contact us at:

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IOWATER/Iowa Department of Natural Resources
Kentucky Water Watch
LaMotte Company
Ohio Department of Natural Resources
Ohio Environmental Protection Agency
Tennessee Valley Authority
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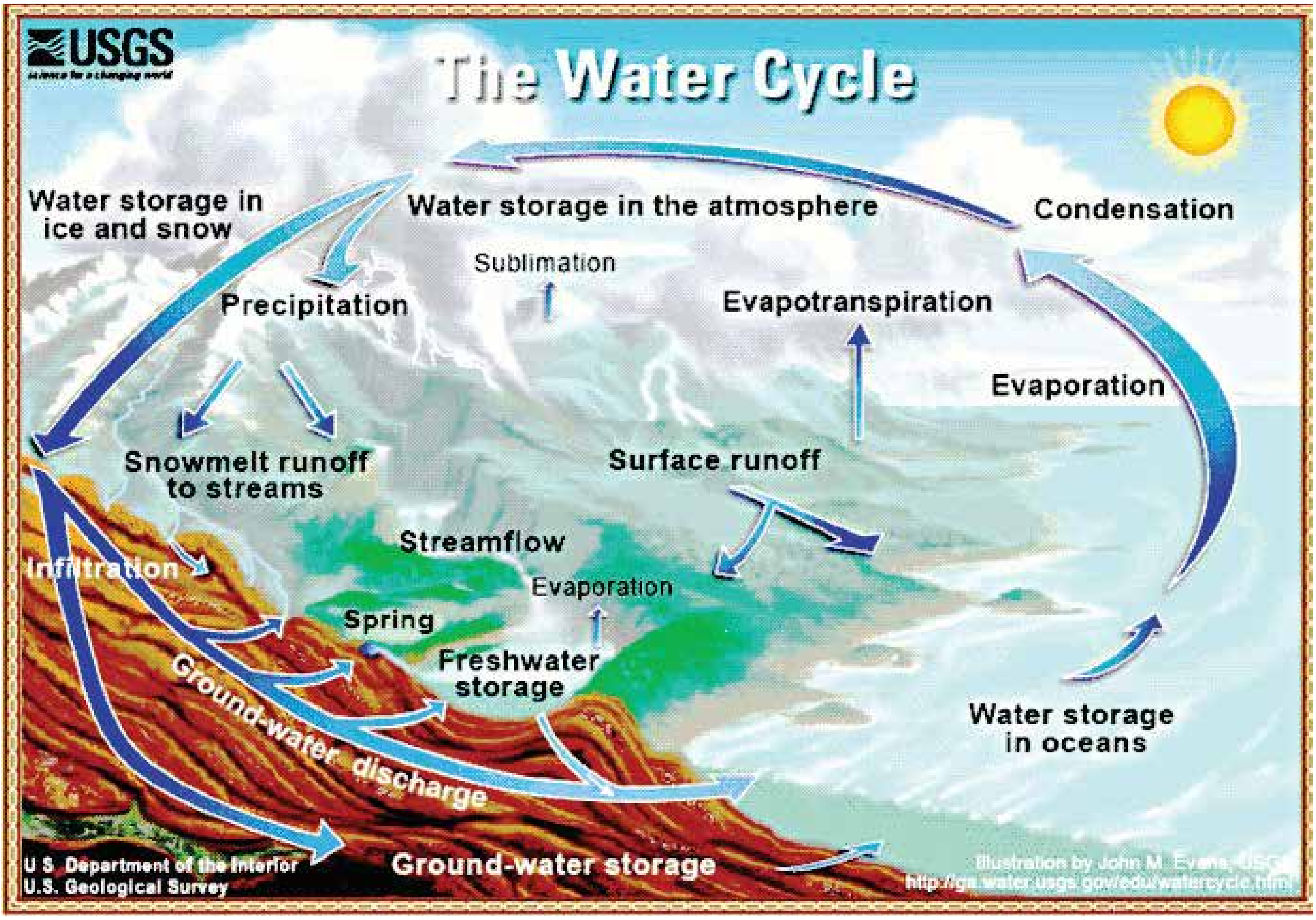
Chapter 1 -
Introduction to Water Quality Monitoring

How do Volunteers Get Started?

Water is important for many reasons, from recreation to irrigation for agriculture. Further, plants and animals rely on clean water. Water covers over 70% of the Earth's surface and makes-up 50 – 80% of every living thing. Fresh, clean, drinkable water constitutes only one half of one percent of all the Earth's water. Therefore, we all have a responsibility to manage and maintain our water resources and one way we can accomplish this is through water quality monitoring.

Figure 1



The amount of water on Earth is the same at all times and has been the same throughout the history of the Earth. The state of water can change (liquid, solid, gas) as it moves through the water cycle (Figure 1), but the total amount of water doesn't change.

Monitoring Parameters

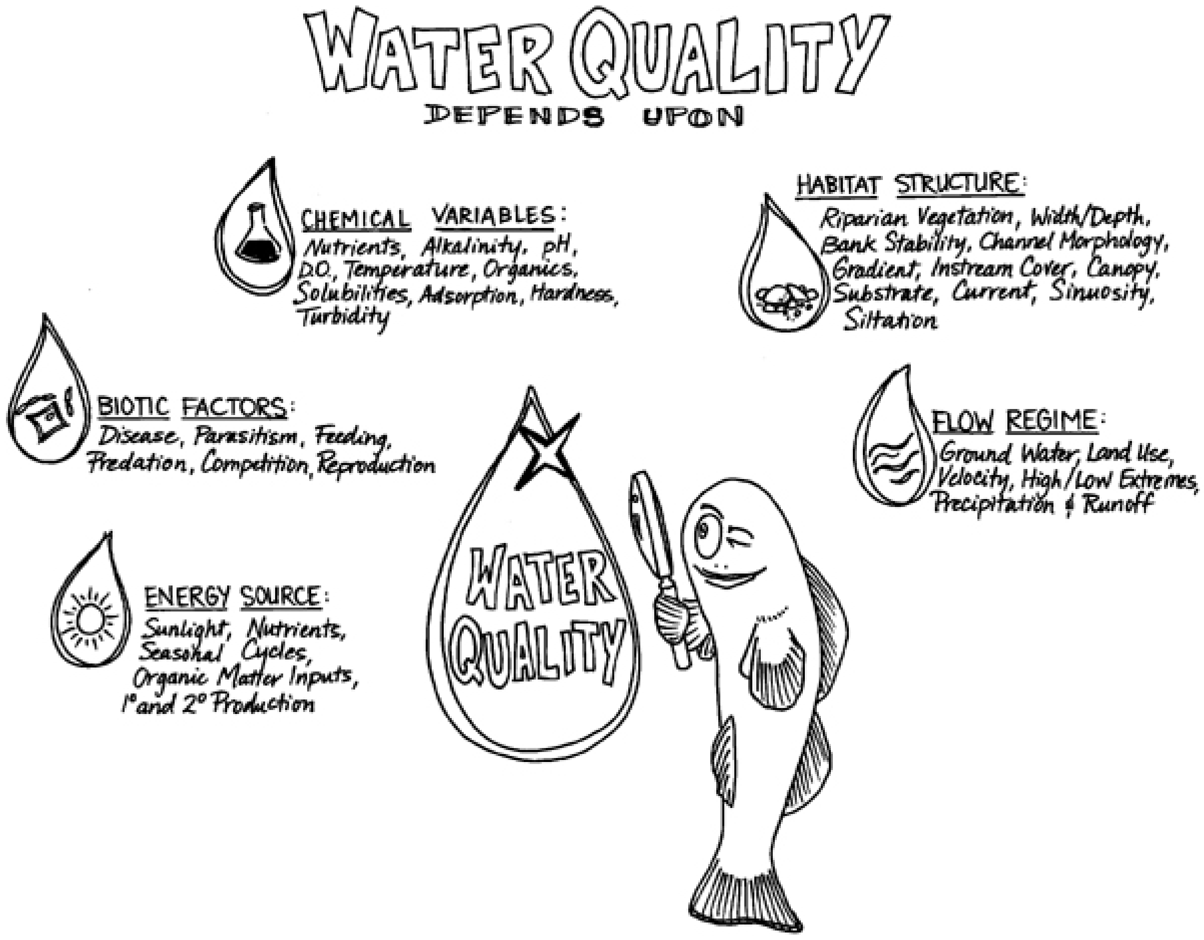
Water quality is determined by a variety of factors (Figure 2). However, due to time and resource constraints, Hoosier Riverwatch volunteers only monitor a fraction of the possible parameters.

Habitat - Land use, Substrate, Flow, Depth, Riparian Vegetation, Stream Shape, Erosion

Chemical - Dissolved Oxygen, *E. coli*, Nitrate, Turbidity, Phosphate, pH, BOD, Temperature change

Biological - Benthic Macroinvertebrates

Figure 2



Training Workshops

To start a successful local Hoosier Riverwatch monitoring program, you should attend a training workshop and thoroughly read this manual. **Volunteer Stream Monitoring Training** introduces citizens and educators to water quality monitoring utilizing physical, chemical, and biological assessment methods. After completion of this training, participants become “Certified Volunteer Monitors.” Riverwatch volunteers are able to perform stream testing, submit data to the statewide volunteer stream monitoring database, and teach students how to monitor.

Equipment Application Program

Hoosier Riverwatch has been awarding water monitoring equipment to volunteer groups since 1996. Equipment recipients form the foundation of the Hoosier Riverwatch volunteer stream monitoring network. These volunteers agree to monitor their selected stream or river segments at least four times per year for two years and must attend a Riverwatch training workshop. Any school, nonprofit organization, or governmental agency in Indiana is eligible to apply. Contact Hoosier Riverwatch for this year's guidelines and application procedures. Equipment packages offered:

- **Chemical Testing Equipment**
  This package provides simple chemical testing methods suitable for adults with no previous experience, as well as students from the elementary through college level. This package provides tests for dissolved oxygen, BOD, temperature, phosphate, nitrate, nitrite, pH and turbidity.

  [See Appendix A for information on the testing equipment Hoosier Riverwatch uses.]

Figure 3

- **Biological Monitoring Equipment**
  This package includes equipment necessary to sample a shallow (wadeable) stream or river site for benthic macroinvertebrates – aquatic organisms living in the streambed. Supplies provided include sampling nets and identification keys. If your site is too deep for this type of monitoring, you do not need this equipment.

- **Both the Chemical Testing and Biological Monitoring Equipment Packages**

Citizen/Individual Volunteer Participation
Although individual citizens cannot receive equipment through the application program (because equipment packages are awarded to organizations), you can still participate in the program! Volunteer stream monitoring equipment is available (Figure 3) to be checked out and used through Riverwatch loaner sites established throughout the state. Check the web at www.idem.IN.gov/riverwatch/2334.htm to find loaner kits near you. In addition, see *Appendix A – Monitoring Equipment* for information on purchasing or making your own sampling equipment.

Organizing Your Group
To get a "Riverwatchers" group started in your area, begin by contacting existing organizations already involved with stream or lake activities. A successful Hoosier Riverwatch group can use the support of a well-organized and like-minded constituency. Some individuals and/or organizations that you may want to contact for support include: citizen and civic groups, local government officials, lake associations, university specialists, community health officials, water utilities, canoe or fishing clubs, and county Soil and Water Conservation Districts. Contact the IDEM watershed specialist for your area to assist with your efforts. See page 155 in the appendices for specialist contact information.

Safety

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

- **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. The right of public access to Indiana streams is determined by whether the waterway is classified as "navigable." While all flowing surface water in Indiana is owned by its citizens, the public may only enter or access without permission the streambeds and banks (up to the Ordinary High Water Mark) of navigable waterways. The streambeds and banks of non-navigable waterways are privately owned and, therefore, require permission to enter or access. To learn if a particular stream is navigable, non-navigable, or currently unclassified, please refer to. www.in.gov/nrc/nonrule-policy-documents-npd/navigable-waterways-roster.
- **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. If you have a potential drowning situation, remember the lifeguarding tenant: Reach, Throw, Go! First, try to reach with a pole, net, branch, or yardstick. Then, throw something (life preserver) that floats or that is tied with a rope and will enable you to pull him/her into shore. Only attempt a swimming rescue as a last resort. A drowning person can panic and pull you under, too.
- **Beware of polluted streams that are known to be unsafe for handling.** Check with your County Health Department or the Indiana Department of Environmental Management 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 eye wear. Never drink the water in a stream. Wash with soap if your hands have been in contact with stream water.
- **Have a first aid kit on hand.** Preferably, at least one team member should have first aid/CPR training. Your first aid kit should contain the following items (at a minimum):

  ☐ Several bandages for minor cuts
  ☐ Antibacterial soap or alcohol wipes
  ☐ First aid cream or ointment
  ☐ Several gauze pads 3-4" square for deep wounds with excessive bleeding
  ☐ Aspirin or other pain reliever/fever reducer
  ☐ A needle and tweezers for removing splinters
  ☐ A first aid manual that outlines diagnosis and treatment procedures
  ☐ A single-edged razor blade for minor surgery and cutting tape to size
  ☐ A 2"-wide roll of gauze and a triangular bandage for large wounds
  ☐ A large compress bandage to hold a dressing in place
  ☐ A 3"-wide elastic band for sprains, applying pressure to bleeding wounds
  ☐ If a participant is sensitive to bee stings, include their doctor-prescribed antihistamine
  ☐ An eyewash to flush chemicals
  ☐ Telephone numbers of emergency personnel

- **Develop a safety plan.** Take a cell phone with you. Locate the nearest medical center and write down directions for traveling there. Have a medical form for each volunteer monitor including emergency contacts, insurance and pertinent health information such as allergies, diabetes or epilepsy.

- **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 animals and plants.** Watch for irate dogs, farm animals, wildlife (e.g., snakes), and insects such as ticks, mosquitoes, and hornets. Know what to do if you are bitten or stung. Watch for poison ivy, sumac, giant hogweed, and other skin-irritating vegetation.

The chemical reagents supplied in the testing kits are laboratory grade reagents. Some of the chemicals are concentrated, some are irritating, some are poisonous and some will just make you itch. Please read thoroughly the directions and the Safety Data Sheets (SDS) provided with each kit. The reagents provided in the CHEMetrics kits are mild skin and eye irritants.

- **Wear safety goggles and rubber gloves.** Avoid contact between chemical reagents and your skin, eyes, nose, and mouth. Never use your fingers to stopper a bottle when shaking a solution.
- **Do not mix chemicals indiscriminately.** Use only the designated chemicals in specified amounts when performing tests.
- **Provide wash water** at the monitoring site to wash any chemicals from the eyes or the body.
- **Know chemical clean-up, disposal, and first aid procedures. Wipe up all spills when they occur.** Use sealed plastic containers filled with an absorbent material (e.g., kitty litter) to store waste before disposal. If accidental consumption of chemical reagents occurs, have your SDS on hand and contact your local poison control office or one of the following:

Phone Numbers for EMERGENCY only:

Indiana Poison Control Center	**(800) 382-9097**
Rocky Mountain Poison Center	**(800) 623-5716**

- **A first aid kit may not be enough. In addition, carry such safety equipment as life buoys, life jackets, river rescue throw bag, a flashlight, a whistle and insect repellent.**

These guidelines were adapted from the Environmental Protection Agency's 1997 Volunteer Stream Monitoring Manual.

Prevent the Spread of Aquatic Invasive Species (AIS)

As Riverwatch volunteers, you will be coming into regular contact with Indiana's waters. As a result, we would like you to help us prevent the spread of aquatic invasive species (see chapter 6 for more information).

- Remove all mud and plants from sampling equipment before transporting.
- Drain all water from equipment before transporting.
- If multiple locations on a stream are sampled in the same day, begin upstream and work downstream. If working in this order no drying or decontamination of equipment is necessary. If an upstream area is infested with an invasive then downstream areas likely are also. An infested downstream area does not necessarily mean upstream areas are infested too. This is why you should sample from upstream to downstream.
- Equipment decontamination is necessary following each sampling location if working from downstream to upstream or working on different water bodies in the same day. The simplest decontamination is to rinse equipment well with 104° F or hotter water.
- Ideally, sampling of different water bodies should be put off for 5 days following the last sampling. Sampling gear should be allowed to completely dry during these 5 days to allow any unseen hitchhikers to die.
- Dispose of unwanted live bait and worms in trash.
- NEVER transfer plants, fish, or animals to another body of water. They should only be released if they came out of that body of water.

STOP AQUATIC HITCHHIKERS!™

Prevent the transport of nuisance species.
Clean all recreational equipment.
www.ProtectYourWaters.net

When you leave a body of water:

- Remove any visible mud, plants, fish or animals before transporting equipment.
- Eliminate water from equipment before transporting.
- Clean and dry anything that comes into contact with water (boats, trailers, equipment, clothing, dogs, etc.).
- Never release plants, fish or animals into a body of water unless they came out of that body of water.

A Few More Details Before We Get Started...

Volunteer Monitoring Network

There is no national volunteer water quality monitoring program, but many states have a statewide program with their own set of parameters and methods. Our neighboring states, Ohio, Illinois, Kentucky, and Wisconsin have statewide volunteer stream and river monitoring programs. Hoosier Riverwatch has many state and national partners with whom we collaborate; we are truly part of something bigger. In Indiana, many lakes are also monitored by volunteer monitors who are trained and coordinated through IU/SPEA with funding from IDEM. Could there be one in your area?

What You Can Expect From Hoosier Riverwatch

What is Hoosier Riverwatch's role in our partnership with you? Our primary responsibilities are to provide hands-on training, as well as supply water monitoring equipment, ongoing technical support, information and education, and maintenance of the online volunteer stream monitoring database (www.hoosierriverwatch.com). Our job is to empower you, to provide you with help and support to monitor Indiana's water quality, and to help you find solutions to problems if they arise.

Riverwatch Wouldn't Exist Without You

As a volunteer monitor, you have the freedom to monitor when and where (with permission from private property owners) you choose. You should make these decisions based on your monitoring goals and monitoring plan. Remember, you are the primary user of the data collected, but it is possible that it could also be of interest to others (e.g., Indiana Department of Environmental Management, consultants, universities, local governmental agencies and watershed groups). The best way to share your data and for your data to be used is to submit it to the Hoosier Riverwatch database. Your findings, as a volunteer, may indicate that professional testing is needed to determine the extent of a potential problem.

Preparation for Participation

You're going to learn a lot of new information as you attend a Riverwatch training workshop or read through this training manual on your own. You may feel a little overwhelmed with new information at times. But, we guarantee that with some advanced preparation (e.g., planning, scheduling, financing, networking, gaining permission, and possibly getting through a little red tape) and practice with the equipment and data sheets, any educator, community group, or interested citizen can make a difference by participating in this program.

Take a deep breath and relax! You will be fine!

Smile - this stuff is fun!

Chapter 2 - Designing a Water Monitoring Study

The first step in developing a water monitoring study design is identifying your watershed. The ability of a stream to support beneficial uses such as fishing, boating and swimming is influenced by the major land uses in the watershed, the nature of the stream channel, the diversity of in stream habitats, and the character of the riparian area.

Planning is critical to a successful water monitoring program. Knowing why you are monitoring will determine where, when, and how often you monitor.

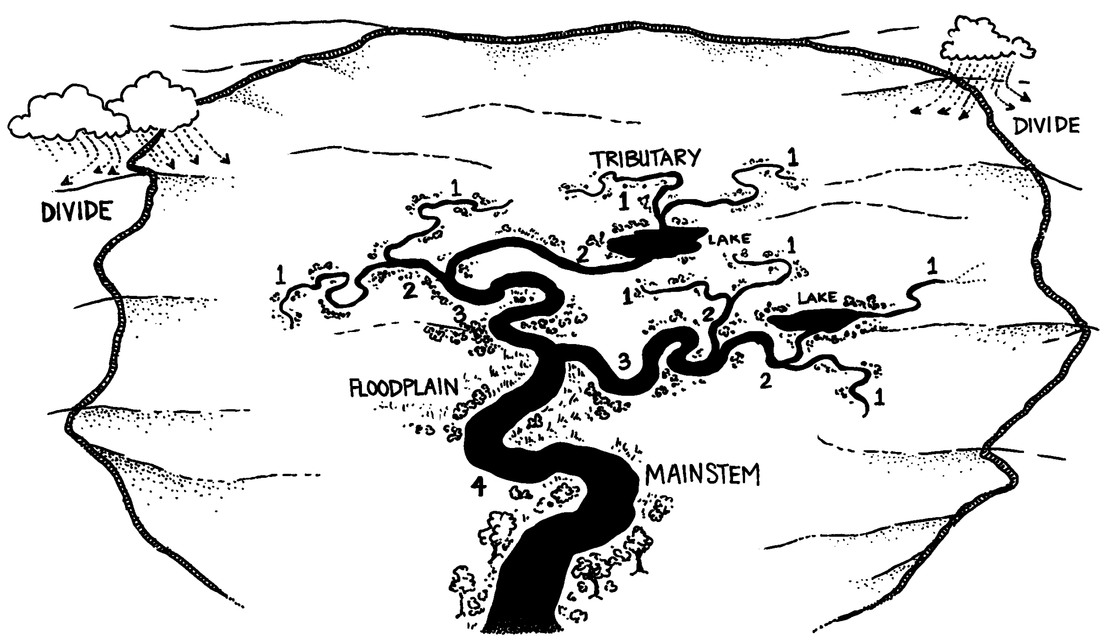
What is Your Stream Address?

"Just as everyone in Indiana lives within the boundaries of a county, everyone also lives within a watershed; although we may live, work or play in different watersheds or in different parts of the same watershed." A watershed is the total area of land that drains into a particular waterbody (wetland, stream, river, lake, or sea). Land uses and run-off in a watershed determine the quality of surface water in smaller streams and waterways. They can then influence the water quality of larger streams. For example, point source discharges, urban run-off from landfills and run-off from agricultural areas may contain sediments, organic material, nutrients, toxic substances, bacteria or other contaminants. When these substances are present in significant concentrations, they may interfere with some stream uses.

Approximately one percent of a watershed is stream channels. The smallest channels in a watershed have no tributaries and are called first-order streams. When two first-order streams join, they form a second-order stream. When two second-order streams join, a third-order stream is formed, and so on. (Figure 4) First- and second-order channels are often small, steep or intermittent. Stream orders that are six or greater constitute large rivers.

A stream channel is formed by runoff from the watershed as it flows across the surface of the ground following the path of least resistance. The shape of the channel and velocity of flow are determined by the terrain, unless changes have been made by man. When the terrain is steep, the swiftly moving water may cut a deep stream channel and keep the streambed free of sediments. In flatter areas, the stream may be shallow and meandering, with a substrate comprised largely of fine sediments.

Figure 4



What is your Watershed Address?

Hydrologic Unit Code Areas

Knowing your “watershed address” is very important to understanding the influences on the water quality in your stream or river. Hoosier Riverwatch organizes data from volunteer stream monitors by watershed location using the map: “ 8-Digit Hydrologic Unit Code (HUC) Areas in Indiana” (Page 15-Figure 6). Delineated by the U.S. Geological Survey, hydrologic units represent the geographic boundaries of water as it flows across the landscape. But not every HUC is a “watershed” in the pure sense, since longer streams are divided along their length. As you can see on the map, each HUC has an associated 8-digit number or code. This number is representative of the size of the basin. Larger basins are represented by smaller numbers. Look at the first six numbers of two or more watersheds near each other on the map; if they are the same (e.g., Chicago, Kankakee, and Iroquois in northwest Indiana, which are 071200), then they are part of the same larger watershed. You could use colored pencils to delineate these larger watershed boundaries on this map.

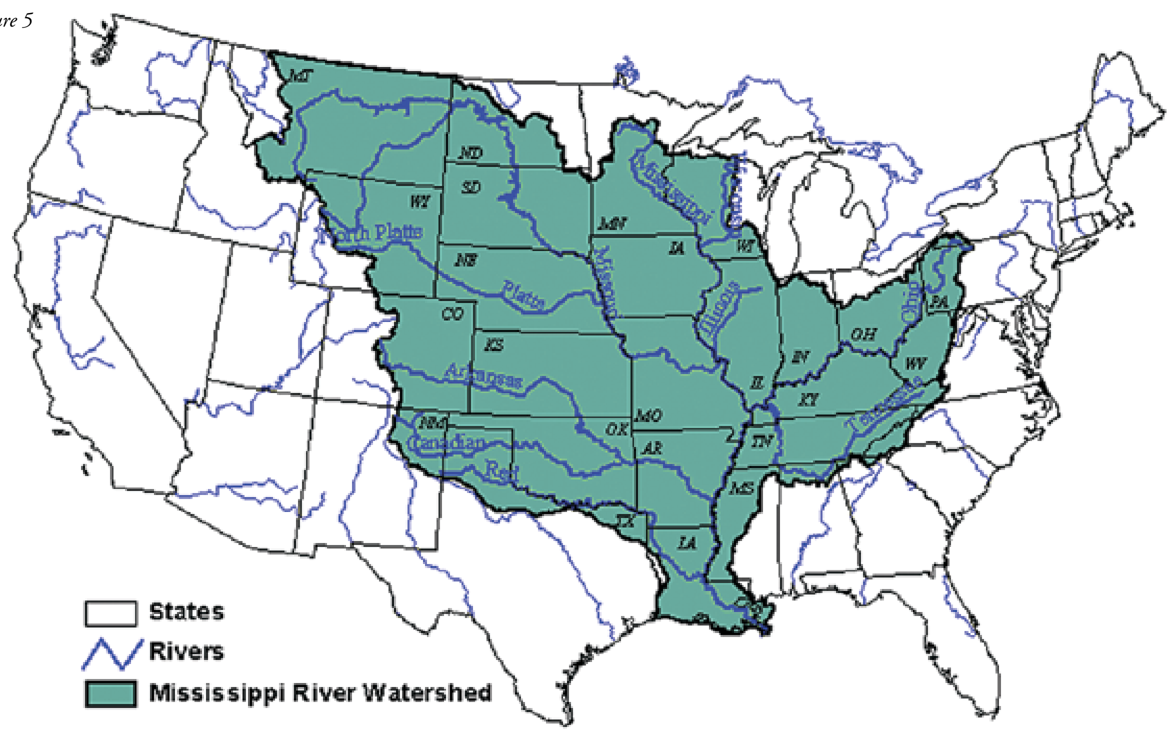
Check the map on page 15 and write your watershed address (HUC) here:

Watershed Name ______________________________

Watershed # ____ ____ ____ ____ ____ ____ ____ ____

Water within watersheds beginning with 04s flow into Lake Michigan or Lake Erie and are part of the Great Lakes Watershed. The 07s flow west into the Illinois River before entering the Mississippi River. Water from the 05 watersheds flows into the Wabash or Ohio Rivers before also joining the Mississippi River and discharging into the Gulf of Mexico. The Mississippi River watershed is the largest in the United States (Figure 5).

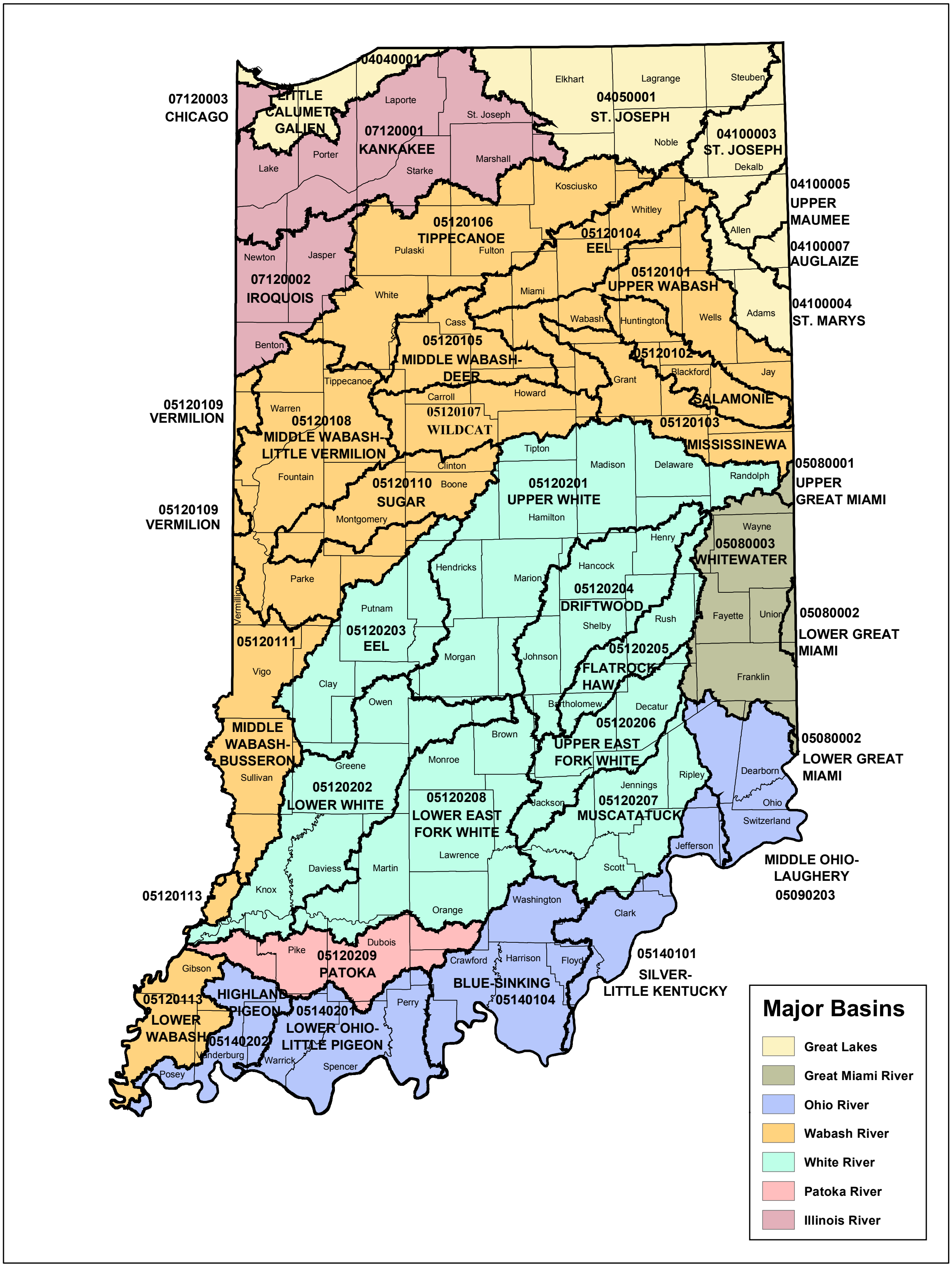
Figure 5



Indiana is divided into 39 watersheds at the 8-digit level (including Lake Michigan proper). Each of these watersheds can also be divided into smaller sub-watersheds which are represented by 10-digit numbers, and even smaller units with 12-digit numbers. Visit, http://www.idem.IN.gov/cleanwater/indiana-huc-finder to find your watershed.

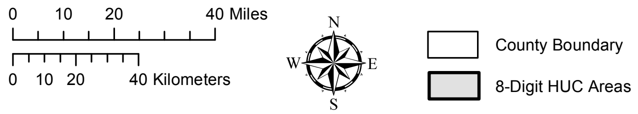
8-Digit Hydrologic Unit Code (HUC) Areas in Indiana

Figure 6



This map is intended to serve as an aid in graphic representation only. This information is not warranted for accuracy or other purposes.

Mapped By: Joanna Wood, Office of Water Quality
Date: 11/05/2014



Data Sources - Obtained from the State of Indiana Geographic Information Office Library
Map Projection: UTM Zone 16 N Map Datum: NAD83

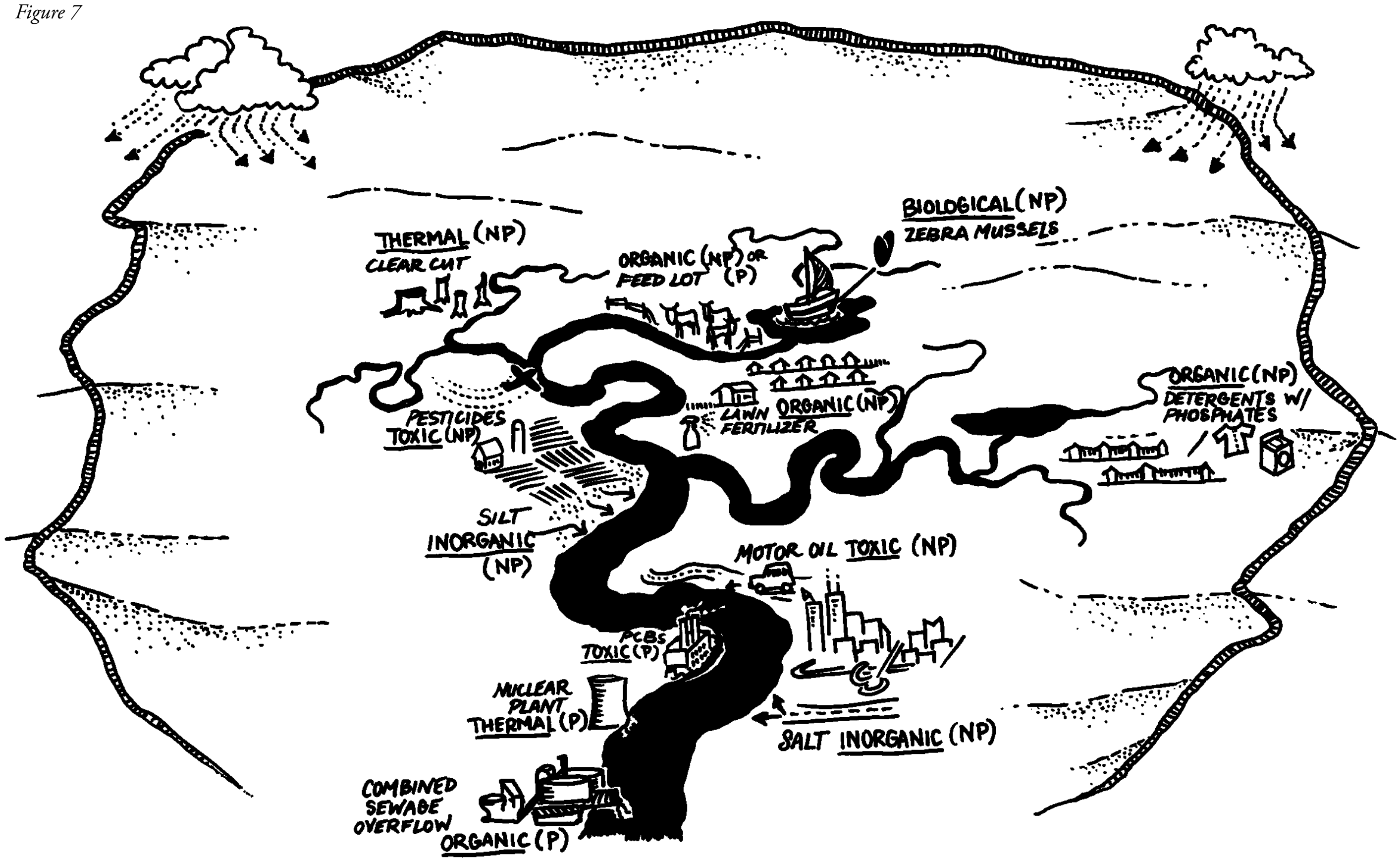
What is Water Pollution and Where Does it Come From?

Many volunteers monitor because they are concerned about pollution. Volunteer 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 nonpoint 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 the Indiana Department of Environmental Management.

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 (Figure 7).

Figure 7



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

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, PCBs) - some of these are transferred via the atmosphere and air 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 watermilfoil)

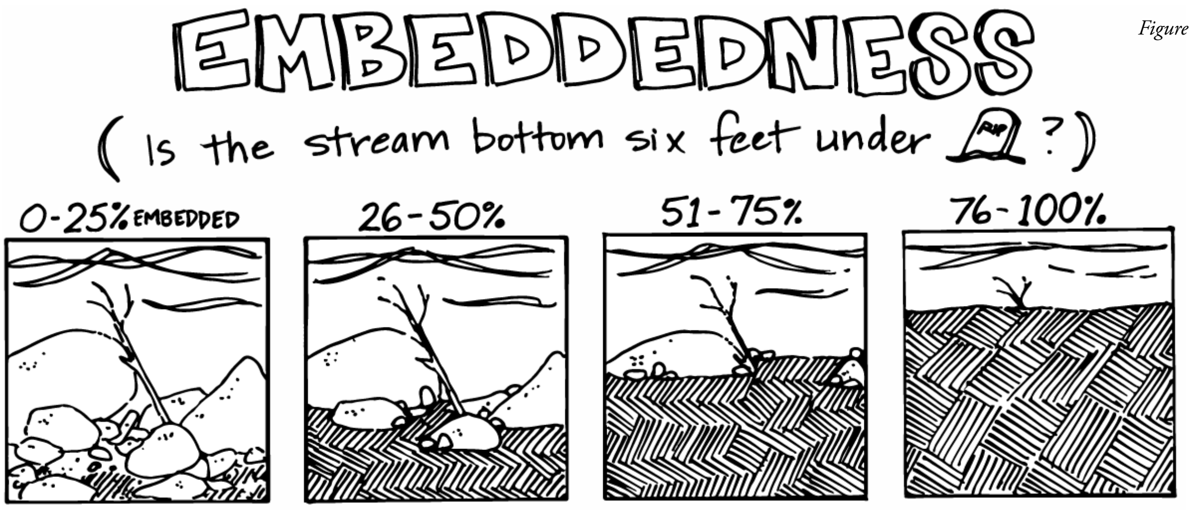
Sediment is a Leading Source of Water Pollution by Volume to Indiana Streams and Rivers!

Soil erosion and sediment as a result of 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.

Sediment impacts on streams	Resulting Direct and Indirect Effects on Aquatic Organisms
• Heat is absorbed resulting in increased water temperature.	• Metabolic rates of organisms increase, leading to wasted energy not available for growth and reproduction.
• Water clarity is decreased, thereby increasing turbidity. • Increased siltation and embeddedness on stream bottom (Figure 8).	• 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 with soil, which may result in increased Biochemical Oxygen Demand (BOD) 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," so algal growth increases, leading to higher daytime dissolved oxygen and lower nighttime levels. • Can upset normal feeding on the aquatic food chain.
• Heavy metals may be leached from the soil leading to increased toxicity.	• Developmental deformities. • Behavioral changes in feeding, mate attraction and activity, and parental care.

One way to measure sediment impacts on a stream is by looking at embeddedness (Figure 8), which refers to the degree to which rocks, gravel, cobble, boulders, and snags are covered or sunken into silt, sand or mud of the stream bottom.

Figure 8



Watershed Inventory

Information in this section is reprinted and modified from Hudson Basin River Watch Manual, Ohio EPA Explore Your Stream, and the IOWATER Program Handbook.

We know where water pollution might originate, now it's time to take a look around your watershed and discover the potential pollution sources there. The purpose of a watershed inventory is to learn about the current uses, values, and threats to the water resources in your watershed. In general, there are two ways to gather information:

Desktop Inventory: Use maps and aerial photos. Get copies of existing reports, including possible watershed management plans. Visit www.idem.IN.gov/nps/resources/watershed-management-plans to see if a watershed plan has been developed for your community. Find out the designated uses for streams in your area. Identify your water's special attributes and threats to these uses and values. Survey people. Know what municipalities govern your watershed.

Field Inventory: No matter how much information you discover through your research, the best way to know what's really going on is to get out into the field. You can perform a driving survey or "windshield tour" and also get out of your vehicle and take a look around (respecting private property rights, of course). What should you be looking for? ANYTHING that may affect your stream.

Land Use

This list includes just a few things to look for and is not a complete list. It's meant to start you "down the road" considering what is in your own watershed and what may impact your water quality as you begin your water study. The information collected during your watershed inventory is for your use only - but it is strongly recommended that you consider doing it at the beginning of your monitoring!

- **Agricultural Crops/Fields** - Are buffers in place? What kind of tillage is occurring? What kind of fertilizer is being applied and is it staying on the field
- **Pasture/Livestock** - Is there a manure management system? Is the waterway protected with fences?
- **Logging** - Are there clear-cuts (all trees) or selective cuts of individual trees?
- **Mining** - What kind: surface, underground, quarry? Is it active, abandoned, reclaimed?
- **Waste Disposal** - What kind: landfills, home septic systems, sewers, pet waste?
- **Construction Areas** - What types: homes/buildings, roads, bridges? Is sediment contained or buffered?
- **Residential/Suburban** - Are there storm drains, lawns, commercial businesses (malls/strip malls, retail shops, car washes, gas stations, restaurants), dog parks?
- **Urban** - How are services provided: drinking water/wastewater treatment facilities, factories, power plants? Are there known brownfields, leaking underground storage tanks (LUSTs), other remediation sites, combined sewer overflows (CSOs)?
- **Recreation Areas** - What types do you have: zoos, forests, nature preserves, parks, greenways, campgrounds, golf courses, hiking and horseback trails, swimming areas, fishing areas, power boating?

Instream Conditions

As you walk along the stream bank, take note of...

- **Litter/Garbage** - small litter, piles of trash, illegal dump, appliances
- **Algae** - floating, attached, color
- **Water Color** - clear, muddy, milky, tea-colored, red, gray, green, black
- **Water Appearance** - oily sheen, lots of foam/bubbles, scum
- **Water Odor** - sewage, petroleum (gas), rotten eggs, fishy, chlorine, soapy
- **Discharge Pipes** - field tiles, storm drain, industry, municipal wastewater, sewer, flowing in dry weather

Study Design - 5 Ws of Water Quality Monitoring

WHY - Define your purpose or goal. Initially this may be simple and straightforward, is the water safe for recreational activities (swimming, wading, and boating)? However, over time, the knowledge you gain may prompt you to ask bigger questions and prompt action in your watershed.

Goals will differ among groups. Some common reason folks may monitor include:

- Identify pollutants and sources
- Establish baseline data
- Document changes and trends
- Measure effectiveness
- Inform stakeholders
- Assess use attainment
- Provide information and data to support modeling
- Characterize the watershed

This definition will influence decisions on what, where, when…

WHAT - What parameters you choose to monitor will depend upon your goals. There is no right or wrong answer; however, parameters should align with the question you want to answer and your budget for monitoring. For example, if you are interested in algae blooms, you may sample for nutrients and collect representative algae samples for identification.

WHERE - Where you monitor depends upon your sampling goals/objectives. Before you select one or more sites, it is important to research, visit, and learn about your watershed, land uses, and potential sources of pollution. If you are interested in the effects of agriculture on water quality, you may want to sample a stream with a primarily agricultural watershed. If you want to determine the effects of industrial discharge on stream water quality, you may choose to monitor at three points, one upstream (control site), immediately below the source, and one further downstream to gauge recovery. It is up to you to choose where you would like to monitor.

If you need help choosing a spot, your watershed specialist (Appendix F, page 155) or your county Soil and Water Conservation District (www.iaswcd.org) may have some suggestions. A watershed management plan may be in development in your community.

Each sampling site is a 200-foot stream segment. You should use local landmarks (bridges, trees) or survey tape to define the boundaries of your sampling site. Take photos, but also sketch your site to capture things missing from photos. You must also ensure safety by considering bank accessibility, water depth, and private property rights. Review the safety section (Chapter 1) for other important safety considerations.

Each sampling site is 200 feet in length.

WHEN - Once again, when you monitor will depend upon your goals. Consider the following impacts on water quality to help determine your sampling schedule.

Trend monitoring is the primary testing method preferred by Hoosier Riverwatch. To get an accurate picture of a stream's water quality, tests have to be performed on a regular basis (consistently), over a period of years (persistently). Without long-term continued monitoring, data obtained by Riverwatch volunteers may have limited uses. A random, one-time sample provides a limited picture of water quality and overall health of a water body at the particular site and time it was monitored. Many things can affect a one-time sample, and weather can be the largest single outside influence on many water quality parameters. Trend monitoring provides a broad view of the stream allowing the seasonal variations to be sorted out from long-term changes. In order to obtain data useful for trend analysis, volunteers should consider the long-term commitment involved in this type of monitoring.

Daily Changes - Water samples taken at different times of the day may yield different results. Changes in stream flow, air temperature, and photosynthesis of aquatic plants influence chemical properties of water.

Seasonal Changes – Nutrient levels may vary by season depending on the number of aquatic plants, as they take up nutrients from the water. Spring run-off may increase water levels, thereby changing the pollutant levels one may find. In addition, macroinvertebrate populations vary seasonally. You should find the greatest diversity in spring and fall.

The best way to ensure you get out to the stream is to make a sampling schedule. Consider how many people will be monitoring, how many sites you or your group plan to sample, and whether sampling is feasible year-round (e.g., due to drought, flooding, or ice cover). Think about the types of tests you will perform, the time requirements, and the goals you have set.

Many Riverwatch groups monitor four times a year, but if sampling can only be done once or twice a year, it is preferable to do it in early spring and fall.

WHO - Groups of 2-3 students or adults can take measurements. Tasks within a group include collecting samples, processing samples, and recording data. It is very useful to have multiple groups testing for each parameter (for example, two groups measure dissolved oxygen). This allows more participants to get involved and builds in some quality control. Groups conducting the same test should compare results to determine if the data are similar. If there are different results for the same sample, group members should check the procedures and repeat the test to determine the cause of the difference. Quality control is an important part of the science and the learning experience.

Remember – no matter what your goal for monitoring, any water study must be founded on sound, scientific, and objective research.

Quality Assurance & Quality Control

Many volunteers strive to obtain the best data possible. We think this is important, as YOU are one of the primary users of the data. The following are some suggestions on how you can improve the quality of your water monitoring data.

A **Quality Assurance Project Plan (QAPP),** is a written document outlining the procedures a monitoring project will use to ensure the data it collects and analyzes meets project requirements. A QAPP helps the data user and monitoring project leaders ensure that the collected data meet their needs and that the quality control steps needed to verify this are built into the project from the beginning. By law, any EPA-funded monitoring project must have an approved QAPP before it can begin collecting samples.

The American Society for Quality states that **"quality assurance"** and **"quality control"** are often used interchangeably to refer to ways of ensuring the quality of a service or product. They do, however, have different meanings.

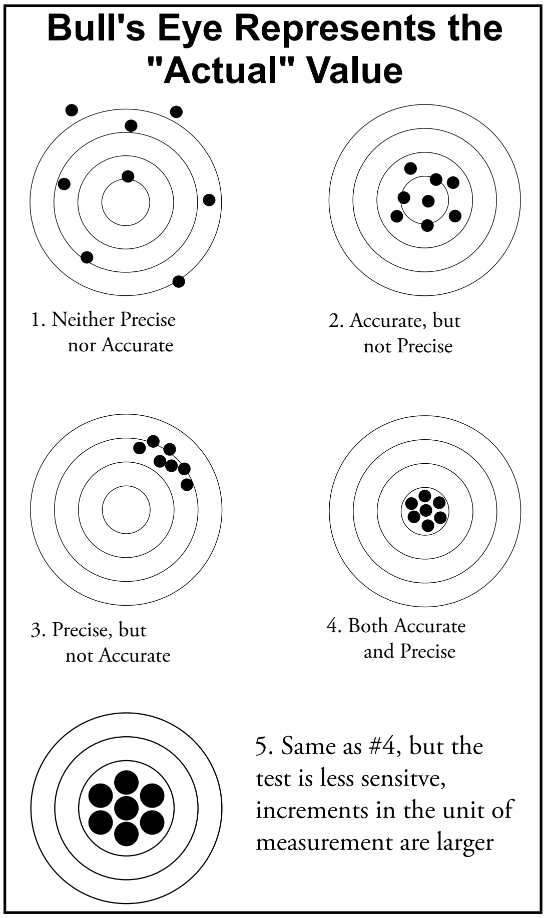
- **Quality Assurance:** The planned and systematic activities implemented in a quality system so that quality requirements for data will be fulfilled.
- **Quality Control:** The observation techniques and activities used to fulfill requirements for quality.

Accuracy and Precision

The reliability of water quality data depends on its accuracy and precision (Figure 9). Both tend to increase when more sophisticated technologies are used. Even though Riverwatch uses less sophisticated technologies, and limitations to the data exist, it is still valuable and can be used to identify trends, "hot" spots, areas in need of further monitoring, and, if enough data is available, can be used for watershed planning. This is possible because Riverwatch data are comparable to professional data. Although not exact, the data provide a "ball park" figure.

Data collected following Riverwatch methods may be considered accurate, but not as precise (#5) as methods utilizing higher technology. For example, using the pH test strip, a volunteer can consistently find the result to be 8.5 (showing precision); however, if the actual value was 8.65, she would not be able to obtain this result (with accuracy) because the pH test strip has the limitation of a 1/2 unit on the pH scale.

Figure 9



Comparability refers to how well data can be compared with other data from the same project or data from another project. **Reliability** in both accuracy and precision is achieved by:

- Collecting the water sample as directed
- Rinsing bottles and tubes with sample water before collecting the sample and with distilled water after completing the test
- Performing tests immediately after collecting the water sample
- Careful use and maintenance of testing equipment (check by using blanks and standards)
- Following the specific directions of a testing protocol exactly as described
- Repeating measurements to check for accuracy and to understand any sources of error
- Minimizing contamination of stock chemicals and testing equipment
- Storing kits away from heat and sunlight
- Checking expiration dates on chemicals and replacing before they expire
- Checking to be sure the results submitted to the Hoosier Riverwatch database are the same as those recorded on the data sheets.

Replicating Measurements

By replicating or repeating measurements, volunteers collect better data. Streams and rivers are variable. The water flowing past a point in the stream constantly changes. Taking *multiple measurements* and *averaging the values* captures some of the natural variation and provides a more representative result. In addition, taking more than one measurement reduces the chance of reporting incorrect data. If more than one person and/or testing kit are used, replicates provide an opportunity to test for both operator error and bad reagents. If one person obtains a value considerably different from another, repeat the test. If you are working with a group of student or adult volunteers, the purchase of a few additional items for chemical and biological monitoring (e.g., nets, color comparators) will improve efficiency in performing replicates.

Standards, Blanks and Splits

A standard is a sample of known concentration. Standards can be purchased from Hach or other chemical companies. A blank is a sample run using distilled water. By testing standards and blanks, volunteers can check for bad reagents and equipment contamination. A split is one sample tested twice (for example, two nitrate tests performed out of the same bucket of water taken from a stream). Splits test for operator error, as both tests should yield the same result.

Chapter 3 -
Habitat Assessment

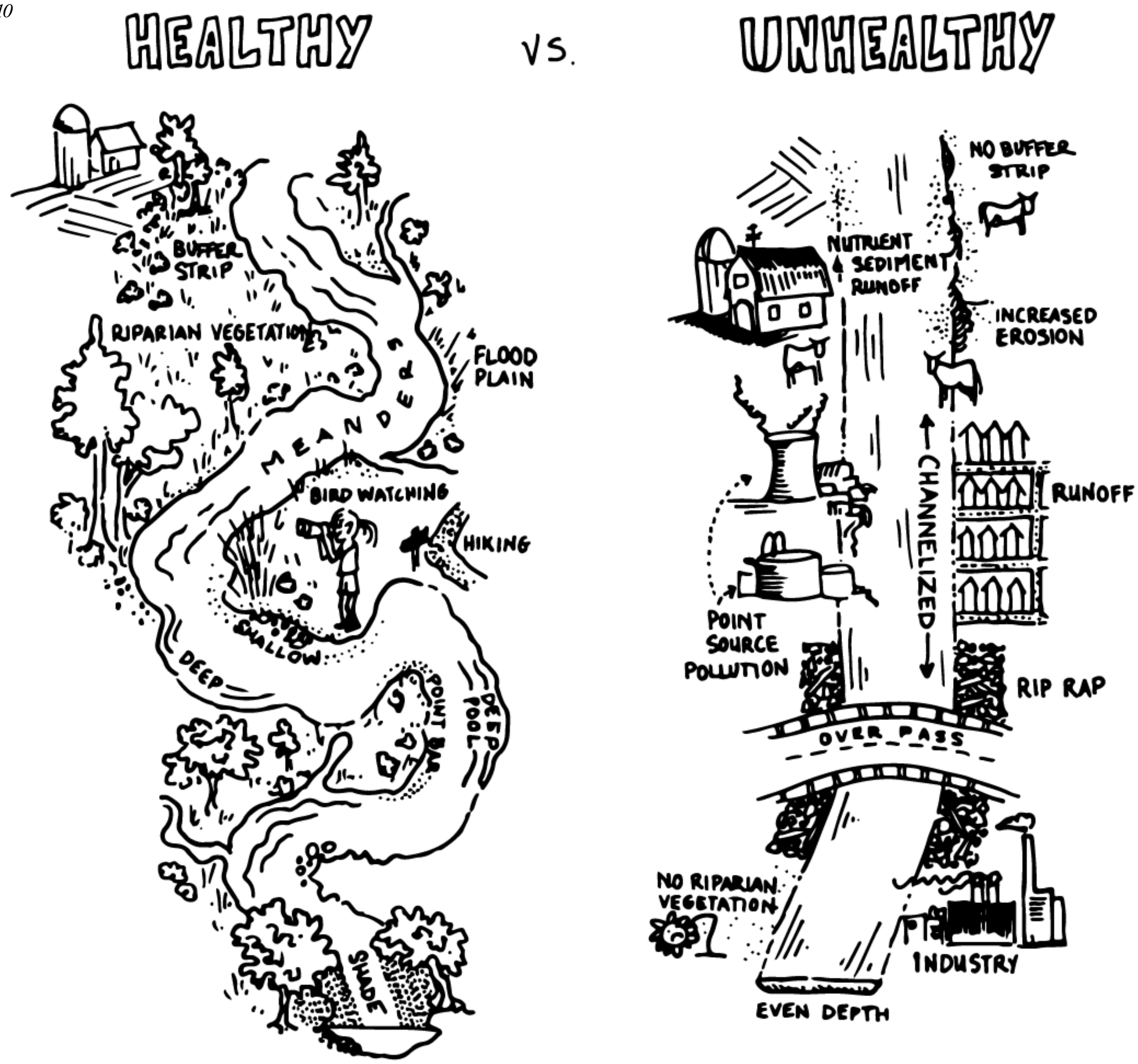
Chapter 2 discussed how water quality is a reflection of the land use in the watershed. However, the condition of land within and along the stream channel is also critical to the health of the stream and its ability to support aquatic life.

What is a Healthy Stream Habitat?

A natural stream channel does not flow in a straight line; it meanders. Rivers meander as they flow because this pattern releases the kinetic energy of the water in the most even or uniform manner. Meanders also provide 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 Figures 10 and 11.

Figure 10



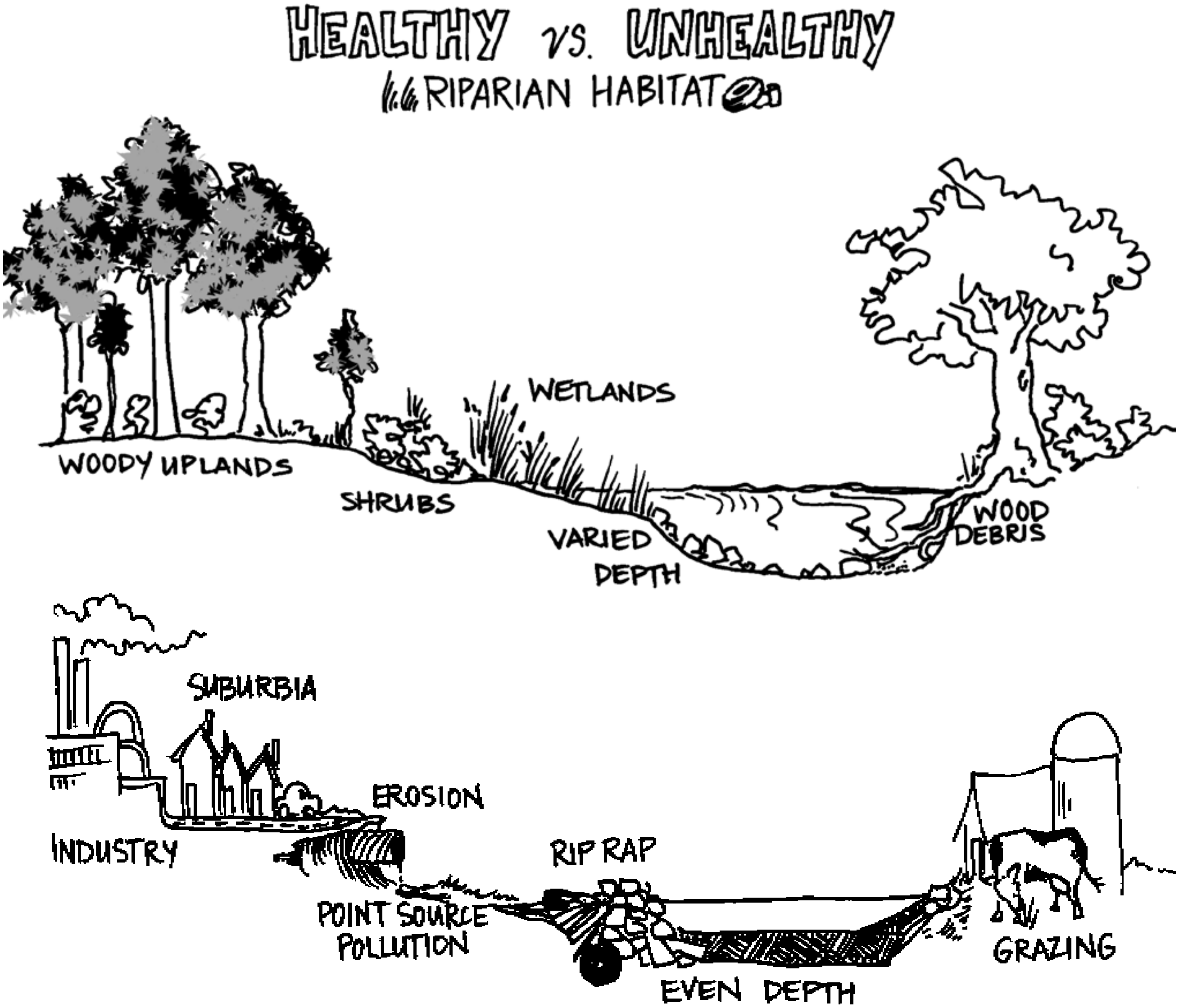
What is a riparian zone?

The term "riparian zone" refers to the areas adjacent to stream channels (Figure 11). The riparian zone is the strip of land between the stream channel and upland hills. Stream riparian zones form an important transition zone between land and freshwater systems. Riparian vegetation refers to the plants that occur naturally on stream banks and along stream channels. They serve as filters for water entering a stream, just as kidneys filter waste products from the bodies of living animals.

Streamside vegetation and wetlands are important components of a stream ecosystem because they provide streams with bank support and stabilization, erosion and flood control, water quality protection, fish and wildlife habitat, and scenic beauty. Plant roots bind soil to stream banks and reduce erosion, and deflect the cutting action of swift flowing stormwater, expanding surface ice, and strong winds. Streamside vegetation keeps the water cool by providing shade, and it provides habitat for aquatic and terrestrial creatures. In addition, plant litter that falls in upland streams is a major source of food for organisms in the stream.

(From the "Streamwalk Training Manual," Thames River Basin Partnership Initiative.)

Figure 11



Citizens Qualitative Habitat Evaluation Index (CQHEI)

This index was developed by the Ohio Environmental Protection Agency as a "Citizens" companion to the Qualitative Habitat Evaluation Index (QHEI) used by the state's professional staff. The diagram's data sheet on pages 26-27 were modified from information provided by the Ohio EPA. The purpose of the index is to provide 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 two 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' 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). An example is provided on page 27.

I. Substrate (Bottom Type) - Max 24 pts
(***Note:*** "smothering" is the same as "embeddedness." See Figure 8 on page 17. Check "yes" for smothering, if the stream bottom is more than 50% embedded.)

II. Fish Cover (Hiding Places) - Max 20 pts
Select all the cover types that you see using Figure 12 on page 25 as a guide. Add 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?"

b) See **Appendix C - Glossary** for a description of conservation tillage.

V. Depth & Velocity - Max 15 pts

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

b) Select all the flow types that you see and add the points.

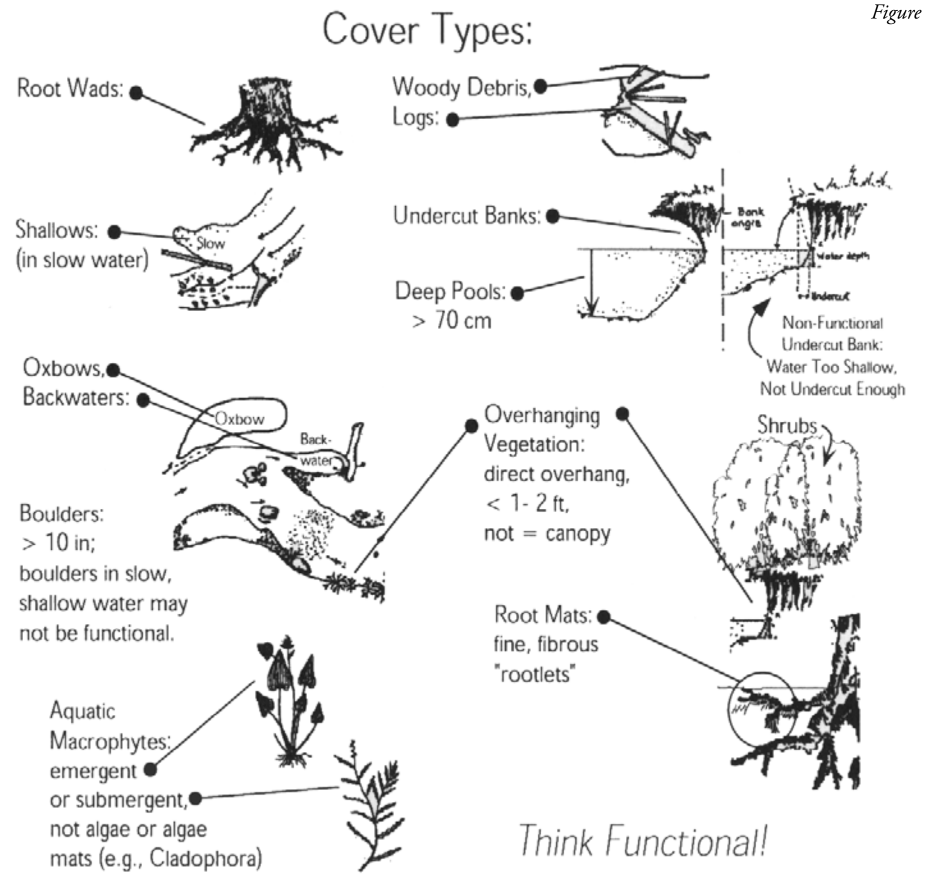
VI. Riffles/Runs (where the current is turbulent) - Max 15
Using the lower diagrams (Figure 13) on page 25 as a guide.

Maximum Total Points for the CQHEI is 114

If the score is over 100, consider it "extra credit." You have an exceptionally 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.*"

CQHEI Section II: Fish Cover (Hiding Places)

Figure 12



CQHEI Sections V & VI: Depth & Velocity and Riffles/Runs

Figure 13

Riffle and Run Habitats:

Riffle - areas of the stream with fast current velocity and shallow depth; the water surface is visibly broken.

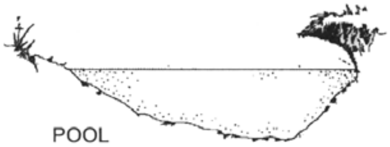
RIFFLE

Run - areas of the stream that have a rapid, non-turbulent flow; runs are deeper than riffles with a faster current velocity than pools and are generally located downstream from riffles where the stream narrows; the stream bed is often flat beneath a run and the water surface is not visibly broken.

RUN

Pool and Glide Habitats:

Pool - an area of the stream with slow current velocity and a depth greater than riffle and run areas; the stream bed is often concave and stream width frequently is the greatest; the water surface slope is nearly zero.



POOL

Glide - this is an area common to most modified stream channels that do not have distinguishable pool, run, and riffle habitats; the current and flow is similar to that of a canal; the water surface gradient is nearly zero.

GLIDE

HINT: These habitat types typically grade into one another. For example a run gradually changes into a pool.

Citizens Qualitative Habitat Evaluation Index (CQHEI)

Date: __/__/__ Volunteer ID: ____________ Site ID: ____________

Stream Name: ____ CQHEI Total

I. SUBSTRATE (bottom type) Score:

a) Size

- [ ] Mostly Large (Fist Size or Bigger) — 14 pt
- [ ] Mostly Small (Smaller Than Fingernail, but Coarse, or Bedrock) — 6 pt
- [ ] Mostly Medium (Smaller than Fist, larger 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?

- [ ] No — 5 pt
- [ ] Yes — 0 pt

Symptoms: Hard to move pieces, often black on bottom.

c) "Silting"

Are Silts and Clays Distributed Throughout Stream?

- [ ] No — 5 pt
- [ ] Yes — 0 pt

Symptoms: Light kicking results in substantial clouding for more than a minute.

II. FISH COVER (hiding places) - Add 2 Points For Each One Present Score:

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

III. STREAM SHAPE and HUMAN ALTERATIONS Score:

a) "Curviness" or "Sinuousity" of Channel

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

b) How Natural Is The Site?

- [ ] Mostly Natural — 12 pt
- [ ] Many Man-Made Changes, but Some Natural Conditions left (e.g., trees, meanders) — 6 pt
- [ ] Few Minor Man-Made Changes (e.g., a bridge) — 9 pt
- [ ] Heavy, Man-made Changes (e.g., leveed or channelized) — 0 pt

IV. STREAM FORESTS & WETLANDS (riparian area) & EROSION Score:

a) Riparian Width Mostly:

- [ ] Wide (Can't throw a rock through it) — 8 pt
- [ ] Narrow (can throw a rock through it) — 5 pt
- [ ] None — 0 pt

b) Land Use - Mostly:

- [ ] 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
- [ ] Park (Grass) — 2 pt
- [ ] Urban/ Industrial — 0 pt

c) Bank Erosion

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

d) Stream Shading

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

V. DEPTH & VELOCITY Score:

a) Deepest Pool is At Least:

- [ ] Chest Deep — 8 pt
- [ ] Knee Deep — 4 pt
- [ ] Waist Deep — 6 pt
- [ ] Do Not Exist — 0 pt

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

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

VI. RIFFLES/RUNS (areas where current is fast/turbulent, surface may be broken) Score:

a) Riffles/Runs Are:

- [ ] Knee Deep or Deeper and Fast — 8 pt
- [ ] Ankle Deep or Less and Slow — 4 pt
- [ ] Ankle/Calf Deep and 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
- [ ] Smaller Than Fist Size, but Larger Than Fingernail — 4 pt

Citizens Qualitative Habitat Evaluation Index (CQHEI)

Date: 10/ 04 2009 Volunteer ID: 1000 Site ID: 1000

Stream Name: Example Stream Indiana

CQHEI Total: 83.5

I. SUBSTRATE (bottom type) — Score: 20

a) Size

- [ ] Mostly Large (Fist Size or Bigger) — 14 pt
- [ ] Mostly Small (Smaller Than Fingernail, but Coarse, or Bedrock) — 6 pt
- [X] Mostly Medium (Smaller than Fist, larger 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 pieces, often black on bottom.

c) "Silting"

Are Silts and Clays Distributed Throughout Stream?

- [X] No — 5 pt
- [ ] Yes — 0 pt

Symptoms: Light kicking results in substantial clouding for more than a minute.

II. FISH COVER (hiding places) - Add 2 Points For Each One Present — Score: 14

- [X] Underwater Tree Roots (Large) — 2 pt
- [ ] Shrubs/Small Trees Hang Over the Bank — 2 pt
- [X] Downed Trees, Logs, or Branches — 2 pt
- [ ] Water Plants — 2 pt
- [ ] Undercut Banks — 2 pt
- [X] Underwater Tree Rootlets (Small) — 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] Boulders — 2 pt

III. STREAM SHAPE and HUMAN ALTERATIONS — Score: 15

a) "Curviness" or "Sinuousity" of Channel

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

b) How Natural Is The Site?

- [ ] Mostly Natural — 12 pt
- [ ] Many Man-Made Changes, but Some Natural Conditions left (e.g., trees, meanders) — 6 pt
- [X] Few Minor Man-Made Changes (e.g., a bridge) — 9 pt
- [ ] Heavy, Man-made Changes (e.g., leveed or channelized) — 0 pt

IV. STREAM FORESTS & WETLANDS (riparian area) & EROSION — Score: 13.5

a) Riparian Width Mostly:

- [X] Wide (Can't throw a rock through it) — 8 pt
- [ ] Narrow (can throw a rock through it) — 5 pt
- [X] None — 0 pt

Average: 4 pts

b) Land Use - Mostly:

- [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

Average: 3.5 pts

c) Bank Erosion

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

d) Stream Shading

- [ ] Mostly — 3 pt
- [X] Partly — 2 pt
- [ ] None — 0 pt

V. DEPTH & VELOCITY — Score: 11

a) Deepest Pool is At Least:

- [X] Chest Deep — 8 pt
- [ ] Knee Deep — 4 pt
- [ ] Waist Deep — 6 pt
- [ ] Do Not Exist — 0 pt

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

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

VI. RIFFLES/RUNS (areas where current is fast/turbulent, surface may be broken) — Score: 10

a) Riffles/Runs Are:

- [ ] Knee Deep or Deeper and Fast — 8 pt
- [ ] Ankle Deep or Less and Slow — 4 pt
- [X] Ankle/Calf Deep and 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

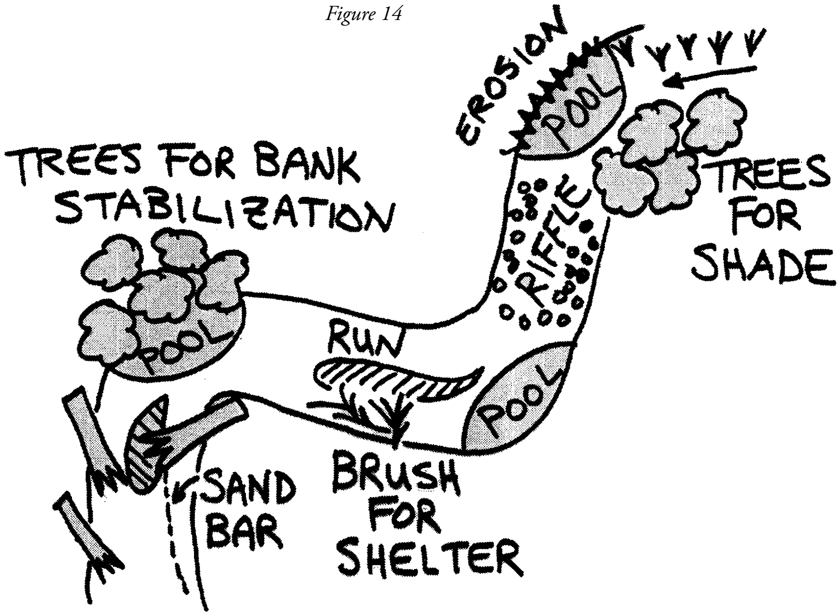
Site Map & Stream Flow

Site Map

Drawing a map of your site location is an excellent first step in getting to know your 200-foot stream segment. Photographs help but don't always capture all the details. 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 map is shown below (Figure 14) with a map sheet on page 29. The stream map can now be scanned and uploaded to the database, as can photos you take of the site or your sampling event.

Stream Flow Calculations

Figure 14



A work sheet is provided on Page 30 to assist volunteers in determining the stream flow or discharge rate. (See page 31 for a completed example.) Discharge is the amount (volume) of water flowing in the stream per second. Riverwatch uses cubic feet per second as the standard unit of discharge. 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. All measurements are taken (or converted) into feet. The data sheet includes a diagram and instructions. Stream flow calculations can be entered into the volunteer monitoring online database (*See Chapter 7)*.

Average Width (W) - width of the stream (flowing area 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

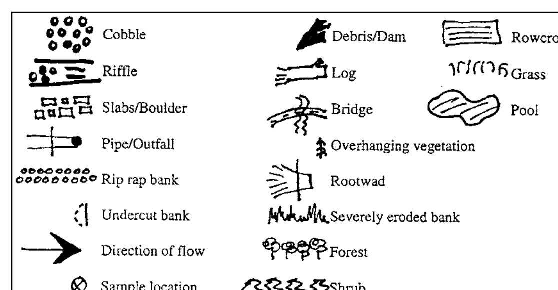
Average Depth (Z) - three depth measurements are taken (using a yardstick) across the stream on three transects - nine total measurements

Average Velocity (V) - how fast the water is moving - measure a distance and time how long it takes a floating object to travel that distance - repeat three times

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

Flow (D)= W^{x}Z^{x}V^{x}n

Stream Site Map



Hoosier Riverwatch

Stream Flow (Discharge) Data Sheet

Date ____/____/____ Volunteer ID________________ Site ID ______________________________

Stream Name____

Solving the equation:

FLOW (D) = W x Z x V x n

Where:

W = Average Width

Z = Average Depth

V = Average Velocity

n = Coefficient - 0.8 for gravel/rocky bottom streams
0.9 for muddy or bedrock bottom streams

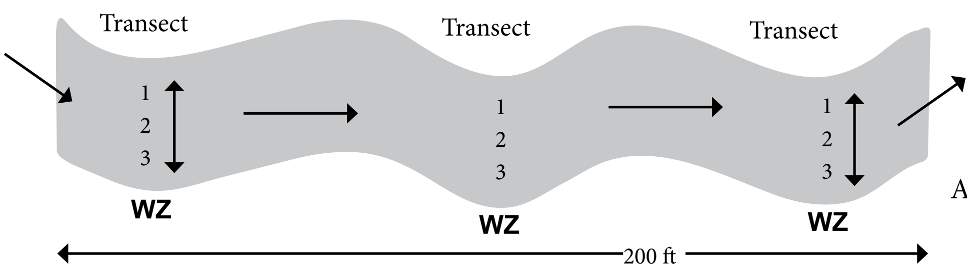
D = Flow/Discharge

Convert measurements of feet + inches to 10ths of feet. **1 inch = 0.0833 feet**

W

River Width

(one measurement at each transect)



Transect	Width (ft)
1	
2	
3	
Average	

Z

River Depth

(three measurement along each transect)

Transect	Transect 1 (ft)	Transect 2 (ft)	Transect 3 (ft)
1			
2			
3			
Average of Transects			

Average of Averages

V

Surface Velocity = Length/Time

(allow the object to attain velocity before timing)

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

D

Stream Flow or Discharge

W	x	**Z**	x	**V**	x	**n***	=	**D (cfs)**

**Coeffecient (0.8 for gravel/rocky bottom streams, 0.9 for muddy or bedrock bottom streams*

Hoosier Riverwatch
Stream Flow (Discharge) Data Sheet

Date 10 / 04 / 09 Volunteer ID 1000 Site ID 1000

Stream Name Example Stream Name

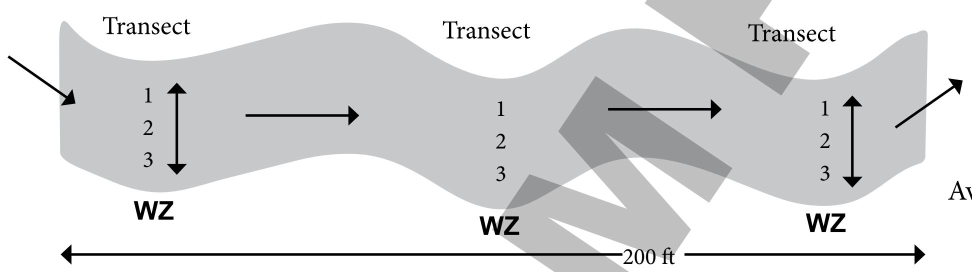
Solving the equation:

FLOW (D) = W x Z x V x n

Where:
W = Average Width
Z = Average Depth
V = Average Velocity
n = Coefficient - 0.8 for gravel/rocky bottom streams
0.9 for muddy or bedrock bottom streams
D = Flow/Discharge

Convert measurements of feet + inches to 10ths of feet. **1 inch = 0.0833 feet**

W
River Width
(one measurement at each transect)



Transect	Width (ft)
1	10.03
2	9.67
3	11
Average	10.33

Z
River Depth
(three measurement along each transect)

Transect	Transect 1 (ft)	Transect 2 (ft)	Transect 3 (ft)	Average of Averages
1	0.83	1	1.54	
2	1.42	1.58	1.11	
3	1.08	0.58	1.33	
Average of Transects	1.11	1.05	1.33	*1.16*

V
Surface Velocity = Length/Time
(allow the object to attain velocity before timing)

Transect	Length (ft)	Time (seconds)	Velocity (ft/sec)
1	10	25	0.4
2	10	28	0.36
3	10	26	0.38
		Average	0.38

D
Stream Flow or Discharge

W	x	Z	x	V	x	n*	=	D (cfs)
10.33	x	1.16	x	0.38	x	0.8	=	*3.64*

**Coeffecient (0.8 for gravel/rocky bottom streams, 0.9 for muddy or bedrock bottom streams*

Chapter 4 -
Chemical Monitoring

Chemical Parameters

Many types of chemical tests can be performed to assess varying aspects of stream water quality. However, volunteer monitoring programs are faced with both financial and technical limitations. Given these constraints, Hoosier Riverwatch trains volunteers to conduct eight of the chemical parameters considered by the National Sanitation Foundation to be most useful in determining stream water quality (as well as a few additional tests):

Dissolved Oxygen	***E. coli* and Coliform Bacteria**
pH	**Water Temperature Change**
Biochemical Oxygen Demand	**Nitrate and Nitrite**
Orthophosphate	**Transparency/Turbidity**

Riverwatch Chemical Testing Instructions

Hoosier Riverwatch does not require volunteers to use a standard set of equipment or methods for chemical testing. However, the majority of volunteer groups actively participating in the program have received equipment through the Riverwatch Equipment Application program. The chemical testing instructions provided are for the most common methods used by volunteer stream monitoring groups in Indiana. They are also the methods presented during Hoosier Riverwatch training sessions.

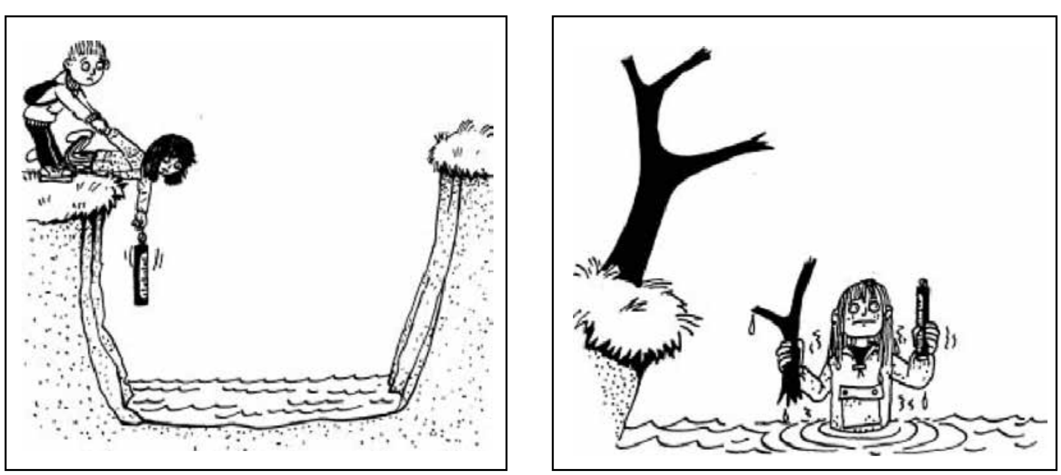
Tips on Collecting Water Samples

How you physically obtain the water sample depends on the size, depth, and banks of your stream. Hoosier Riverwatch volunteers should sample wadeable streams. If you are wading, make sure that you collect water from a point upstream of where you are standing, being careful not to stir up any sediment. The sample must be collected in a clean container to avoid contamination. Collecting water directly from the stream with the container used for the chemical test is preferred. Lower your container down 3 to 5 inches below the surface of the water (or until your wrist is completely submerged) so that your sample is representative of the whole stream. Rinse your collection container three times with sample water before collecting your final sample.

Deep water or steep banks are dangerous (Figure 15). Depending on conditions at your site, you may need to use alternative sampling techniques. If you have a bridge, you may be able to lower a sampling container or bucket down to the stream. When sampling with a bucket and line, it is helpful to have a small (~6 oz.) weight fastened to the rim of the bucket to tip it over. Or you may be able to use an extension rod or a cup on a stick (see Appendix A) from the edge of the stream. Regardless of the method, sample water should be collected from the *main stream flow*.

Figure 15

What not to do



Images from GLOBE 1997

Chemical Monitoring Critical Thinking Questions

(For Use During Hoosier Riverwatch Basic Training Workshops)

What is / are:

- Dissolved oxygen?
- Biochemical Oxygen Demand 5 day?
- pH?
- Nutrients (N and P)?
- Turbidity
- *E. coli*

What are sources of:

- Nutrients?
- Turbid water?
- *E. coli*?

What problems can result from:

- High BOD_5?
- Excess nutrients?
- Excessive turbidity?

What other parameters are associated with or affected by:

- Dissolved oxygen?
- pH?
- High nutrients?
- High *E. coli?*

Notes:

Hints For Performing Chemical Tests

- Practice, practice, practice! The more familiar you are with the tests, the easier they will be to perform, and the more accurate your results will be.
- Do not store chemical testing kits in your car, in direct sunlight, or in any extreme temperatures. The chemical reagents will degrade.
- Perform each test multiple times or have another volunteer read the results to assure precision.
- Wear protective gloves and safety goggles. Do not wear sunglasses when reading the test results.
- Rinse testing tubes or bottles with *sample* water before collecting the sample.
- Obtain your water sample from the stream's main stream flow (usually in the middle). Take the sample 3-5 inches under the surface.
- Rinse testing tubes and bottles with *distilled* water after completing each test.
- Wash your hands when you are finished.

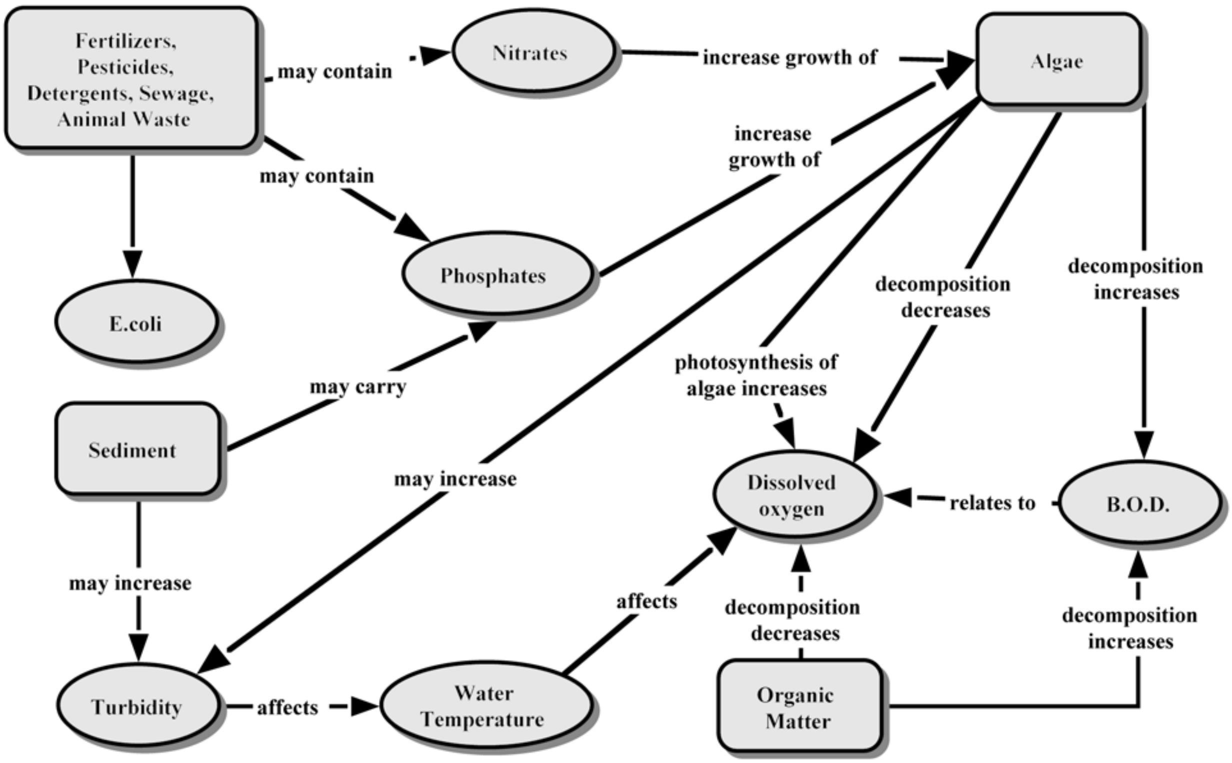
How to Discard Chemical Waste

Label a plastic container with a secure lid (such as a margarine or milk container) with "Chemical Waste". Place liquids and solids in the plastic container along with kitty litter. The chemical waste is in a solid form and can be discarded with your regular trash.

Water Monitoring Parameters are Interrelated

Aquatic chemistry is complex and is influenced by many interrelated factors. The simplified concept map below (Figure 16) may help in understanding these relationships in an aquatic environment. The rectangles represent watershed inputs into a river or stream, while the circles represent chemical parameters we measure to determine water quality.

Figure 16



Units of Measurement and Indices

(Information modified from Rivers Curriculum Guide: Biology)

Units of Concentration (ppm vs mg/L)

What does part per million (ppm) mean? How much are we talking about? The following examples are listed on "Water on the Web" (http://www.waterontheweb.org/resources/conversiontables.html) to provide further understanding of these units of concentration. One part-per-million is equal to:

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

Parameter	Unit of measurement
Water Temperature Change (1 mile)	°C
Dissolved Oxygen	mg/L and % Saturation
Biochemical Oxygen Demand (BOD)	mg/L
pH	Standard Units
Orthophosphate	mg/L
Nitrate/Nitrite	mg/L
Transparency/Turbidity	cm or NTU
E. coli and general coliforms	cfu/100 mL

So, how can it be that one part per million (ppm) of something in water (e.g. dissolved oxygen) is the same as one milligram per liter (mg/L)? It is 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 (1 g/mL = 10^{-3} g/103 mL = 10^{-6}, or 1 ppm), but it does not hold for saltwater because density increases with salinity. The units mg/L and ppm are equal in freshwater. They are used interchangeably throughout this chapter.

Index

An index is a rating system that assigns a value to an object or process, or to specific qualities it may possess. Grades are indices of academic achievement; other index examples include movie guides, TV ratings, wind chill factors, and pollen counts. An index easily allows you to observe and quantify fluctuations in river or stream water quality. Using an index ratio over a period of time can indicate whether the water is becoming more polluted or cleaner. The indices used in studying a river or stream offer a mathematical picture that reduces many values having different units to one or two overall numbers.

Chemical Monitoring Water Quality Index: To compare apples and oranges, you must find a unit that is common for both (e.g., apples and oranges are both fruits). The same is true for comparison of water quality parameters. Water quality experts have developed a unit common to all eight water quality tests performed by Hoosier Riverwatchers – it is called a Q-value. Determining overall water quality or comparing the results of different types of tests requires converting results from each of the eight tests to the common Q-value. Each test for water quality has its own Q-value chart and table that facilitates this conversion. Each Q-value chart appears after the instructions for each test and is also listed in Appendix C.

Chemical Testing Instructions

Background information and instructions were copied or modified with permission from CHEMetrics, Inc., Water Works, Inc., Earth Force-GREEN, and the Student Watershed Research Project/Saturday Academy of Oregon.

Typical Ranges

After each set of test instructions, you will find values representing the likely ranges into which your chemical test results may fall. These ranges were taken from the 2012 Monitoring Water in Indiana: Choices for Nonpoint Source and Other Watershed Projects, also known as the Environmental Indicators Manual. This manual can be found at https://engineering.purdue.edu/watersheds/monitoring/MonitoringWaterinIndiana.2012.1.pdf . Data from existing monitoring sites in Indiana have been compiled to provide target ranges (also in Appendix F, page 143). These are here to give you a better idea what might be found in Indiana rivers and streams. The data used to compile ranges comes from IDEM's Fixed Station Data (rather than volunteer data) compiled by IDEM staff or Purdue University. In addition, the Indiana water quality standards for rivers are included for each applicable parameter.

Times and Locations for Completing Tests

The table below provides estimated times needed to perform each test and whether or not they should be completed on-site. If samples are taken off-site, they must be kept on ice or refrigerated until testing is completed (except BOD and turbidity). All tests should be completed the same day, except BOD and *E. coli*, and as soon as feasible to obtain the best possible results.

Test	Time to Complete	Location
Water Temperature Change (1 mile)	5 minutes	On-site
Dissolved Oxygen	5 minutes	On-site
Biochemical Oxygen Demand-5 day (BOD_5)	5 days to incubate, then 5 minutes to test	On-site/Off-site
pH	2 minutes	On-site
Orthophosphate	5 minutes	On-site
Nitrate/Nitrite	2 minutes	On-site
Transparency/Turbidity	5 minutes	On-site
***E. coli* and general coliforms**	24 hours to incubate, 15+ minutes to count	On-site/Off-site

Other Results

Other water chemistry test results sometimes obtained by volunteers include ammonia, total solids, chlorine, chloride, conductivity, alkalinity, hardness, heavy metals, or pesticides. Any water quality results you obtain (either by your own testing or from a laboratory) may be recorded on the data sheet and in the database. Some chemical tests require extremely sensitive and expensive equipment, and are not usually performed by volunteer monitors. A few examples of these tests include: mercury, PCBs, some pesticides, DNA source-tracking of bacteria, and pharmaceuticals. Contact your Watershed Specialist (page 155) to find out what type of data has been collected in your area.

Chemical Monitoring Data Sheet

Why use the chemical monitoring data sheet?

The chemical monitoring data sheet can be taken into the field to record the results of multiple samples. Use of the data sheet is optional. Hoosier Riverwatch recommends that volunteers take multiple samples to assure higher quality stream monitoring results. Up to three replicates can be recorded on this data sheet. Obvious outliers (results that are drastically different from other values) should not be recorded or used in calculations. The average of the test results is calculated then used in the average column on the Chemical Monitoring Data Sheet.

How the water quality index (WQI) works

The Chemical Monitoring Data Sheet utilizes a Water Quality Index (WQI). The Water Quality Index provides a simple analysis of the results of eight of the chemical test parameters. **If you complete at least six of the eight test parameters** you can derive a single score that will let you know if the stream results are: Excellent, Good, Medium, Bad, or Very Bad for that particular monitoring session. You can also use this value to track changes in your site over time, or compare the quality with other stream sites.

Each of the test parameters is weighted according to its level of importance to the overall water quality (in this particular index). Dissolved oxygen has the highest weighting factor (0.18); therefore, the oxygen results are the most important value in determining the water quality rating using the index. The weighting scheme allows analysts to condense complex test results into a common water quality measurement that can be readily communicated to the public and to other volunteers. The Water Quality Index score is like a final grade - weighting the results of multiple tests and exams.

How to use the Q-value charts

In order to obtain a WQI Rating, you must first determine the Q-value for each test. Each parameter (except Orthophosphate and Nitrite) has its own Q-chart immediately following the instructions. To find the Q-value locate your test result on the bottom of the appropriate chart (x-axis). Draw a vertical line up from your test result until it intersects the curved line (Q-line). From this point of intersection draw a line across to the left hand side (y-axis). Read the number on the left side of the chart closest to this intersection; this is the Q-value for that particular test result. Record the Q-value in the second column of the Chemical Monitoring Data Sheet.

You can also check the Q-value table (as an alternative to reading the graph) if your result is close to a given value. In addition, the Riverwatch database will calculate your Q-value when you submit chemical data online.

What does a Q-value mean?

You can think of a Q-value as a "Quality-value." It helps interpret your results in terms of the overall health or water quality of your stream. Think of it like a grade. The higher the Q-value, the better the test results (100 is the maximum value; 0 is the minimum).

Water Quality Index Instructions

As you complete each chemical test (or average your results for up to three test events for a parameter from the Chemical Monitoring Data Sheet), record the values on the chemical monitoring data sheet. Use the Q-charts or Q-tables in this chapter to derive the Q-values for the average of each parameter. Record those in the Q-value column. After the Q-values have been determined and recorded in the appropriate column, multiply the Q-value for each test by the Weighting Factor provided and record the value in the Calculation column. Once the calculations are completed for each parameter, you can then sum the Weighting Factor column and the Calculation column. Divide the total of the Calculation column by the total of the Weighting Factor column to obtain the Water Quality Index (WQI). See example on page 40.

If you complete all eight parameters, the total of the Weighting Factor column is 1.00 (or 100%). If you are missing one or two test parameters (but no more than two) you can calculate an adjusted Water Quality Index (WQI) Rating. Follow the same procedures. Divide the total of the Calculation column by the total of the Weighting Factor column for the tests you completed to obtain the adjusted WQI. In the example on page 41, if the Total Phosphate and *E. coli* tests were not completed, the total of the Weighting Factor column would be 0.72, and the total of the Calculation column would be 55.9. This results in a WQI score of 77.6, compared to 72.93 on page 40.

Hoosier Riverwatch
Chemical Monitoring Data Sheet

Date _____ / _____ / ______ Volunteer ID _______________ Site ID ___________________

Stream Name ____ Latitude ____________ Longitude ____________

Time _____ : _____ AM / PM Time Sampling ___________ hrs Air Temp.: _____________ °C

Current Weather: ☐ Clear/Sunny ☐ Overcast ☐ Showers ☐ Rain (steady) ☐ Storm (heavy)

Worst Weather (past 48 hours): ☐ Clear/Sunny ☐ Overcast ☐ Showers ☐ Rain (steady) ☐ Storm (heavy)

	Units	Sample # 1	Sample # 2	Sample # 3	Avg.	**Q-Value**	x Weighting Factor	= **Calculation** *(Q-value x Wt. Factor)*
Temperature								
Water Temp at Site	°C							
Water Temp 1 Mile Upstream	°C							
Water Temp Change: *Site Temp - Upstream Temp*	°C						0.11	
Dissolved Oxygen								
Dissolved Oxygen	mg/L							
DO% Saturation: *Determine from chart or table/equation*	%						0.18	
BOD								
Avg. Dissolved Oxygen: *(Calculated Above)*	mg/L							
Dissolved Oxygen after 5 days	mg/L							
BOD *Avg DO (original)-DO after 5 days*	mg/L						0.12	
pH								
pH							0.12	
Nutrients								
Orthophosphate	mg/L							
Total Phosphate *(boil in acid)*	mg/L						0.11	
Nitrate (NO3) *multiply by 4.4*	mg/L						0.10	
Nitrite (NO2) *multiply by 3.3*	mg/L							
Turbidity								
Transparency *(from tube)*	cm							
Turbidity *(convert from chart/table)*	NTU						0.09	
Bacteria								
E.Coli Bacteria	cfu/100 mL						0.17	
Fecal Coliforms	cfu/100 mL							

Use Average DO value for BOD calculation.

Remember to convert your reading from the tube to NTUs.

Add Weighting Factors for test completed.

Add the calculation column.

TOTALS ________ ________

Divide Total of Calculation Column by Total Weighting Factor Column

WQI ____________

WQI Ratings

Excellent	90 - 100%
Good	70 - 87%
Medium	50 - 69%
Bad	25-49%
Very Bad	0-24%

Hoosier Riverwatch
Chemical Monitoring Data Sheet

Date 10 / 04 / 2009 Volunteer ID 1000 Site ID 1000

Stream Name Example Stream Indiana Latitude 39.52533 Longitude -85.76369

Time 12 : 15 AM / PM Time Sampling 2.5 hrs Air Temp.: 29.5 °C

Current Weather: ☐ Clear/Sunny ☒ Overcast ☐ Showers ☐ Rain (steady) ☐ Storm (heavy)

Worst Weather (past 48 hours): ☒ Clear/Sunny ☐ Overcast ☐ Showers ☐ Rain (steady) ☐ Storm (heavy)

	Units	Sample # 1	2	3	Avg.	**Q-Value**	x Weighting Factor	= **Calculation** *(Q-value x Wt. Factor)*
Temperature								
Water Temp at Site	°C	22.0	22.0	22.0	22.0			
Water Temp 1 Mile Upstream	°C	22.0	21.0	21.0	21.3			
Water Temp Change: *Site Temp - Upstream Temp*	°C	0.0	1.0	1.0	0.7	90	0.11	9.9
Dissolved Oxygen								
Dissolved Oxygen	mg/L	8.0	7.0		7.5	Use Average DO value for BOD calculation.		
DO% Saturation: *Determine from chart or table/equation*	%				86.2	92	0.18	16.6
BOD								
Avg. Dissolved Oxygen: *(Calculated Above)*	mg/L	7.5	7.5	7.5	7.5			
Dissolved Oxygen after 5 days	mg/L	6.0	5.0	5.5	5.5			
BOD *Avg DO (original)-DO after 5 days*	mg/L				2.0	80	0.12	9.6
pH								
pH		8.0			8.0	82	0.12	9.8
Nutrient								
Orthophosphate	mg/L	0			0			
Total Phosphate *(boil in acid)*	mg/L	0.06			0.06	98	0.11	10.8
Nitrate (NO3) *multiply by 4.4*	mg/L	10			10	51	0.10	5.1
Nitrite (NO2) *multiply by 3.3*	mg/L	0			0			
Turbidity								
Transparency *(from tube)*	cm	25	26	27.5		Remember to convert your reading from the tube to NTUs.		
Turbidity *(convert from chart/table)*	NTU	30	29	25	28	54	0.09	4.9
Bacteria								
E.Coli Bacteria	cfu/100 mL	215	185		200	37	0.17	6.3
Fecal Coliforms	cfu/100 mL	440	320		382			

Add the calculation column.

Add Weighting Factors for test completed.

TOTALS 1 72.93

Divide Total of Calculation Column by Total Weighting Factor Column

WQI 72.93 - Good

WQI Ratings	
Excellent	90 - 100%
Good	70 - 87%
Medium	50 - 69%
Bad	25-49%
Very Bad	0-24%

Hoosier Riverwatch
Chemical Monitoring Data Sheet

Date 10 / 04 / 2009 Volunteer ID 1000 Site ID 1000

Stream Name Example Stream Indiana Latitude 39.52533 Longitude -85.76369

Time Sampling 2.5 hrs Air Temp.: 29.5 °C

Time 12 : 15 AM / PM

Current Weather:	☐ Clear/Sunny	☒ Overcast	☐ Showers	☐ Rain (steady)	☐ Storm (heavy)
Worst Weather (past 48 hours):	☒ Clear/Sunny	☐ Overcast	☐ Showers	☐ Rain (steady)	☐ Storm (heavy)

	Units	Sample # 1	Sample # 2	Sample # 3	Avg.	**Q-Value**	x Weighting Factor	= **Calculation** *(Q-value x Wt. Factor)*
Temperature								
Water Temp at Site	°C	22.0	22.0	22.0	22.0			
Water Temp 1 Mile Upstream	°C	22.0	21.0	21.0	21.3			
Water Temp Change: *Site Temp - Upstream Temp*	°C	0.0	1.0	1.0	0.7	90	0.11	9.9
Dissolved Oxygen								
Dissolved Oxygen	mg/L	8.0	7.0		7.5			
DO% Saturation: *Determine from chart or table/equation*	%				86.2	92	0.18	16.6
BOD								
Avg. Dissolved Oxygen: *(Calculated Above)*	mg/L	7.5	7.5	7.5	7.5			
Dissolved Oxygen after 5 days	mg/L	6.0	5.0	5.5	5.5			
BOD *Avg DO (original)-DO after 5 days*	mg/L				2.0	80	0.12	9.6
pH								
pH		8.0			8.0	82	0.12	9.8
Nutrients								
Orthophosphate	mg/L	0			0			
Total Phosphate *(boil in acid)*	mg/L						0.11	
Nitrate (NO3) *multiply by 4.4*	mg/L	10			10	51	0.10	5.1
Nitrite (NO2) *multiply by 3.3*	mg/L	0			0			
Turbidity								
Transparency *(from tube)*	cm	25	26	27.5				
Turbidity *(convert from chart/table)*	NTU	30	29	25	28	54	0.09	4.9
Bacteria								
E.Coli Bacteria	cfu/100 mL						0.17	
Fecal Coliforms	cfu/100 mL							

Use Average DO value for BOD calculation.

Remember to convert your reading from the tube to NTUs.

Add Weighting Factors for test completed.

Add the calculation column.

TOTALS 0.72 55.9

Divide Total of Calculation Column by Total Weighting Factor Column

WQI 77.6 - Good

WQI Ratings	
Excellent	90 - 100%
Good	70 - 87%
Medium	50 - 69%
Bad	25-49%
Very Bad	0-24%

Water Temperature

Water temperature is very important to overall water and stream quality. Temperature affects:

1. **Dissolved Oxygen Levels** – Colder water can hold more dissolved oxygen than warmer water, thus colder water generally has higher macroinvertebrate diversity. Warmer water has less dissolved oxygen. Lower oxygen levels weaken fish and aquatic insects, making them more susceptible to illness and disease (Figure 17).

2. **Rate of Photosynthesis** – Photosynthesis by algae and aquatic plants increases with increased temperature, this leads to an extremely high amount of oxygen produced when sunlight is present and a sag during the dark hours. Increased plant/algal growth leads to increased death and decomposition, resulting in increased oxygen consumption (BOD_5) by bacteria.

3. **Metabolic Rates of Aquatic Organisms** – Many animals require specific temperatures to survive. Water temperature controls their metabolic rates, and most organisms operate efficiently within a limited temperature range. Aquatic organisms die when temperatures are too high or too low. Water temperature varies naturally with changes of the seasons, the amount of rainfall and flow rates. Thermal pollution (artificial temperature increases such as, through the addition of cooling waters or cutting down shade trees) can threaten the balance of aquatic ecosystems. To determine if your river or stream is thermally polluted you must take a temperature reading at two different locations. Increased water temperature may be caused by many sources, some of which are listed below. If water temperature decreases within a mile of the sampling site, there may be a source of cold water, such as a spring, entering the stream.

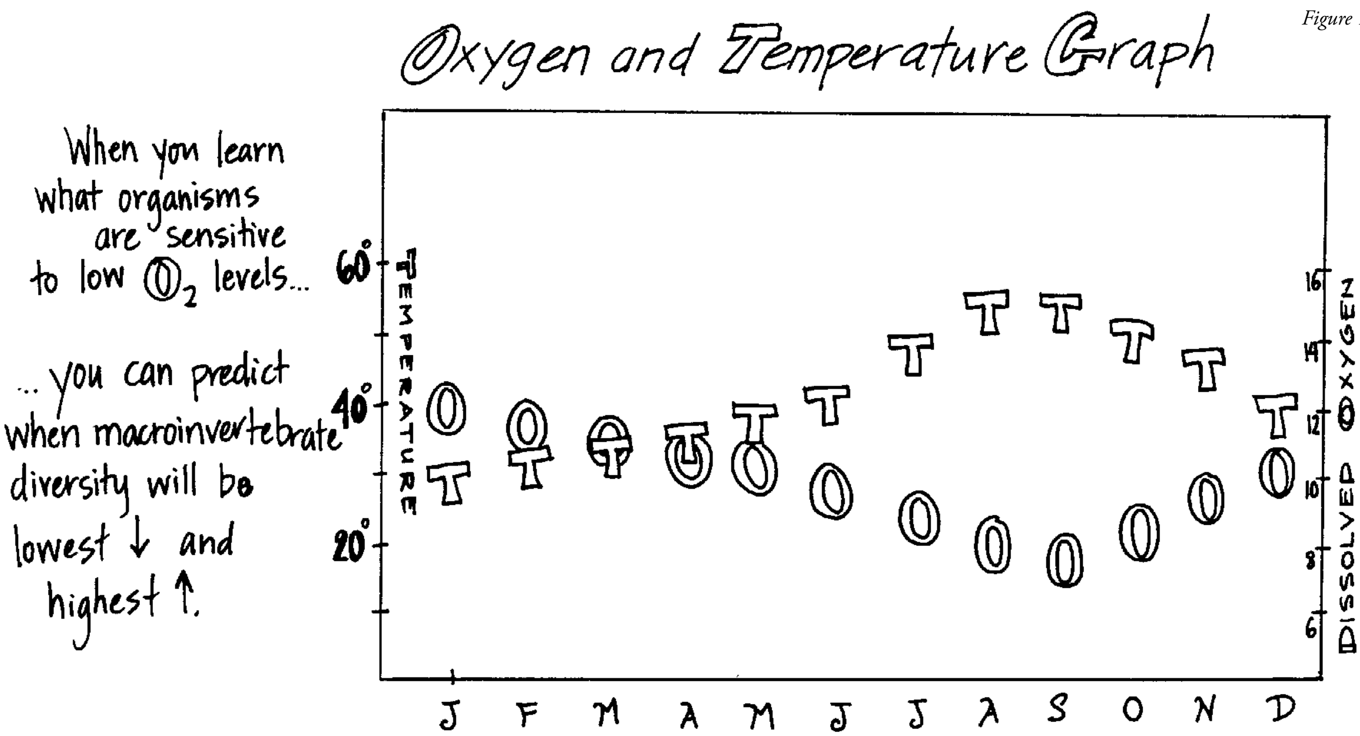
Problem:

Aquatic organisms have narrow optimal temperature ranges. In addition warmer water holds less dissolved oxygen.

Causes:

- Loss of shading by trees in the riparian zone and the watershed.
- Runoff from roads and parking lots.
- Discharges from municipal wastewater and industrial sources.

Figure 17



The *air temperature* needs to be taken while the thermometer is completely dry, **so do that first.** Hang the thermometer somewhere where it's not leaning against a solid object and where it is protected from direct wind and sunlight. *The thermometer will take 5-10 minutes to equilibrate.* **Record the result.**

Temperature Change Instructions

1. Place the thermometer below the water's surface (e.g., the same depth at which other tests are performed). If possible, obtain the temperature reading in the main streamflow.
2. Swirling gently, hold the thermometer in the water for approximately 2 minutes or until the reading stabilizes.
3. Record your reading in Celsius. (Note: If you are using a thermometer that reads only in Fahrenheit, look at Figure 18 or use the following equation to convert to Celsius):

$$C = (F - 32.0)°/ 1.8$$

4. Choose a portion of the stream with roughly the same degree of shade and velocity as in Step 1, and conduct the same test approximately 1 mile upstream as soon as possible using the same thermometer.
5. Calculate the difference between the downstream and upstream results. Record the temperature change in Celsius and note if the change is positive or negative.

Example:

Downstream Temp (Your Site)
- Upstream Temp (~1 mile away)

= Temperature Change (+/-)

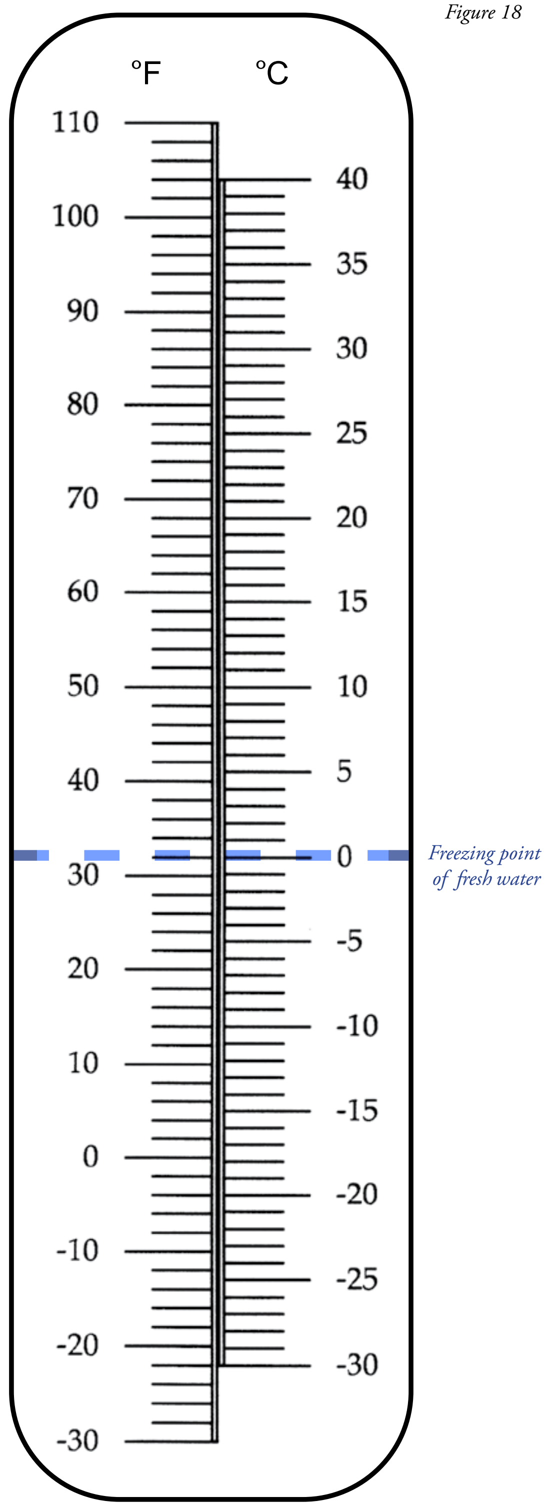
Because water temperature is influenced by time of day, season, and thermal inputs, typical values do not exist.

The maximum temperature rise at any time or place above natural temperatures shall not exceed **State Water Quality Standard:**

<5° F (approximatively 2.8° C)

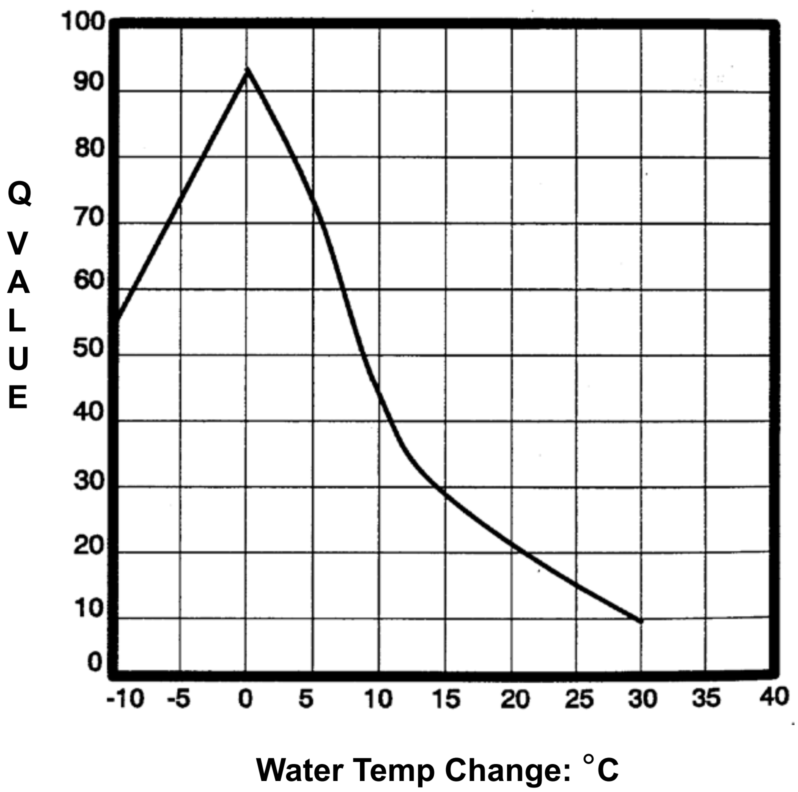
<2° F (approximatively 1.1° C) for trout streams

Figure 18



Temperature conversion image and air temp instructions provided by Friends of Casco Bay, ME.

Temperature Change Q-Values



Change in Temp. (°C)	Q-Value
-10	56
-7.5	63
-5	73
-2.5	85
-1	90
0	93 (max)
1	89
2.5	85
5	72
7.5	57
10	44
12.5	36
15	28
17.5	23
20	21
22.5	18
25	15
27.5	12
30	10

Dissolved Oxygen

Oxygen is as important to life in water as it is to life on land. Most aquatic plants and animals require oxygen for survival. Although oxygen atoms are present in the water molecule (H_2O), most aquatic life require oxygen in the free elemental state (O_2) as a dissolved gas. The amount of oxygen in water is called the dissolved oxygen (DO) concentration. Oxygen dissolves into the water from the atmosphere until the water is saturated. Aquatic plants, algae, and plankton also produce oxygen as a by-product of photosynthesis; which is why oxygen levels rise during the day and fall at night during respiration. DO is an important measure of stream health. Presence of oxygen in water is a positive sign, while absence of oxygen from water often indicates water pollution. Aquatic organisms require different levels of DO. Dissolved oxygen levels below 3 ppm are stressful to most aquatic life. DO levels below 2 or 1 ppm will not support fish. Levels of 5 to 6 ppm are usually required for healthy growth and activity of aquatic life. Some of the factors affecting DO are:

- Temperature (water can't hold as much dissolved oxygen at higher temperatures)
- Altitude/atmospheric pressure
- Turbulence
- Plant growth/photosynthesis
- Amount of decaying organic material

Percent (%) Saturation

Two pieces of information are needed to interpret dissolved oxygen levels: the DO concentration (in ppm or mg/L) and the water temperature. From these two values, the percent saturation can be determined. Percent saturation expresses the current amount (in milligrams) of oxygen gas dissolved in one liter of water at a given temperature compared with the maximum milligrams of oxygen gas that can remain dissolved in one liter of water at the same temperature and pressure. The table on page 48 shows the mg/L of DO that represents 100% saturation at each given temperature. Cold water can hold more dissolved oxygen than warm water.

For example, water at 27°C is 100% saturated with 8 ppm dissolved oxygen. However, water at 8 °C can hold up to 11.8 ppm DO before it is 100% saturated. Thus, daily and seasonal temperature changes, as well as thermal pollution, greatly impact oxygen levels and aquatic life in streams and rivers.

Problem:
Lack of sufficient dissolved oxygen required by most aquatic organisms to breathe. Lack of oxygen increases the toxicity of other chemicals (e.g., hydrogen sulfide and ammonia).

Causes:

- Rapid decomposition of organic materials, including dead algae, shoreline vegetation, manure or wastewater decreases oxygen.
- High ammonia concentrations in the stream use up oxygen in the process of oxidizing ammonia (NH_4+) to nitrate (NO_3-) through nitrification.
- Less oxygen can dissolve in water at higher temperatures.
- Lack of turbulence or mixing to expose water to atmospheric oxygen results in low dissolved oxygen concentrations.

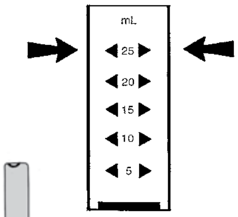
Supersaturation

High levels of bacteria or large amounts of rotting organic material can consume oxygen very rapidly and cause the percent saturation to decrease. Conversely, water may become supersaturated for short periods of time, holding more than 100% of the oxygen it would hold under normal conditions. Supersaturation is often caused by high levels of photosynthesis in streams overloaded with aquatic plants and algae. Supersaturation may also occur at the base of dams due to increased pressure. Supersaturation can be harmful to aquatic organisms, causing gas bubble disease, a condition similar to "the bends", which scuba divers may get if they surface too fast. Supersaturation during daytime hours, along with evidence of high photosynthetic activity may indicate a possible oxygen sag during the evening hours, which would limit aquatic life use.

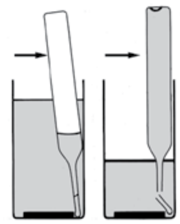
Dissolved Oxygen Instructions

These instructions are for use with the CHEMetrics Dissolved Oxygen Test Kit K-7512.

1. Triple rinse the sample cup with water to be tested. Fill the sample cup to the 25mL mark.

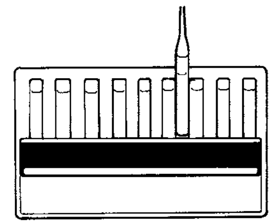


2. Place the CHEMet ampoule in the sample cup. Snap the tip by squeezing the ampoule against the wall of the cup. The ampoule will fill itself, leaving a small bubble to facilitate mixing.



3. Mix the contents of the ampoule by inverting it five times, allowing the bubble to travel from end to end each time. Do not place your finger over the broken tip. Wipe all liquid from the exterior of the ampoule. **Wait 2 minutes** for color development.

4. Hold the comparator in a nearly horizontal position while standing beneath a source of bright light. You may remove the color comparator from the lid. Place the ampoule between the color standards until the best color match is found. If the ampoule is between two color standards, you can estimate half-way between these two values.



5. Use the equation on page 48 or the graph in Figure 19 to calculate percent saturation. On page 19, run a straight edge from the appropriate water temperature to DO (mg/L) to determine % saturation along the angled (middle) scale. If you took the temperature in Fahrenheit, use this conversion equation, $C = (F - 32.0)/1.8$, or use the diagram on page 48 to obtain Celsius degrees.

6. Record the dissolved oxygen concentration to the nearest mg/L as well as the percent saturation. Rinse the glass tip out of sample cup into a waste container along with the spent ampoule.

Important Note:

The CHEMet ampoules and color standards contain a reagent which deteriorates upon prolonged exposure to light. They will remain stable only if stored in the dark. The reagent should be a light straw color with no hint of blue or green when the ampoule is removed from the box. The normal shelf life of the color standards is two years.

Examples:

DO = 8 mg/L   Temp = 16 ºC

Look on chart (page 47) = 81% Saturation

Or use table and equation on page 48:

$$\frac{8.0 \text{ mg/L}}{9.9 \text{ mg/L}} \times 100\% = 81\% \text{ Saturation}$$

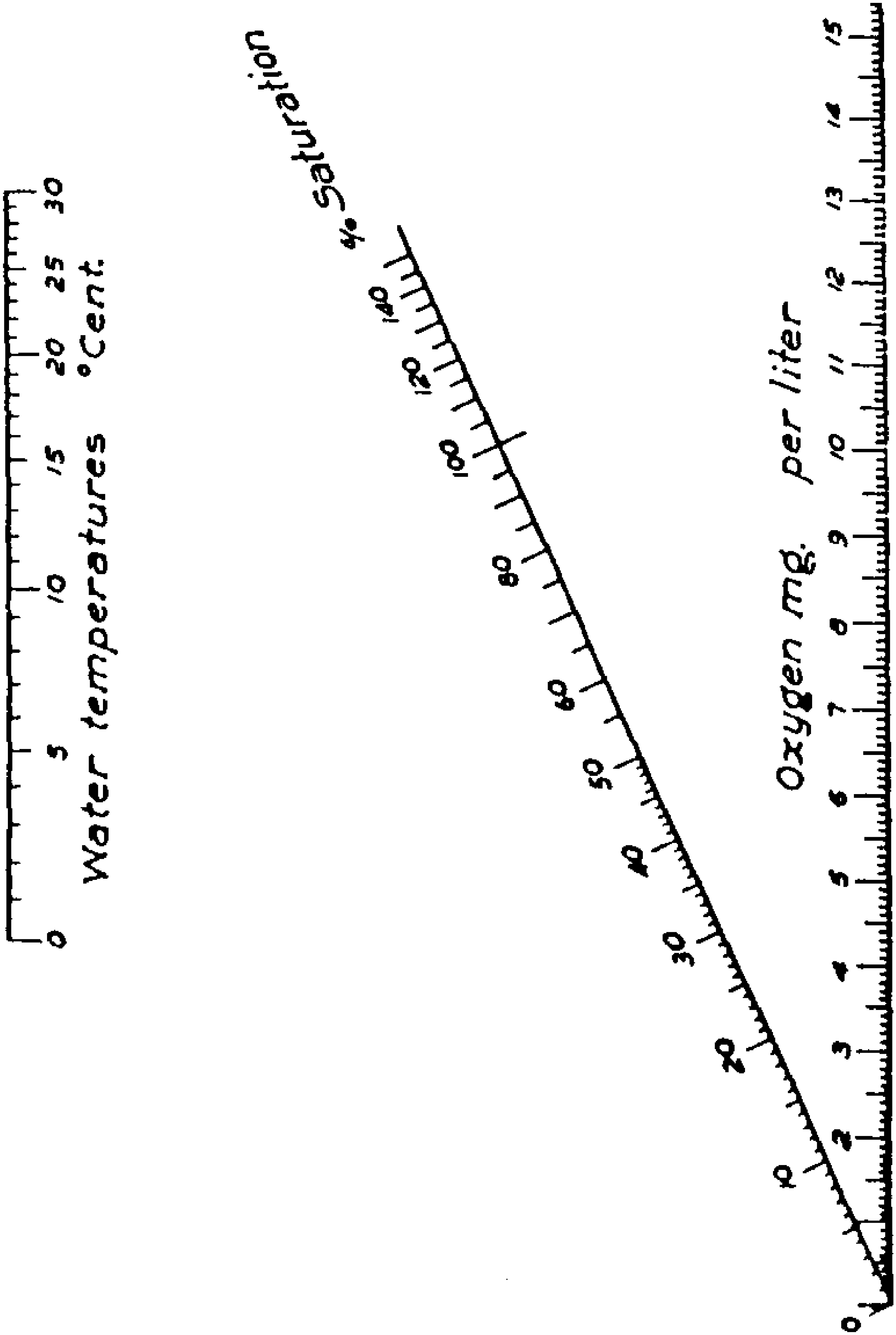
Typical range for DO =
1.2 to 22.3 mg/L

Indiana Average = 9.6 mg/L

State Water Quality Standard: 4.0 mg/L - 12.0 mg/L
Min: 6.0 mg/L in coldwater fishery streams
Min: 7.0 mg/L in spawning area of coldwater fishery streams

Dissolved Oxygen % Saturation Chart

Figure 19



Approximate amount of Dissolved Oxygen (mg/L) needed for your water sample to be 100% Saturated at the given temperature.*

Temp °C	Dissolved Oxygen (mg/L)	Temp °C	Dissolved Oxygen (mg/L)
0	14.6	15	10.1
1	14.2	16	9.9
2	13.8	17	9.7
3	13.5	18	9.6
4	13.1	19	9.3
5	12.8	20	9.1
6	12.5	21	8.9
7	12.1	22	8.7
8	11.8	23	8.6
9	11.6	24	8.4
10	11.3	25	8.3
11	11.0	26	8.1
12	10.8	27	8.0
13	10.5	28	7.8
14	10.3	29	7.7

Calculating Percent Saturation:

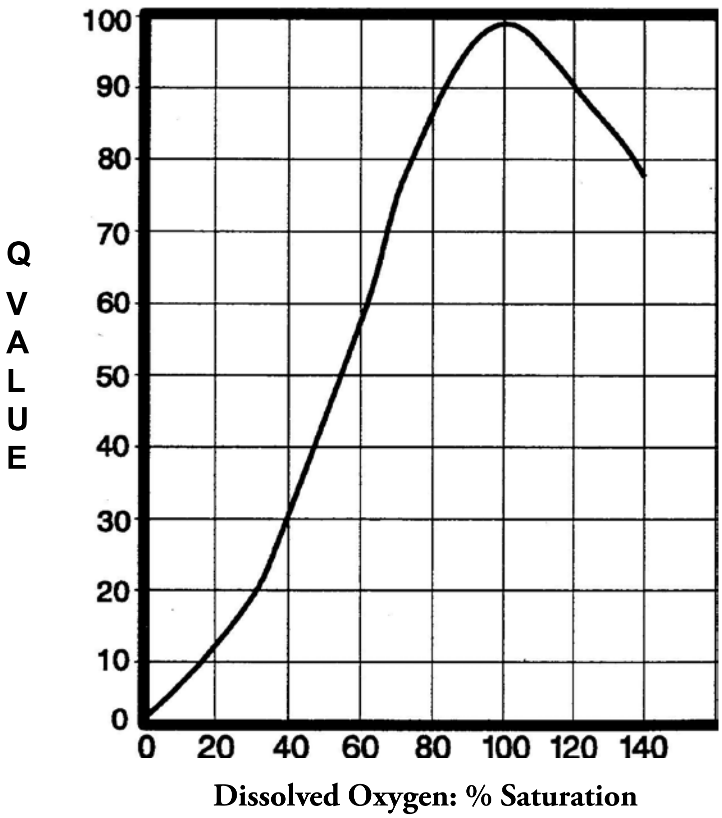
$$\frac{\textbf{DO mg/L} \text{ (your sample) } \textbf{x 100\%}}{\textbf{Max DO mg/L} \text{ (from chart at left determined by water temperature)}}$$

Example at 16 °C:

$$\frac{8.0 \text{ mg/L}}{9.9 \text{ mg/L}} \text{ x } 100\% = 81\%$$

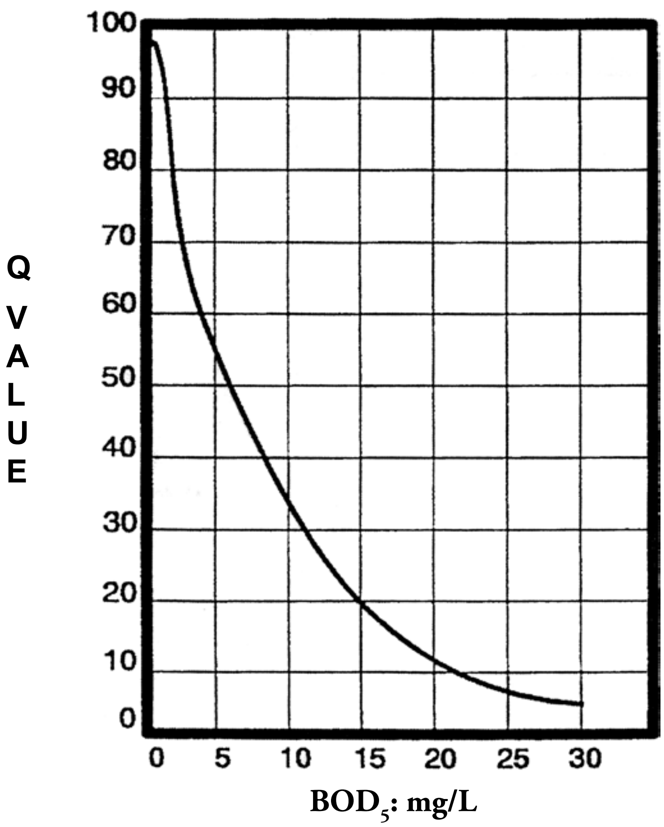
*for fresh water at sea level

Dissolved Oxygen Q-Values



DO (% Saturation)	Q-Value
0	0
10	8
20	13
30	20
40	30
50	43
60	56
70	77
80	88
85	92
90	95
95	97.5
100	99
105	98
110	95
120	90
130	85
140	78
>140	50

BOD_5 Q-Values



BOD_5 (mg/L DO)	Q-Value
0	96
1	92
2	80
2.5	73
3	66
4	58
5	55
7.5	44
8	40
10	33
12.5	26
15	20
17.5	16
20	14
22.5	10
25	8
27.5	6
30	5
>30	2

Biochemical Oxygen Demand (5-day)

Biochemical oxygen demand 5-day (BOD_5) is a measure of the amount of oxygen used by aerobic (oxygen-consuming) bacteria as they break down organic wastes over five days. Polluted streams, or streams with a lot of plant growth (and decay), generally have high BOD_5 levels. High levels indicate that large amounts of organic matter are present in the stream. Streams that are relatively clean and free from excessive plant growth typically have low BOD_5 levels. In slow moving and polluted waters, much of the available dissolved oxygen (DO) is consumed by bacteria, which rob other aquatic organisms of the oxygen needed to live. Streams with higher DO levels, such as fast-moving, turbulent, cold-water streams, can process a greater quantity of organic material. Therefore, interpretation of BOD_5 levels depends upon the conditions of the stream sampled, as some streams can "handle" more waste than others. However, in general, a healthy stream has high DO levels and low BOD_5 levels. Be careful not to confuse the two.

The following is a rough guide to what various BOD_5 levels indicate:

1-2 mg/L BOD_5	Clean water with little organic waste
3-5 mg/L BOD_5	Fairly clean with some organic waste
6-9 mg/L BOD_5	Lots of organic material and bacteria
10+ mg/L BOD_5	Very poor water quality. Very large amounts of organic material in water.

Instructions

In addition to a darkened (light-free) bottle, use the CHEMetrics Dissolved Oxygen Test Kit K-7512.

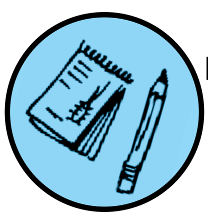
1. Rinse, then lower a stoppered dark (light-free) bottle below the water's surface. Allow water to flow into the bottle for approximately 2 minutes. Ensuring that no air bubbles exist, replace the stopper or lid while the bottle is underwater. Remove bottle from the water.
2. Place the BOD sample in a light-free location (e.g., desk drawer or cabinet) at room temperature and allow it to sit undisturbed at approximately 20 °C (68 °F) for 5 days.
3. After 5 days, remove the BOD bottle and perform Steps 1 through 4 of the DO test (page 46) using the BOD sample water.
4. Determine the BOD_5 level by **subtracting** the mg/L of the BOD sample from that of the original DO sample taken 5 days earlier. This difference is what gets recorded on the data sheet.

Problem:
High levels of organic matter - including leaves, dead fish, garbage, some industrial waste, fertilizer, pet waste, and sewage from poor functioning septic systems or combined sewer overflows - and some ions (ammonia in particular) can lead to rapid exhaustion of dissolved oxygen.

Causes:

- Municipal wastewater and septic tank effluent that has not been completely treated will use up oxygen.
- Eutrophication and hot weather can cause algae blooms. When bacteria decompose dead algae, oxygen is consumed which increases BOD.

Typical range for BOD_5 =
0.4 to 33 mg/L
Indiana Average = 2 mg/L



Example:

11 mg/L (DO Day 1)
-6 mg/L (DO 5 days later)
= 5 mg/L (BOD_5)

pH

The pH test is one of the most common analyses in water testing. Water (H_2O) contains both hydrogen ions (H+) and hydroxide ions (OH-). The relative concentrations of these ions determine whether a solution is acidic or basic.

The activity of the hydrogen ions is expressed in pH units (pH = power of Hydrogen). The concentration of H+ ions is used to estimate pH. The pH scale ranges from 0 (most acidic) to 14 (most basic), with 7 being neutral. If the solution has more H+ ions than OH ions, it is acidic and has a pH less than 7. If the solution contains more OH- ions than H+ ions, it is basic with a pH higher than 7. It is important to remember that pH is measured on a logarithmic scale; it is reported as the negative log of the hydrogen ion concentration (-log [H+]). A change of 1 pH unit means a ten-fold change in the ion concentration. For this reason, pH units are not normally averaged; however, to simplify calculations, Riverwatch allows volunteers to average pH.

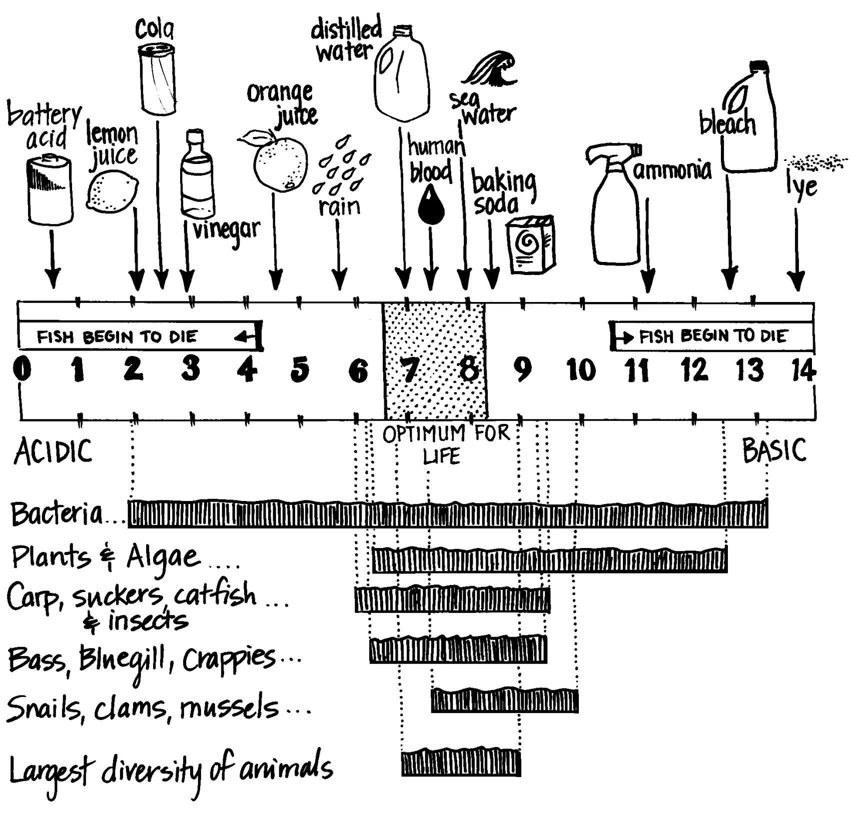
The pH level is an important measure of water quality because aquatic organisms are sensitive to pH, especially during reproduction. Adult organisms may survive, but young will not be produced. A pH range of 6.5 to 8.2 is optimal for most organisms (Figure 20).

Many natural processes affect pH. Waterbodies with higher temperatures have slightly lower pH values. Also, algae blooms remove carbon dioxide (CO_2) from the water during photo-synthesis, which may raise pH to 9 or more.

Runoff from abandoned mine lands can produce acid mine drainage which lowers pH. Lower pH values increase the solubility of some heavy metals, such as copper and aluminum, allowing them to dissolve in water and become toxic to aquatic organisms.

Most natural waters have pH values of 5.0 - 8.5. Freshly fallen rainwater has a pH of 5.5 - 6.0 due to the presence of CO_2 in the atmosphere. But air pollution from automobiles and coal-burning power plants creates acid rain which is even more acidic. Alkaline soils and minerals (limestone) buffer the effects of acid rain and may raise pH to 8.0 - 8.5.

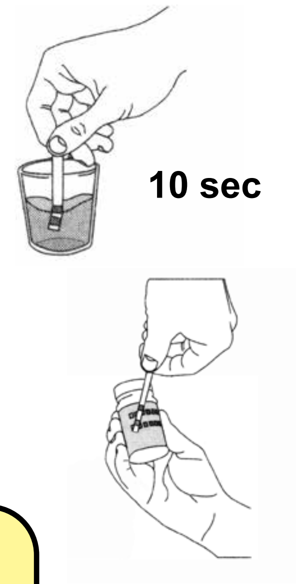
Figure 20

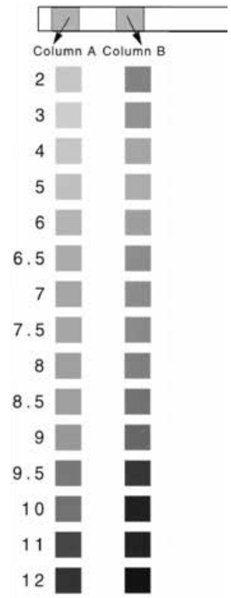


pH Instructions

For use with WaterWorks™ pH Test Strips (#481104).

1. Triple rinse sample collection container with water to be tested, then collect a sample.
2. Dip one test strip into sample for 10 seconds with a constant, gentle back-and-forth motion.
3. Remove the strip and shake once, briskly, to remove excess sample.
4. Wait 20 seconds and match with the closest colors on both charts for Columns A and B at the same time.
5. For best performance, complete the reading within 10 seconds.
6. Record the pH level.

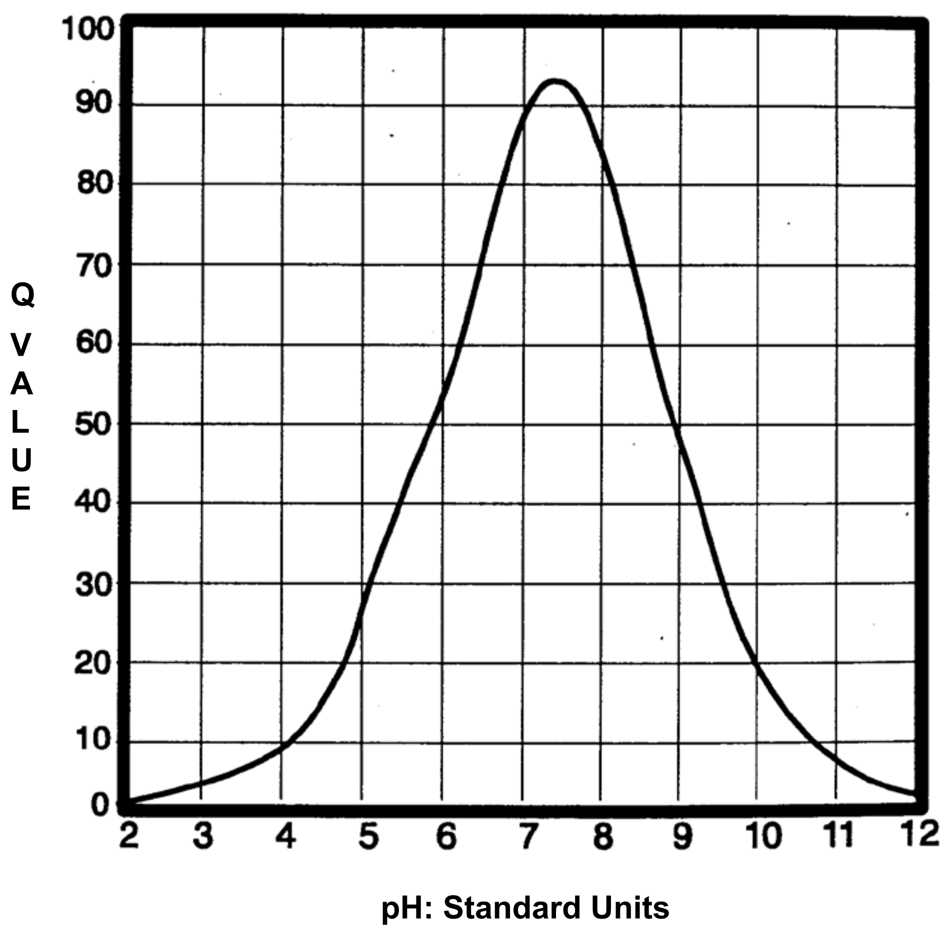




Typical range for pH = **7.2 to 8.8**

Indiana Average = 8.0

State Standard = between 6 - 9
Due to the state's limestone geology, Indiana surface waters will typically have a pH that is relatively basic (> 7).



pH Q-Values

pH (SU)	Q-Value
<2	0
2	2
3	4
4	8
5	24
6	55
7	90
7.2	92
7.5	93 (max)
7.7	90
8	82
8.5	67
9	47
10	19
11	7
12	2
>12	0

Orthophosphate

Phosphorus (P) is essential to plant and animal life, and its presence in the environment is natural. Problems with phosphorus as a water pollutant result not from its presence, but from excessive amounts. Aquatic ecosystems develop with very low levels of phosphorus. The addition of seemingly small amounts of phosphorus can lead to problematic algal blooms in freshwater. Research has indicated nitrogen leads to algal bloom in saltwater systems.

Phosphorus enters surface waters in organic matter (dead plants and animals, animal waste) attached or adsorbed to soil particles, or in a number of man made products (detergents, fertilizers, industrial wastes). Phosphorus is an important nutrient in commercial fertilizer because it increases terrestrial plant growth (vegetation). When transported into aquatic systems, phosphorus increases aquatic plant growth (e.g. algae, weeds), as well (Figure 21).

Phosphorus occurs in nature in the form of phosphates (PO_4). Phosphate levels higher than 0.03ppm contribute to increased plant and algae growth. Orthophosphates are one form of phosphates. Orthophosphates are dissolved in the water and are readily available for plant uptake. Thus, the orthophosphate concentration is useful as an indicator of current potential for algae blooms and eutrophication.

Figure 21

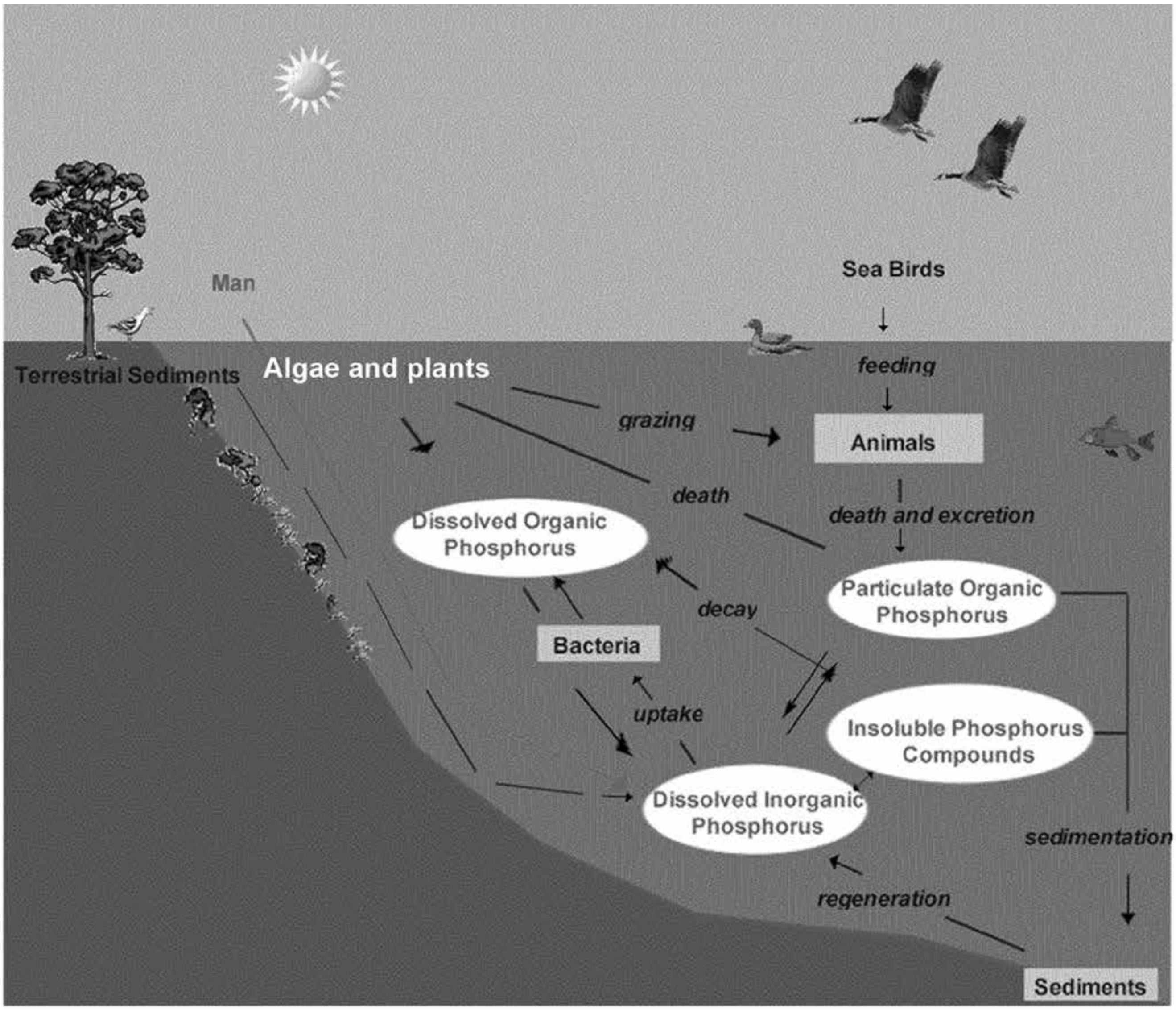
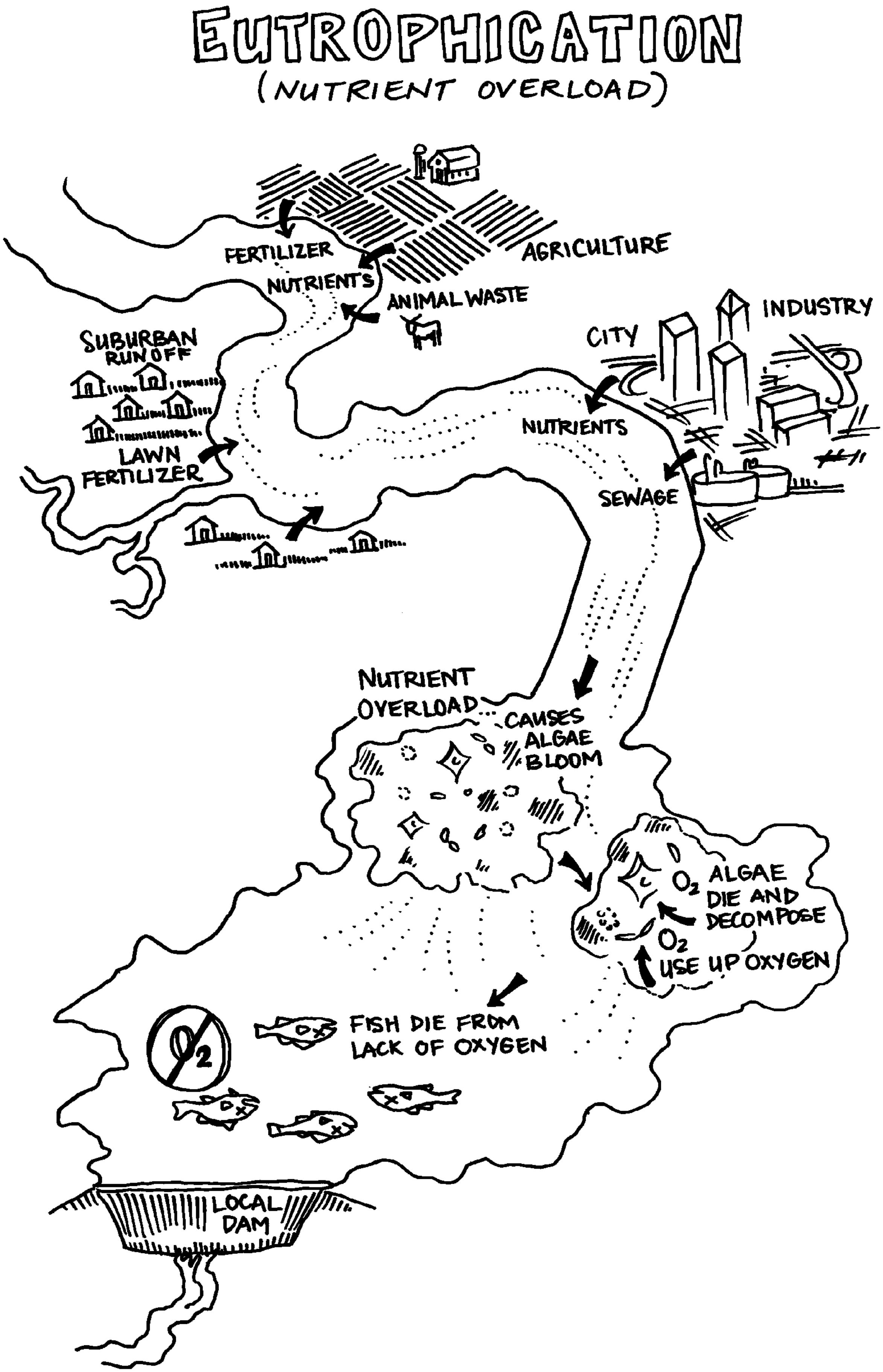


Image from Virginia Estabrook, Michigan Water Research Center

Figure 22


EUTROPHICATION
(NUTRIENT OVERLOAD)
FERTILIZER
AGRICULTURE
NUTRIENTS
ANIMAL WASTE
INDUSTRY
CITY
SUBURBAN RUN OFF
NUTRIENTS
LAWN FERTILIZER
SEWAGE
NUTRIENT OVERLOAD...
CAUSES ALGAE BLOOM
O_2
ALGAE DIE AND DECOMPOSE
O_2
USE UP OXYGEN
O_2
FISH DIE FROM LACK OF OXYGEN
LOCAL DAM

When phosphorus levels are too high, excess plant and algal growth creates water quality problems. Plants begin to die and decompose, depleting the dissolved oxygen supply in the water - a condition called **hypoxia**, which can lead to fish kills in some cases. Phosphorus is also released from the sediments and decomposing plants back into the water, continuing the cycle. The reaction of the aquatic system to an overloading of nutrients is known as **eutrophication** (Figure 22). Hypoxia and eutrophication, to some extent, occur within many of our lakes and stream every year, and, on a larger scale, such as in the western basin of Lake Erie.

Unlike nitrogen and other nutrients, phosphorus does not have a gaseous phase. Once it is in an aquatic system, it remains there and cycles through different forms unless physically removed (e.g. by dredging). Over time some of the other forms of phosphates attached to particles in the water column and in the sediments (including organic forms) can be changed into orthophosphates, becoming available for plant growth. For this reason, it is useful to test for total phosphate levels.

The chemistry methods currently utilized by Hoosier Riverwatch do not include a means for obtaining total phosphate results.

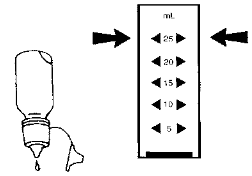
Problem:
Most fresh water has naturally low phosphate levels, and this limits algal growth. If excessive phosphates enter surface water, it can support rapid algal growth. When the algae die, their decomposition by bacteria uses up oxygen and may produce odors and algal toxins.

Causes:

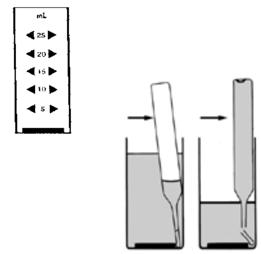
- Phosphorus occurs naturally in soil. Sediments from soil erosion and runoff are often a significant source of phosphorus. These may enter the stream via bank erosion or runoff from forestry, agriculture, and urban lands. Phosphorus can desorb from soil particles and enter solution.
- Phosphorus can come from manure sources, such as treatment lagoons, over-fertilized agricultural fields, or waterfowl.
- Urban sources of phosphorus may include: storm drains, parking lot and road runoff, construction sites, inadequately treated municipal wastewater and septic tank effluent, and lawn fertilizer.

Orthophosphate Instructions

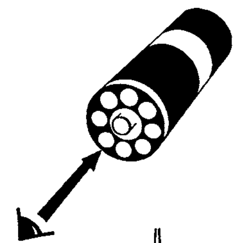
These instructions are for use with the CHEMetrics Phosphate Test Kit K-8510.



1. Triple rinse the sample cup and cap with water to be tested. Fill the sample cup to the 25 mL mark with the sample.
2. Add **2 drops** of A-8500 Activator Solution. Place cap on sample cup and shake it briefly to mix the contents well.

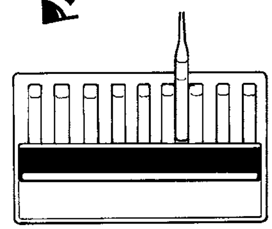


3. Place the CHEMet ampoule into the sample cup. Snap the tip by squeezing the ampoule against the side of the cup. The ampoule will fill leaving a small bubble to facilitate mixing.
4. Mix the contents of the ampoule by inverting it ten times, allowing the bubble to travel from end to end each time. Do not place your finger over the broken tip. Wipe all liquid from the exterior of the ampoule. Wait **2 minutes** for full color development.



5. Use the appropriate comparator to determine the level of orthophosphate in the sample. If the color of the CHEMet ampoule is between two color standards, you can estimate half-way between the concentrations.

   a. <u>Low-range (0-1 ppm)</u> Place the ampoule, flat end downward into the center tube of the low range comparator (broken tip pointing away from you.) Direct the top of the comparator up toward a source of bright light while viewing from the bottom. Rotate the comparator until the color standard below the ampoule shows the closest match.



   b. <u>High Range (0-10 ppm)</u> Hold the high range comparator in a nearly horizontal position while standing directly beneath a bright source of light. You may remove the comparator from the lid. Place the ampoule between the color standards until the best color match is found. If the ampoule is between two color standards, you can estimate half-way between the concentrations.

6. Place ampoule and sample in waste container. Record the results in mg/L on the Chemical Monitoring Data Sheet. There is no Q-value for Orthophosphate, and this result may not be entered on the Water Quality Index Data Sheet.

Note: Results of the Orthophosphate test may be entered on the Chemical Monitoring Data Sheet & submitted to the online database. There are no state water quality standards for Orthophosphate.

However, we do know the Total Phosphate typical range (0-0.85 mg/L) and Indiana average (0.05 mg/L) values.

We generally expect orthophosphate values to be less than total phosphate, since orthophosphate is but one component of total phosphate.

Important Note:

The CHEMet ampoules and color standards contain a reagent which deteriorates upon prolonged exposure to light. They will remain stable only if stored in the dark. The reagent should be completely clear when the ampoule is removed from the box.

Nitrate & Nitrite

Nitrogen makes up about 80% of the air we breathe, and it is found in all living things. Nitrogen occurs in water as nitrate (NO_3), nitrite (NO_2), and ammonia (NH_3). It enters the water from human and animal waste, decomposing organic matter, and runoff of fertilizer from lawns and crops. Nitrates are an essential nutrient for plant growth. Similar to phosphates, these are a main ingredient in fertilizers and can lead to increased aquatic plant growth and eutrophication. Nitrogen is a leading cause of hypoxia in salt waters. Hoosier Riverwatch reports nitrates in units of mg/L (ppm) of the nitrate molecule itself, which is 4.4 times greater than nitrat-as N reported as mg/L of nitrogen.

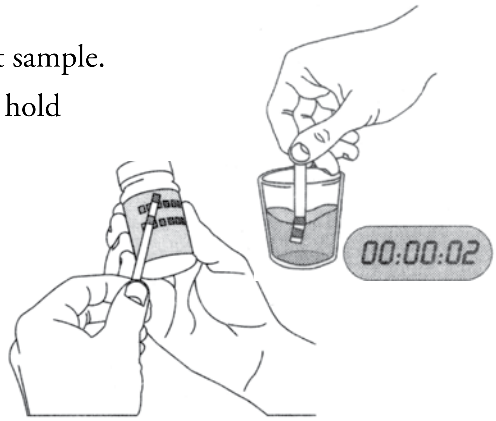
Problem:
Nitrogen works with phosphorus to increase algae growth and cause eutrophication.

Causes:

- Nitrogen can come from manure, such as treatment lagoons and over fertilized fields.
- Nitrogen is the most abundant nutrient in commercial fertilizers. Runoff from agriculture, golf courses, and lawns is high in nitrogen, especially if it rains soon after fertilization.
- Sewage is another source of nitrates in Indiana's surface water.

Instructions

For WaterWorks™ Nitrate/Nitrite Test Strips (#480009)



1. Triple rinse sample collection container with water to be tested. Collect sample.
2. Dip one test strip for 2 seconds without motion. Remove the strip and hold horizontally. Do NOT shake off excess sample water.
3. Wait 1 minute for colors to develop.
4. Match Nitrite as N (pad nearest handle) to the closest color. Then match Nitrate as N (end pad) to the closest color. Record these results separately. Complete color matching within 1 minute.
5. Apply conversions to results before recording:

   Conversion Ratio:
   A) To convert nitrite nitrogen as N to just nitrite (NO_2), multiply the test result by 3.3.

   Example: 1.5 mg/L (test strip) x 3.3 = 4.95 mg/L nitrite (NO_2)

   B) To convert nitrate nitrogen as N to just nitrate (NO_3), multiply the test strip result by 4.4.

   Example: 5 mg/L (test strip) x 4.4 = 22 mg/L nitrate (NO_3)

6. Record the converted values on Chemical Monitoring Data Sheet.

Important Note:
Store test strips in dry, cool place (< 30 ° C) and away from direct sunlight. Use by date printed on package.

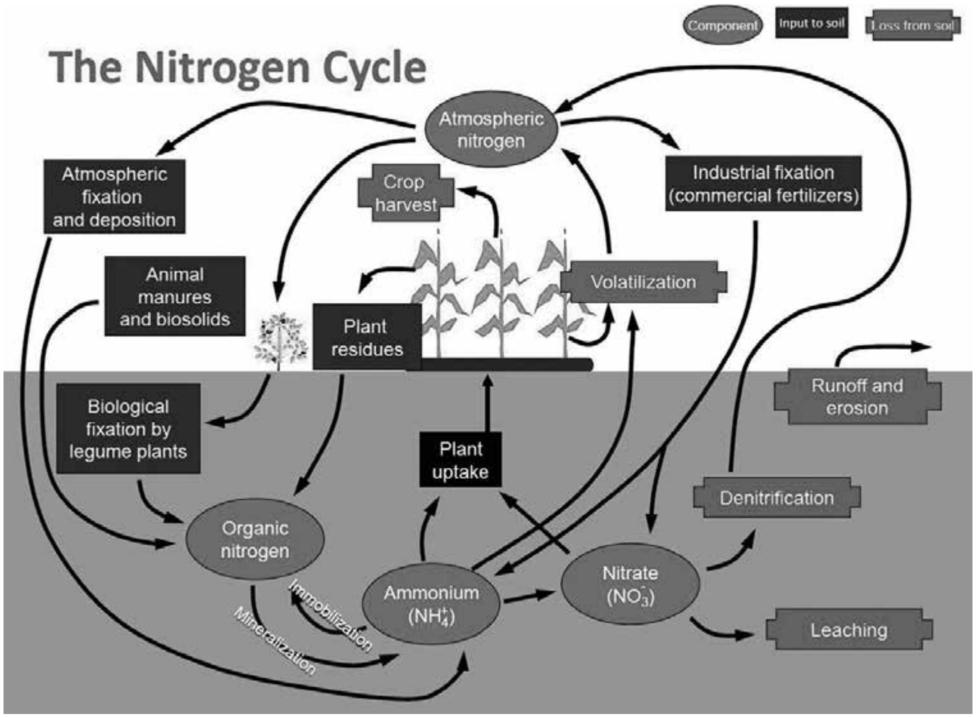
Typical range for nitrate (NO_3) = 0 to 36.08 mg/L

Indiana Average = 12.32 mg/L

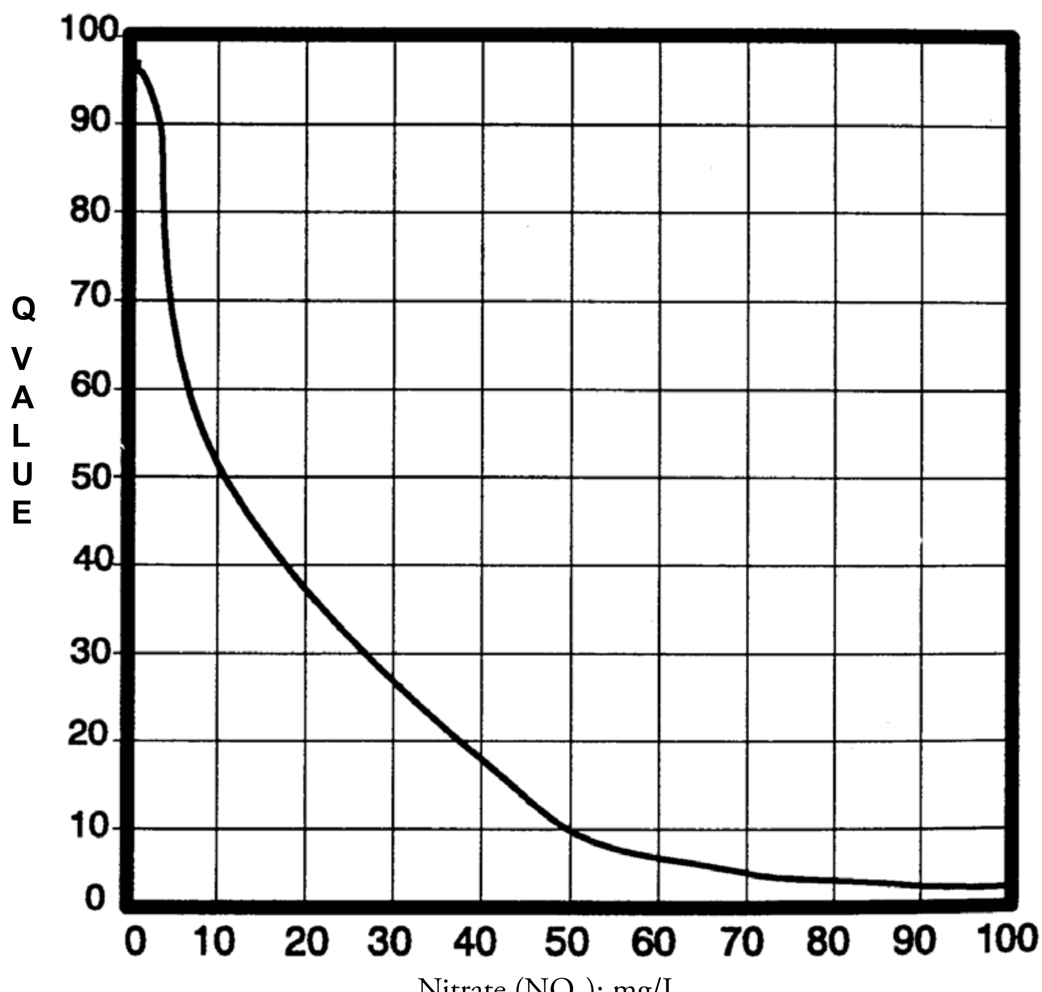
EPA recommends 1.5 mg/L as the dividing line between mesotrophic and eutrophic streams.

Nitrate/NO_3 (the converted value after the result has been multiplied by 4.4) is used in the Q-Value chart and the Water Quality Index Data Sheet.

Figure 23



Nitrate (NO_3): mg/L Q-Values



Nitrate (NO_3): mg/L

Nitrate (mg/L NO_3)	Q-Value
0	98
0.25	97
0.5	96
0.75	95
1	94
1.5	92
2	90
3	85
4	70
5	65
10	51
15	43
20	37
30	24
40	17
50	7
60	5
70	4
80	3
90	2
100	1
>100	1

There is no Q-value chart for Nitrite (NO_2)

Turbidity and Transparency

Turbidity is the relative clarity of the water and is measured by shining a light through the water column. Turbid water is more cloudy, and is caused by suspended matter including clay, silt, organic and inorganic matter, and algae. These materials scatter and absorb light, rather than allowing it to shine through the water column in a straight line. Turbidity should not be confused with color, since darkly colored water (like tea) can still be clear and not turbid.

Turbid water may be the result of soil erosion, urban and agricultural runoff, algal blooms, and bottom sediment disturbances caused by boat traffic or abundant bottom feeding fish. If a stream is very turbid, light will not reach through the water column and many reactions, especially photosynthesis, will be limited. When water is turbid, the floating particles absorb heat from the sun, raising water temperature and thus lowering dissolved oxygen levels. The particles can also kill fish and aquatic invertebrates by clogging their gills and smothering their habitat (Figure 24).

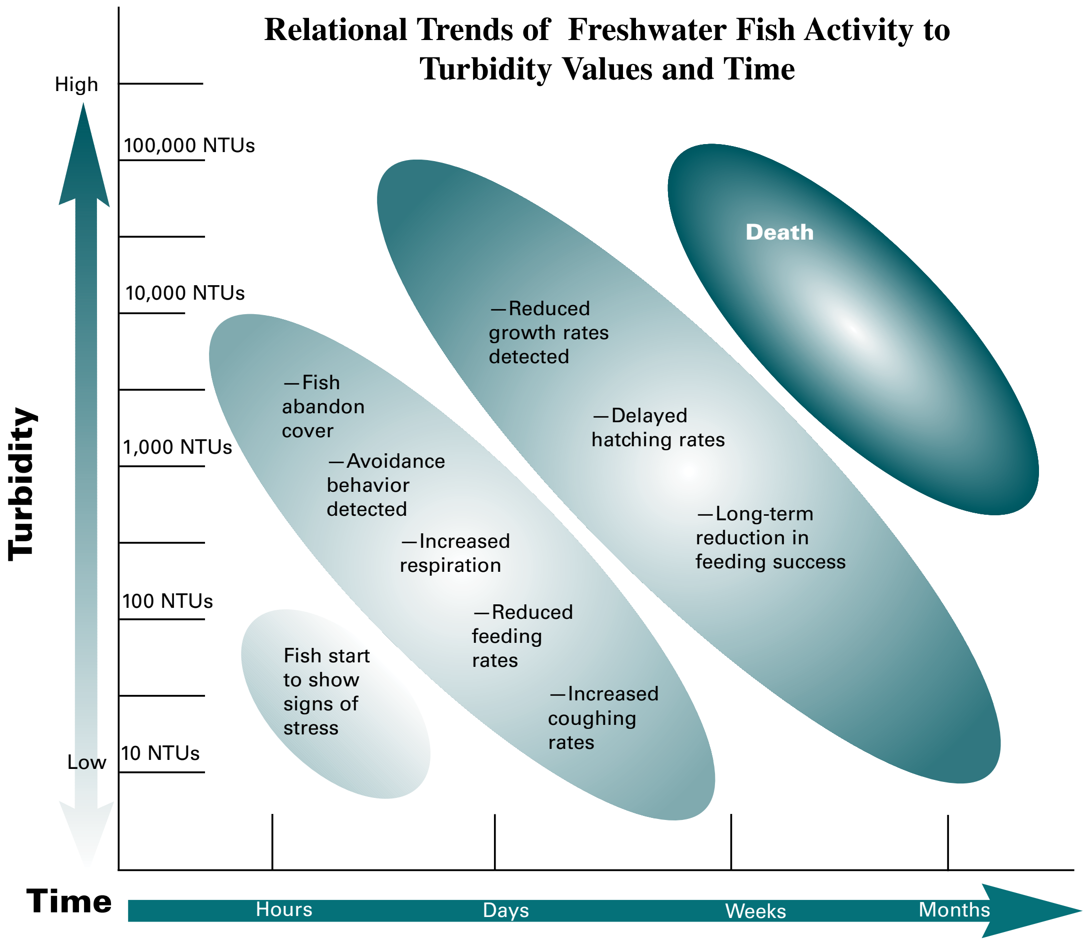
Transparency measures the scattering of light and is observed by the depth at which we can see an object in the water column. We measure the transparency of our water sample, and use a pre-determined relationship to convert our transparency results (cm) to units of turbidity (NTUs).

Problem:
The water looks "dirty." Photosynthesis is limited because organisms in the water column receive no light. Temperature is increased due to light absorption.

Causes:

- Soil erosion and runoff from agricultural fields, lawns, parking lots, construction sites, or the stream bank itself.
- Algae and organic matter also contribute to turbidity.

Figure 24



Transparency Instructions

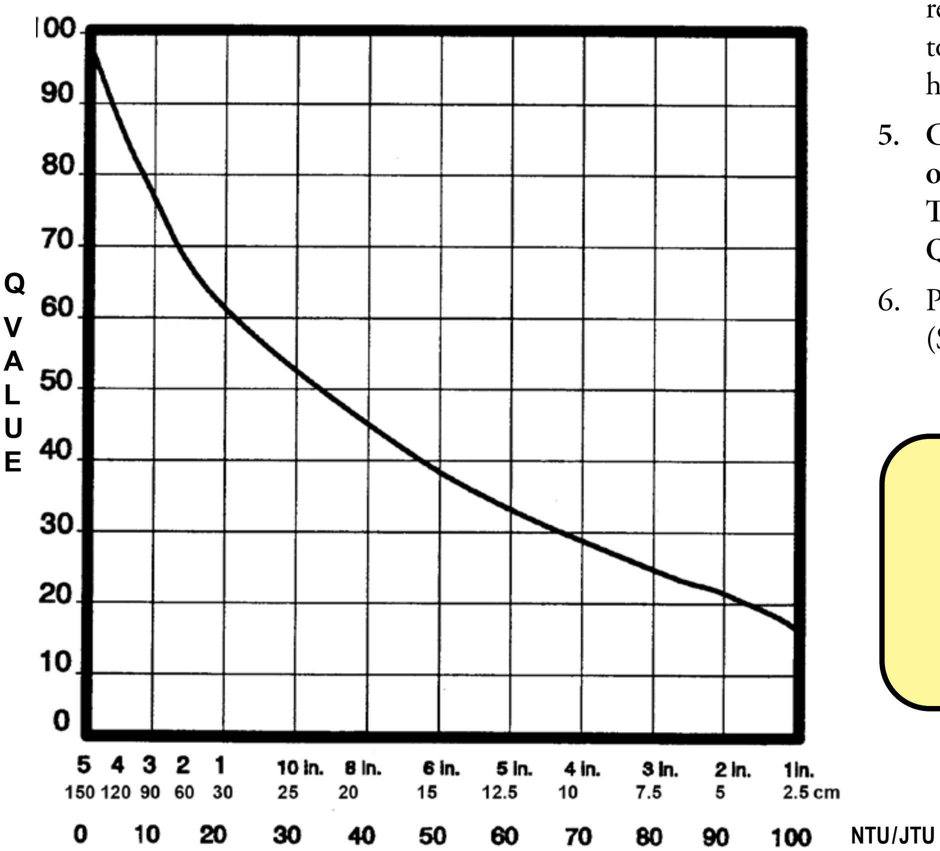
Turbidity can be assessed with a very accurate but expensive electronic turbidimeter. Transparency can be assessed with many types of equipment, including a homemade Secchi disk or transparency tube. As a side note, Secchi disks are usually used for lentic waters, like lakes. A transparency tube is used for lotic waters, like rivers and streams. See Appendix A for information about purchasing or making your own transparency tube.

Transparency (cm) Reading from Tube	Turbidity (NTU) *(Approximate)*	Q Value
150	0	97
120	5	85
90	10	76
67.5	13	70
60	15	68
30	20	62
27.5	25	57
25	30	53
22.5	35	48
20	40	45
15	50	39
12.5	60	34
10	70	28
7.5	80	25
5	90	22
2.5	100	17
<2.5	>100	5

For use with a Transparency Tube:

1. Rinse sample container with sample water. Collect sample water in a bucket or other container from which you can pour the water into a calibrated transparency tube. (*Note:* Avoid stirring bottom sediments when sampling at midstream.)
2. Avoid direct sunlight by turning your back to the sun. Swirl the water in your bucket to mix and slowly pour sample water into the tube.
3. While looking vertically down into the tube, release water until the point at which you can barely see the "X" on the bottom of the tube, and record the result in centimeters or inches. (*Note*: Do not wear sunglasses while taking this measurement.)
4. Repeat the above steps to verify the result. (Note: Allowing one or two people to repeat the test or view the tube may help obtain a more accurate result.)
5. **Convert the tube reading from inches or centimeters to Nephelometeric Turbidity Units (NTUs) using the Q-Value chart on this page.**
6. Properly clean your transparency tube. (See Appendix A)

Turbidity Q-values



Turbidity: inches or cm or NTU/JTU

Typical range for Turbidity: 0 to 2150 NTU

Indiana Average = 15 NTU

EPA recommends 10.4 NTU

E. coli Bacteria

Fecal coliform bacteria are found in the feces of warm-blooded animals, including humans, livestock, and waterfowl. These bacteria are naturally present in the digestive tracts of animals, but are minimal in unpolluted waters. Fecal coliform bacteria typically enter water via wildlife, livestock access to streams, combined sewer overflows (CSOs), poor septic systems, and stormwater runoff from agricultural and urban lands. The bacteria can enter the body through the mouth, nose, eyes, ears, or cuts in the skin.

E. coli is a species of fecal coliform bacteria that is used as an overall indicator of fecal contamination, per Indiana's state water quality standards. Thirty-nine percent (24,627 miles) of Indiana streams do not support primary contact recreation due to high *E. coli* bacteria levels *(Source: IDEM Integrated Water Quality Monitoring and Assessment Report, 2022)*.

Bacteria & Human Health

Occasionally strains of *E. coli* can lead to illness in humans. While not all strains of *E. coli* are pathogenic themselves, they occur with other intestinal tract pathogens that may be dangerous to human health. We test for the presence of *E. coli* as an indicator of overall fecal contamination, which may include many other dangerous bacteria, viruses, protozoa, and microbes which are not so easy to test for.

The U.S. EPA has determined that *E. coli* bacteria counts above 235 colonies per 100 mL indicate that more than 8 people out of 1,000 who come into contact with the water may become sick. But it is important to remember that as *E. coli* counts go up, it is the chance that someone will get sick that goes up. Still, there are many other things that determine if a person will become sick, such as:

- How long someone has been in contact with the water
- If water comes into contact with a person's eyes or mouth
- If the person has skin abrasions or wounds
- The age and health of the person, as that can determine a person's susceptibility to illness.
  (Source: USGS Chattahoochee BacteriALERT website at - https://www2.usgs.gov/water/southatlantic/ga/bacteria/)

Hoosier Riverwatch participated in a six-state research project from 2004-2006 in conjunction with Purdue Extension to determine the most accurate and usable method for detecting *E. coli* and coliform bacteria by volunteers. Details of the study may be found by attending an advanced Riverwatch workshop on this topic or on the web at http://cels.uri.edu/docslink/ww/BacteriaWorkshop/MonitoringEColiStreams_Stepenucketal2010.pdf.

Problem:
High levels of *E. coli* indicate fecal contamination and the potential presence of pathogens that could cause human illness.

Causes:
- Human waste from poorly functioning septic systems, wastewater treatment systems, or combined sewer overflows.
- Pet waste, wildlife (including waterfowl).
- Livestock or manure runoff from fields.

E. coli Testing Instructions – Coliscan Easygel

The following instructions are adapted from those provided by Micrology Laboratories, Inc. for use with the Coliscan Easygel method. For details on use and interpretation of results, please refer to the manufacturer's instructions. **Be sure to request a copy of the color ID photo examples when ordering.**
Contact them (toll-free) at 1-888-EASYGEL or www.micrologylabs.com.

Coliscan media incorporates a patented combination of color-producing chemicals and nutrients that make *E. coli* colonies appear blue, coliform bacteria that are not *E. coli* as a pink magenta and non-coliforms as white or teal green colonies.

Checklist:

- ☐ Pre-treated petri dish from Micrology Labs
- ☐ Sterile pipettes, Whirl-pac bag or other sterile collection container
- ☐ Bottle(s) of Coliscan Easygel (thawed)
- ☐ Permanent marker (e.g. Sharpie)
- ☐ Tape, rubber gloves, ice and cooler (if needed)
- ☐ Bleach and water-tight bag for disposal
- ☐ Incubator

Do not rinse these materials before or after use! They are specially pre-treated or sterilized for use. Be sure to follow the instructions provided!

1. **Preparation** - Thaw Coliscan®Easygel® at room temperature by removing from freezer before sampling. Label the bottom of Petri dishes using a permanent marker. This label should include site ID, date and time of sample collection, volume of water collected, and sample number. Before plating, you may also secure the top and bottom of the petri dish with one piece of tape to make a "hinge."

The amount of sample used will vary according to the suspected conditions of the water you are testing. For Easygel methods, .25 mL is the minimum and 5.0 mL is the maximum amount of sample you can use. If you suspect a high bacteria count after a recent rainfall event, transfer only 0.5-1.0 mL of sample. Typically, 3-5 mL is appropriate. Your goal is to have < 200 colonies in the petri dish.

2. **Collection** - Wearing gloves and using only sterile collection equipment, obtain a sample slightly below the water's surface in one of two ways:

   a) Take a measured sample directly from the source using a sterile pipette and immediately place it into the bottle of Coliscan Easygel, or

   b) Collect your sample in a sterile container (e.g. Whirl-pak Bag) and transport the water to an appropriate test site.

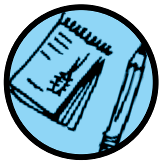
3. **Plating** - Transfer a measured volume of sample water into the bottle of Coliscan Easygel. Gently swirl and invert the bottle to distribute the Easygel and then pour the mixture into the *bottom half* of a Micrology Labs *pre-treated* petri dish. (If you hold the petri dish up to a light, you can see the gelling agent.) Being careful not to splash over the side or onto the lid, gently swirl the dish until the mixture is evenly distributed across the bottom.

Plating offsite is recommended. *Water samples and Easygel bottles containing samples kept longer than 10 minutes prior to plating should be kept on ice in a cooler or in a refrigerator until plating. Samples must be plated within 24 hours.*

While its contents are still in liquid form, place the dish right-side-up directly onto a level location out of direct sunlight. Solidification will occur in approximately 45 minutes.

4. **Incubation** - Turn the petri dish upside down (to reduce condensation) and incubate at 35° C (95° F) for 24-hours.
5. **Counting/Analysis** - After the appropriate incubation period, inspect the dish. Count all of the purple/blue-violet colonies in the dish and record the results in terms of *E. coli* per 100 mL of water. You may also count all of the pink and magenta colonies and record these as coliforms. Do not count pin-point colonies < 1mm in size, and disregard any light blue, teal, or white colonies, as these indicate other types of bacteria.

To report the total number of *E. coli* and coliform bacteria colony forming units (CFU) per 100mL, first divide 100 by the number of mL you used in your sample, then multiply that figure by the # of colonies you counted in your petri dish.



Example:
You used 3 mL of stream water and you counted 4 purple colonies in your dish.

First divide 100 by 3 = 33.3.
Then multiply 33.3 x 4 = 133.2 colonies / 100mL.

6. **Disposal** - To prepare your sample bottle and petri dish for disposal in normal trash, place 5 mL (about 1teaspoon) of bleach onto the surface of the plate. Allow to sit for at least 5 minutes. Place in a watertight plastic bag and discard in trash.

Expiration -
Coliscan Easygel bottles (not petri dishes) need to be stored in a freezer. Coliscan Easygel medium is good for 1 year, and can be refrozen if thawed.

E. coli Testing Instruction – 3M Petrifilm

Storage

Store unopened Petrifilm plate pouches at temperatures <8°C (46°F) – **REFRIGERATE!**

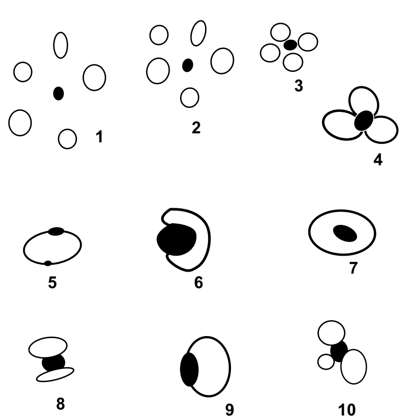
Store plates from opened packages in sets of no more than 8 in a small "snack-size" Ziploc, Glad, or similar type storage bag. Place a weight on top of the package to keep it from curling. Plates may be stored for up to a year.

Checklist:

- ☐ 3M Petrifilm
- ☐ Sterile pipettes, Whirl-pac bag or other sterile collection container
- ☐ Permanent marker (e.g. Sharpie)
- ☐ Rubber gloves
- ☐ Bleach and water-tight bag for disposal
- ☐ Incubator

1. **Preparation** - Allow pouches to come to room temperature before opening – at least 10-15 minutes. Do not use plates that show orange or brown discoloration. Expiration date and lot number are noted on each package. (Example, expiration date: 2015-10, would expire in the 10th month (October) of 2015. The lot number is also printed on individual plates.)
2. **Collection** -Wearing gloves and using only sterile collection equipment, obtain a sample slightly below the water's surface.
3. **Plating** - Inoculate and spread one Petrifilm plate before inoculating the next plate.
    - Place a Petrifilm plate on a level surface.
    - Lift the top film and dispense **1 ml only** of sample or diluted sample on the center bottom film.
    - Slowly roll the top film down onto the sample to prevent trapping air bubbles.
    - Leave plate undisturbed for at least one minute to permit the gel to solidify.
4. **Incubation** - Incubate plates in a horizontal position, with the clear side up in stacks of up to 20 plates. Incubator should be humidified with distilled water. Incubate 24 hours at 35 ºC (95° F) for 24-hours.
5. **Counting/Analysis** - After the appropriate incubation period, inspect the film. Count blue colonies with gas bubbles after 24 hours at 35 ºC (95° F). Do not count artifact bubbles. Approximately 95% of *E. coli* produce gas. In general, *E. coli* colonies are blue to blue-purple and closely associated (approximately one colony diameter) with entrapped gas. General coliform colonies are bright red and closely associated (approximately one colony diameter) with entrapped gas (Figure 25). **Only count blue colonies that have a gas bubble.**
6. **Disposal** - Place in a sealed Ziploc or similar type bag with bleach. The excess bleach will spill out and disinfect the Petrifilm plates, too. Discard with regular trash.

Figure 25



All 10 examples depict various bubble patterns associated with gas producing colonies. Each numbered picture would be counted as one colony. *(From 3MPetrifilm interpretation guide)*

Typical range for *E. coli* =
2 to 1,204 K colonies/100mL

Indiana Average =
210 colonies/100mL

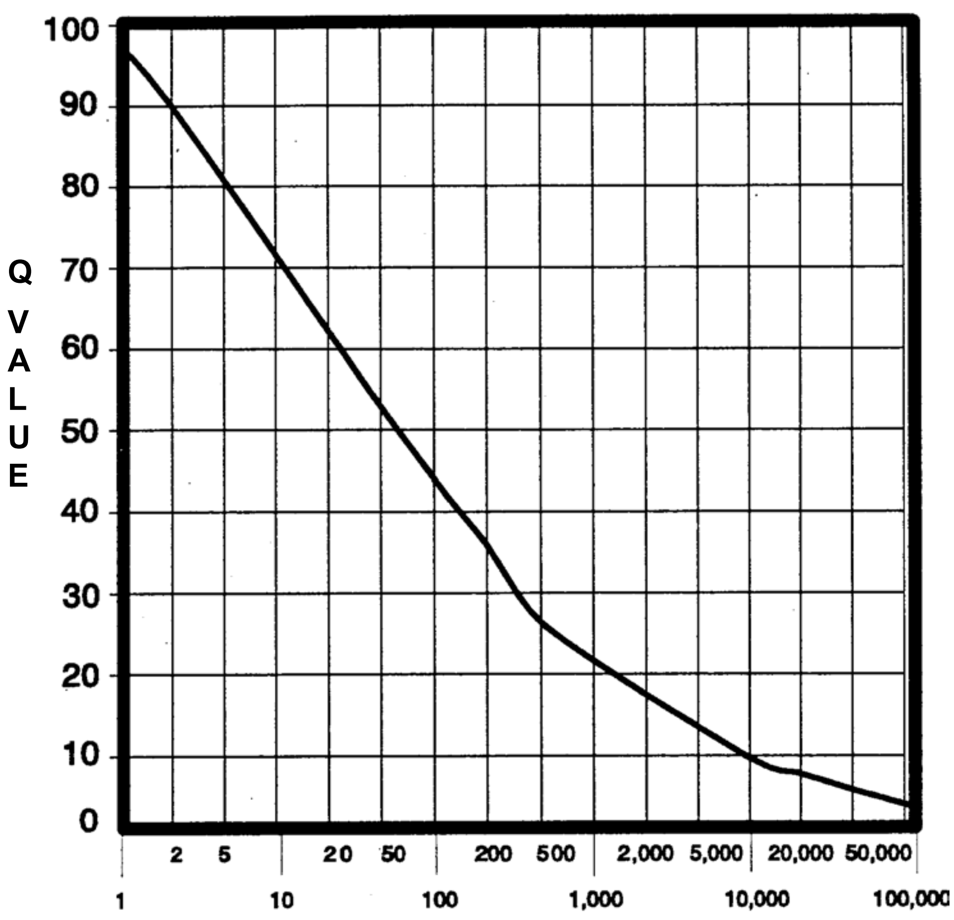
State Water Quality Standard for total body contact recreation:

<235 CFU/100 mL (a single sample)

OR

<125 CFU/100 mL (Geometric mean of 5 samples equally spaced over 30 days)

E. coli Q-Values



E. coli: colonies/100mL

E. coli (colonies/100mL)	Q-Value
0-1	98
2	89
5	80
10	71
20	63
50	53
100	45
200	37
500	27
1,000	22
2,000	18
5,000	13
10,000	10
20,000	8
50,000	5
100,000	3
>100,000	2

Chapter 5 -
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 more than ten inches long.

What is the ecological importance of benthic macroinvertebrates? Benthos are an important part of the food chain, especially for fish. Many feed on algae and bacteria which are on the lower end of the food chain. Some shred and eat leaves and other organic matter that enters the water. Because of their abundance and position as "middleman" in the aquatic food chain, benthos play a critical role in the balance and natural flow of energy and nutrients. As benthos die, they decay, leaving behind nutrients that are reused by aquatic plants and other animals in the food chain. *(Source: Maryland Department of Natural Resources)*

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 or diversity of the biological community. They also observe the total number of organisms in an area, or the density of the community. If diversity and density change over time, it may indicate the effects of human activity on the stream.

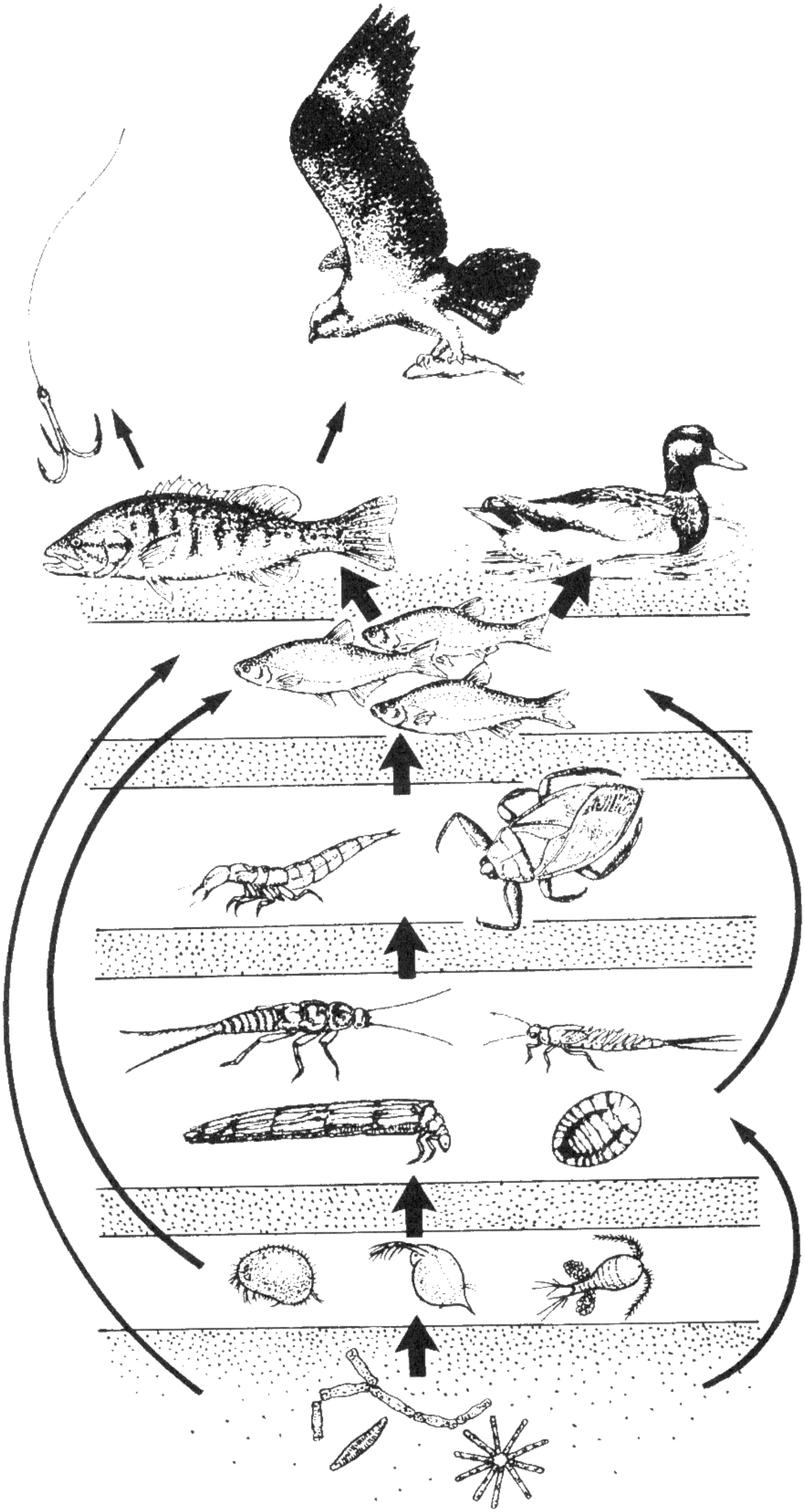
Biological stream monitoring is based on the fact that different species react to pollution in different ways. Pollution-sensitive organisms such as mayflies, stoneflies, and caddisflies are more susceptible than other organisms to the effects of physical or chemical changes in a stream. These organisms indicate the absence of pollutants. Pollution-tolerant organisms such as midges and worms are less susceptible to changes in physical and chemical parameters. The presence or absence of these organisms is an indirect measure of the presence of pollution. When a stream becomes polluted, pollution-sensitive organisms decrease in number or disappear; while 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. Such advantages are:

- Benthic macroinvertebrates are relatively easy to sample. They are abundant and can be easily collected and identified by trained volunteers.
- 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 taken.
- Benthic macroinvertebrates are a critical part of the aquatic food web (Figure 26). 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.

Aquatic Food Web *(from Pond & Stream Safari, Cornell Cooperative Extension)*

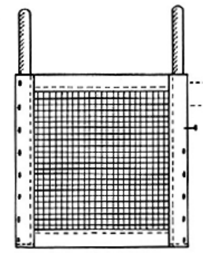
Figure 26



How Do We Collect Them?

Macroinvertebrate Collection Tips

You will want to collect macros no more than three times per year. Collecting more often can impact populations. Limit collection time to 30 minutes, and do not collect between mid-November and mid-April. The time of year in which you monitor will influence the macros you find due to their life cycles.



Aquatic Kick Seine

Kick Seine 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 prefer to live. This method can be quite effective in determining relative stream health. Two to three people work together to perform the method. Carefully read the procedures, and follow them as closely as possible.

1. Locate a "typical riffle." Such a riffle is a shallow, fast moving mud-free section of stream with a stream bed composed of material ranging in size from one-quarter inch gravel or sand to ten-inch cobbles. 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 stream bed 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 is held perpendicular to the flow, but at a slight (45 degree) downstream angle. Stretch the net approximately three feet, being certain that the bottom edge is lying firmly against the bed. You can hold the poles closer at the top to create a pocket for catching macros. 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 in place 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 four to six inches. You can also use a small shovel to disturb the bed. Kick for approximately 3 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 table cloth, garbage bag, or shower curtain. Remove leaves, rocks, and other debris; examining 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. If you happen to collect live mussels (native or exotic) in your net, **please see page 73 for further instruction**.
10. Perform steps 1-9 a total of three times at different locations within your 200' site. Your goal is to collect at least 200 organisms.
11. Sort all the organisms collected from the three samples according to body shape using ice cube trays or petri dishes. Record the number of each type of organism (if more than 100; record >100).

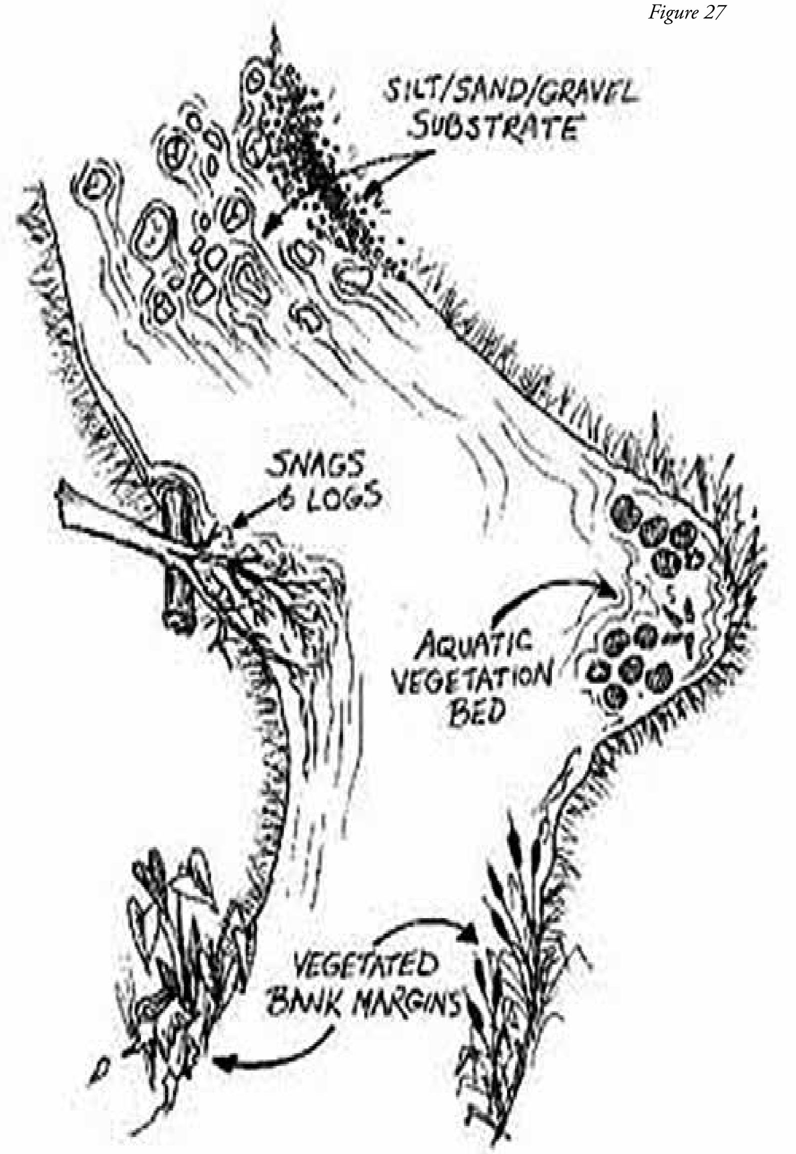
D-Net Sampling Method

If there are no riffles at your stream site to perform the kick seine sampling method, then you should use the D-net to perform your biological monitoring. Take a total of twenty jabs in a variety of habitats (Figures 27 and 28). 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. *(Modified from the Clinton River Watershed Teacher Training Manual)*

D-net

- 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. (See information on the next page for experiments using leaf packs.)
- Tree Roots, Snags (accumulations of debris), and Submerged Logs: Select an area approximately 3 x 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 so that dislodged material floats into it.
- Undercut Banks (page 25 - Figure 12): 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/mud): If there is not much flow, jab the net into the bottom with a sweeping motion. If flow is good, stand upstream of the net holding it against the bottom of the stream and kick in front of the net so that the flow washes organisms into the net. To rinse, keep the opening of the net at least 1-2 inches above the surface of the water, and move it back and forth to wash small particles out of the net.

Figure 27

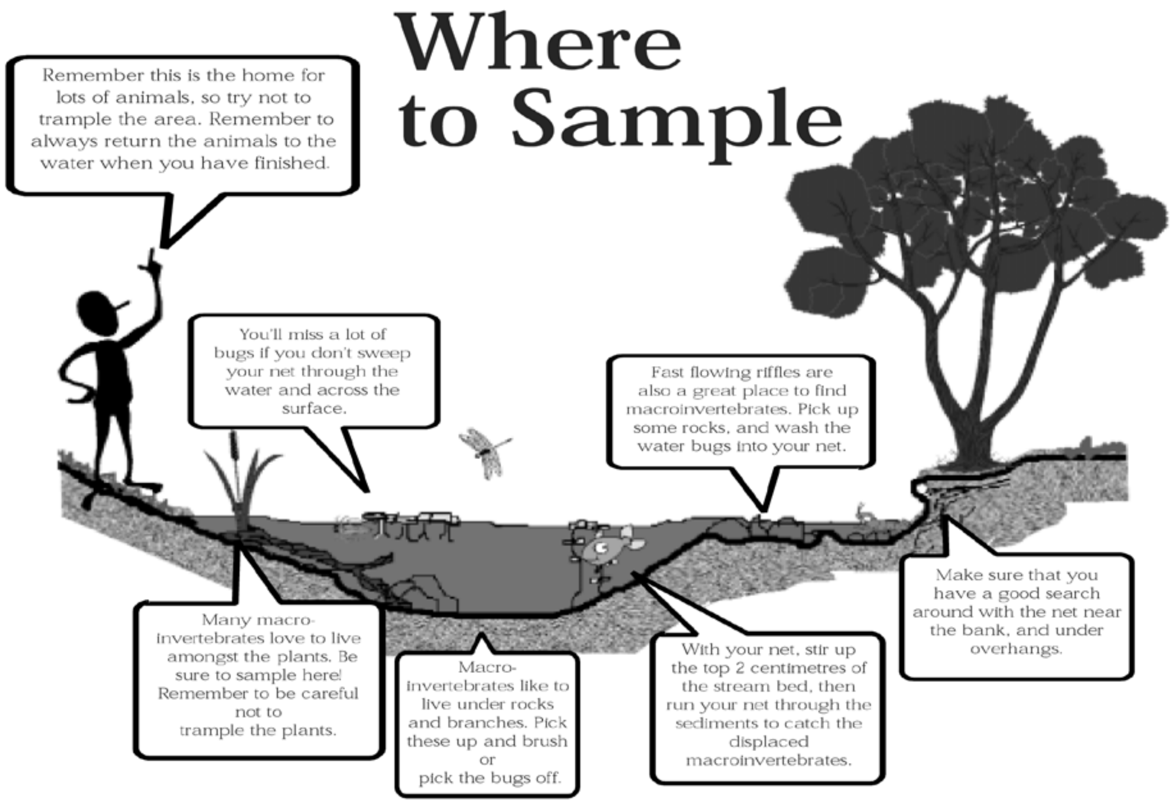


After two or three jabs with one net, dump the collected materials into a shallow white container (a dishpan works well). The materials in the bin may be quite muddy and turbid (depending upon your stream habitat). When you find macroinvertebrates, place them into another container (white pan, petri dish, bug board, ice cube tray) with clear water for easier identification.

Combination Sampling Method

If your 200' site has a variety of habitats, including riffles, then you may perform a combination of sampling methods. Record the equipment used and the types of habitats sampled on the Biological Monitoring Data Sheet (page 75).

Figure 28



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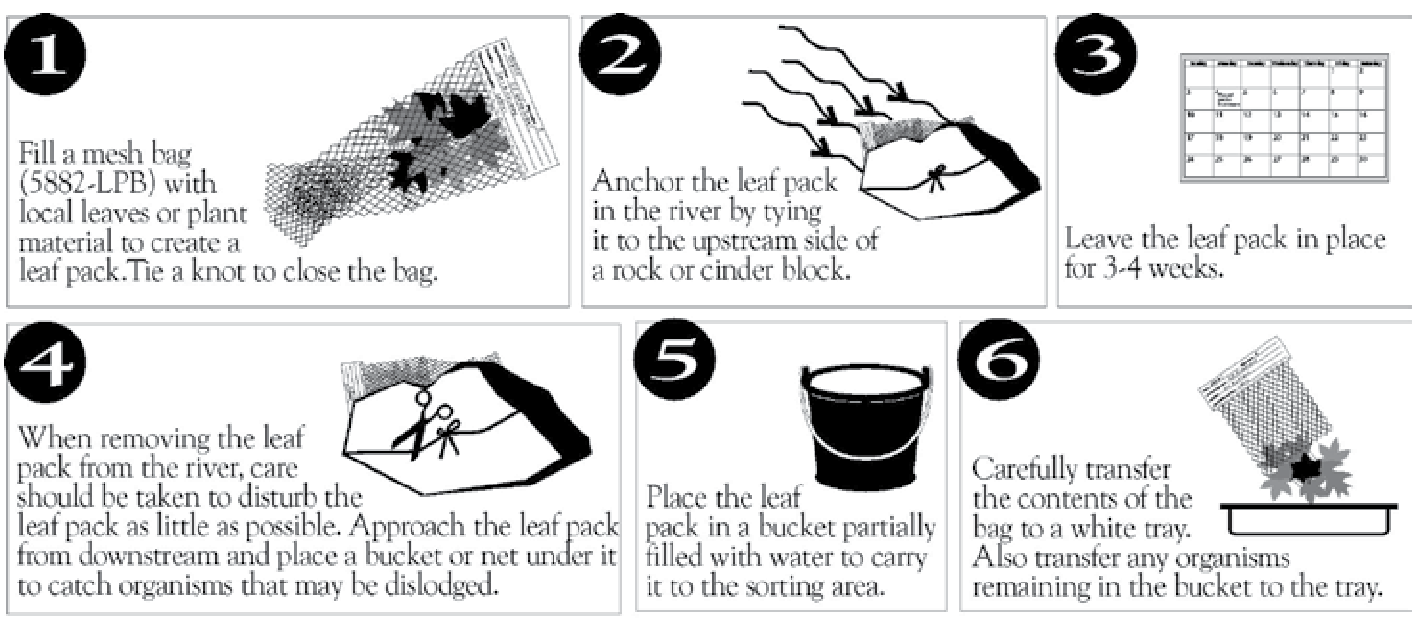
Leaf Pack Experiments or Hester-Dendy Samplers

Another type of sampling involves placing an artificial substrate in the stream for a number of weeks, then collecting it after has been colonized by macroinvertebrates. This method is useful if you are sampling deeper water and use of a net is difficult, or if you do not have sufficient time at the stream to perform the proper kick seine or D-net sampling procedures. Instructions for making your own Hester-Dendy are provided in Appendix A. Leaf pack experiments (below) are flexible. However, each experiment will: 1) provide an understanding of the structure and function of macroinvertebrates within a stream community and 2) relate the abundance and variety of macroinvertebrates colonizing artificial leaf packs to: habitat quality, water quality, and the influence of the forested riparian area.



How do they develop?

Many of the benthic macroinvertebrates you will encounter are aquatic insects. Aquatic insects have complex life cycles and live in the water only during certain stages of development (Figure 29).

Complete Metamorphosis

Aquatic insects may go through one of two kinds of development or metamorphosis. Those that go through complete metamorphosis undergo four stages of development: egg, larva, pupa, and adult. They lay their eggs in water. Eggs then hatch into larvae that feed and grow in the water. (These larval insects do not resemble the adult insects. Many appear wormlike.) The fully grown larvae develop into pupae and then into adults. The fully formed adults of some species (midges and flies, for example) emerge from the water and live in the habitat surrounding the stream. Others, such as riffle beetles, continue to live in the stream as adults. After mating, adults of all aquatic insect species lay eggs in the water, beginning the life-cycle all over again.

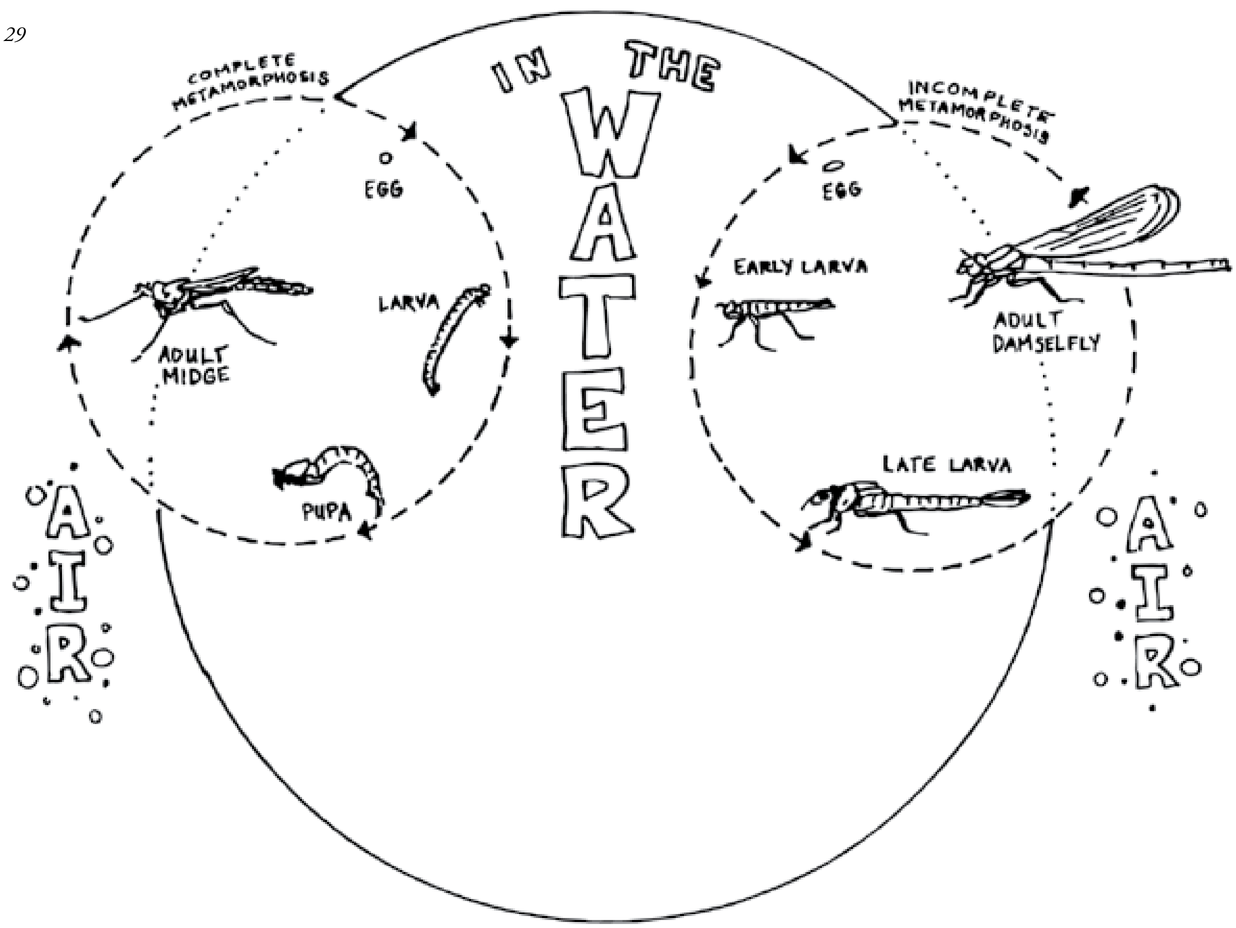
Complete metamorphosis: **egg > larvae > pupa > adult** (true flies, beetles, caddisflies)

Incomplete Metamorphosis

Aquatic insects that go through incomplete metamorphosis undergo only three stages of development: eggs, nymphs and adult. The eggs hatch into nymphs which feed and grow in the water while they develop adult structures and organs. Nymphs often look similar in body shape to the adults. The life cycle begins again when adults lay eggs in the water.

Incomplete metamorphosis: **egg > nymph > adult** (mayflies, dragonflies, stoneflies, true bugs)

Figure 29



What and How Do They Eat?

Macroinvertebrates may be categorized by their feeding groups: according to the type of food they eat and the manner in which their food is obtained/collected.

Shredder: Feeds on coarse, dead organic matter (leaves, grasses, algae, and rooted aquatic plants), breaking it into finer material that is released in their feces. Shredders include stonefly nymphs, caddisfly larvae, cranefly larvae.

Collector: Feeds on fine, dead organic matter, including that produced by the shredders.

> **Filtering collector:** Filters particles out of flowing water.
> Examples include blackfly larvae and net-building caddisflies.
>
> **Gathering collector:** Gathers matter while crawling along the river bottom.
> Gatherers include mayfly nymphs, adult beetles, and midge larvae.

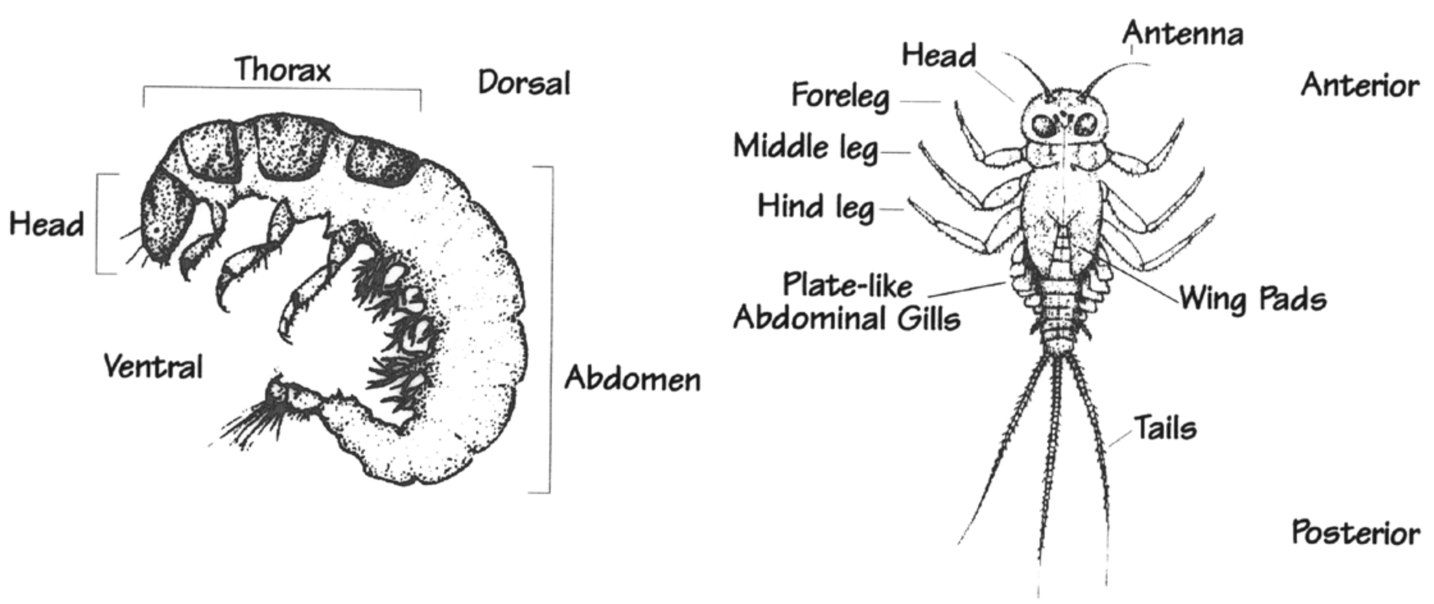
Grazer: Grazes on algae growing on rocks in the substrate or on vegetation. Grazers include snails and water pennies (a type of beetle larvae).

Predator: Feeds on other invertebrates or small fish. Mouth parts are specially adapted to feed on prey. Dragonflies and damselflies have scoop-like lower jaws, the jaws of hellgrammites (larval dobsonflies) are pincher-like, and a water strider's mouth parts are spear-like. Also includes beetle adults and larvae.

What Do They Look Like?

A simple key to benthic macroinvertebrates is provided in Appendix B. The organisms are grouped according to pollution tolerance, starting with the most intolerant families. Figure 30 below (*from the GREEN Standard Water Monitoring Kit*) may help you identify the distinguishing features of many of the organisms.

Figure 30



What If You Find Freshwater Mussels?

Freshwater mussels are the most endangered group of animals in Indiana! Of the 77 species that once inhabited Hoosier lakes, rivers and streams, 10 are now extinct, 17 are endangered, and 7 are of special concern. Since the presence and diversity of freshwater mussels serve as an indicator of river and stream health, we must minimize our impact on the stream substrate to protect these important species.

Follow these guidelines:

- **AVOID** sampling (especially kick seining) where you observe live mussels or a bed of mussel shells (open or closed).
- If you happen to collect mussels when sampling for macroinvertebrates, **you MUST replace ALL mussels** in the stream in the exact location and orientation in which you found them. Observe any live mussel's shell for clues to its original orientation. If part of the mussel is covered in algae and part in mud, the algae side was sticking up toward the sun while the other side was buried in the substrate. Also, the hinge (closure) should face downstream, with the opening toward the streamflow. If you are unsure how to put a mussel that you kicked up back into the substrate, then just lay it gently on the bottom of the stream in the area from which it came and allow it to reorient and re-bury itself.
- Be careful not to spread exotic species. **Volunteers sampling in zebra mussel infested waters should allow their equipment to dry completely** before using it in another water body. Zebra mussel veligers (planktonic larvae) can live for a while out of water. If the equipment must be used in a different waterbody soon after sampling in infested waters, you must rinse the equipment thoroughly with hot water!

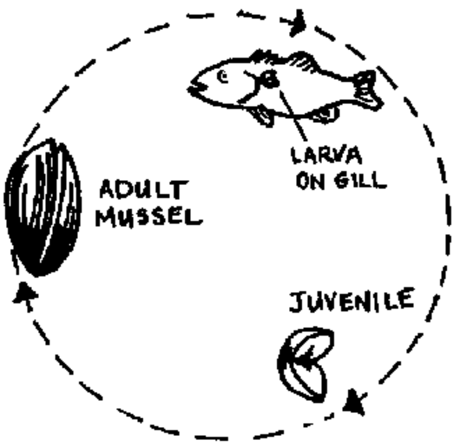
Identifying mussel species is not an easy task; only specially-trained biologists are able to differentiate species. It is unlikely we, as volunteer stream monitors, will be able to distinguish an endangered mussel from a nonendangered species. Therefore, **ALL mussels should be treated as though they are endangered**!

Freshwater Mussels Regulations

In an effort to reverse statewide declines in their populations, the removal of freshwater mussels, both live specimens and dead shells, from Indiana waters became illegal in 1991. It is illegal to have live or dead mussel shells in your possession. (Live shells are closed and are held together by the living mussel inside.) Leaving the mussels in the streams not only protects them, but you as well.

Why are Freshwater Mussels in Danger?

Figure 31



Mussels have a very complicated life cycle (Figure 31), which may make it difficult for some species to persist. Male mussels release their sperm into the water column, and the sperm must then be lucky enough to be siphoned in by a female mussel downstream of the male *(which is why it is VERY important that you replace a mussel exactly where and how you found it)*. After a time, the female will release mussel larvae or glochidia into the water where they will die unless they attach to a host fish. The fish serves as a source of food, shelter and locomotion for the developing larvae. Without the proper fish to serve as host, many mussel species could not expand their range or survive!

Many aquatic populations, including fish and mussels, have suffered because of habitat disturbances (such as dam construction, channelization, dredging) and watershed activities (such as construction and agriculture) which can lead to increased siltation and polluted runoff to rivers, streams, and lakes.

Commercial demands for freshwater mussel shells have also contributed to their decline. Mussel shells were used to make pearl buttons from the late 19th and early 20th centuries until the 1940s when plastic became the material of choice. Current commercial use involves grinding freshwater mussel shells to insert into oysters and stimulate the production of cultured pearls. Poaching remains a threat to mussel populations. If you suspect poaching of mussels, report it to the Indiana Department of Natural Resources immediately through their toll-free number **1 (800) TIP-IDNR.**

Other Biological Indicators of Stream Health

If any of these indicators are present, please check the appropriate box on the bottom of the biological Monitoring Data Sheet.

- Native Mussels
- Zebra Mussels – Invasive species
- Rusty Crayfish – Invasive species
- Aquatic Plants – Indicators of clear water and stable substrate. They provide habitat and stabilize the stream bed during high flow conditions. They also produce oxygen and take contaminants out the sediment via root absorption (From IOWATER Program Handbook). However, exotic invasive plant can cause serious damage to an ecosystem.
- % Algae Cover - Excess algae can be caused by too many nutrients in the stream. Too much algae can lead to oxygen depletion. Estimate the amount of the stream bottom (or the rocks) within your 200' stream section covered with algae - in increments of 25%, 50%, 75%, or 100%.

Biological Monitoring Data Sheet

The biological monitoring data sheet can be taken into the field to record the results of your biological sampling. The sheet includes information about the day, equipment used to collect samples (kick net or D-net), habitats sampled, and organisms collected. The bottom of the sheet includes other biological indicators. Although these do not factor into scoring, they can help you document what is going on in your stream.

The macroinvertebrate index is divided into Pollution Tolerance Groups 1, 2, 3, and 4. These groups represent the different levels of pollution tolerance; the higher the number, the higher the pollution tolerance level. Record the number of macroinvertebrates you find in this space.

An example completed data sheet can be found on page 76. After counting and recording numbers of organisms found in the appropriate space, you count the number of taxa present and record that information in the # of Taxa box. (Do not make the mistake of adding the numbers of total individuals together). You will then multiply the # of Taxa by the appropriate weighting factor and total these to get a Pollution Tolerance Index (PTI) score.

Note: The volunteer stream monitoring database (www.HoosierRiverwatch.com) will perform the calculations for you when you submit data.

Once you have identified the macroinvertebrates in your river or stream samples and noted the number of each taxa, the data can be easily applied to more than one index. These include *Virginia Save our Streams Multimetric Index* and the *Macroinvertebrate Diversity Index*. You can use these indices for education and further reference about your stream.

Hoosier Riverwatch

Biological Monitoring Data Sheet

Date: ____ / ____ / ____ **Volunteer ID:** __________ **Site ID:** __________

Stream Name: ______________________________ **Latitude:** ________ **Longitude:** _______

Time _____:____ AM / PM **Time Sampling:** ______ hrs **Air Temp.:** ___________ °C

Current Weather: ☐ Clear/Sunny ☐ Overcast ☐ Showers ☐ Rain (steady) ☐Storm (Heavy)

Worst Weather (past 48 hours): ☐ Clear/Sunny ☐ Overcast ☐ Showers ☐ Rain (steady) ☐Storm (Heavy)

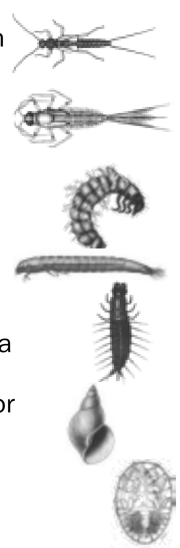
Check Methods Used: ☐ Kick Seine Net (3 times) ☐ Dip Net (20 jabs or scoops)

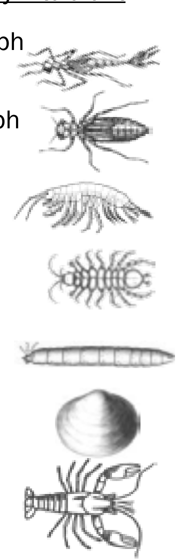
Check Habitats Sampled: ☐ Undercut Banks ☐ Riffles ☐ Leaf Packs ☐ Snags/Vegetation ☐Sediment

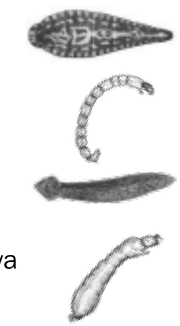
Pollution Tolerance Index (PTI)

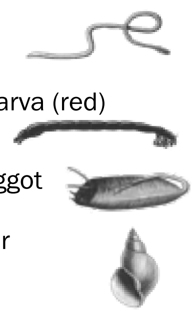
Record the taxa (group) represented in your sampling by either entering the number of organisms you counted or a ✓

Group 1 - Intolerant	Group 2 - Moderately Intolerant	Group 3 - Fairly Tolerant	Groups 4 - Very Tolerant
☐ Stonefly nymph	☐ Damselfly nymph	☐ Leech	☐ Aquatic worm
☐ Mayfly nymph	☐ Dragonfly nymph	☐ Midge larva	☐ Blood midge larva (red)
☐ Caddisfly larva	☐ Scud	☐ Planaria/ Flatworm	☐ Rat-tailed Maggot
☐ Riffle Beetle	☐ Sowbug	☐ Black fly larva	☐ Left-Handed or Pouch snail
☐ Dobsonfly Larva	☐ Cranefly larva		
☐ Right-Handed or Gilled snail	☐ Clam/Mussel		
☐ Water Penny	☐ Crayfish		
☐ **# of TAXA represented**	☐ **# of TAXA represented**	☐ **# of TAXA represented**	☐ **# of TAXA represented**
☐ Weighting Factor (x4)	☐ Weighting Factor (x3)	☐ Weighting Factor (x2)	☐ Weighting Factor (x1)









Pollution Tolerance Index Rating ☐

(Add the final index values for each group)

PTI Ratings	
Excellent	23 or More
Good	17 - 22
Fair	11 - 16
Poor	10 or Less

Please check other Biological Indicators you observed:

☐ Native Mussels ☐ Zebra Mussels ☐ Rusty Crayfish ☐ Aquatic Plants ______ % Algae Cover ______ Diversity Index

Hoosier Riverwatch
Biological Monitoring Data Sheet

Date: 10/04/2009 | Volunteer ID: 1000 | Site ID: 1000

Stream Name: Example Stream Indiana | Latitude: 40.76054 | Longitude: - 85.76369

Time: 12:15 AM / PM | Time Sampling: 2.5 hrs | Air Temp.: 29.5 °C

Current Weather: ☒ Clear/Sunny ☐ Overcast ☐ Showers ☐ Rain (steady) ☐ Storm (Heavy)

Worst Weather (past 48 hours): ☐ Clear/Sunny ☐ Overcast ☒ Showers ☐ Rain (steady) ☐ Storm (Heavy)

Check Methods Used: ☒ Kick Seine Net (3 times) ☒ Dip Net (20 jabs or scoops)

Check Habitats Sampled: ☒ Undercut Banks ☒ Riffles ☐ Leaf Packs ☒ Snags/Vegetation ☐ Sediment

Pollution Tolerance Index (PTI)

Record the taxa (group) represented in your sampling by either entering the number of organisms you counted or a ✓

Group 1 - Intolerant		Group 2 - Moderately Intolerant		Group 3 - Fairly Tolerant		Groups 4 - Very Tolerant	
6	Stonefly nymph		Damselfly nymph		Leech	25	Aquatic worm
5	Mayfly nymph	15	Dragonfly nymph	>100	Midge larva		Blood midge larva (red)
10	Caddisfly larva		Scud	16	Planaria/ Flatworm		Rat-tailed Maggot
	Riffle Beetle		Sowbug		Black fly larva	1	Left-Handed or Pouch snail
	Dobsonfly Larva		Cranefly larva				
	Right-Handed or Gilled snail		Clam/Mussel				
30	Water Penny	2	Crayfish				
4	# of TAXA represented	2	# of TAXA represented	2	# of TAXA represented	2	# of TAXA represented
16	Weighting Factor (x4)	6	Weighting Factor (x3)	4	Weighting Factor (x2)	2	Weighting Factor (x1)

Pollution Tolerance Index Rating 28

(Add the final index values for each group)

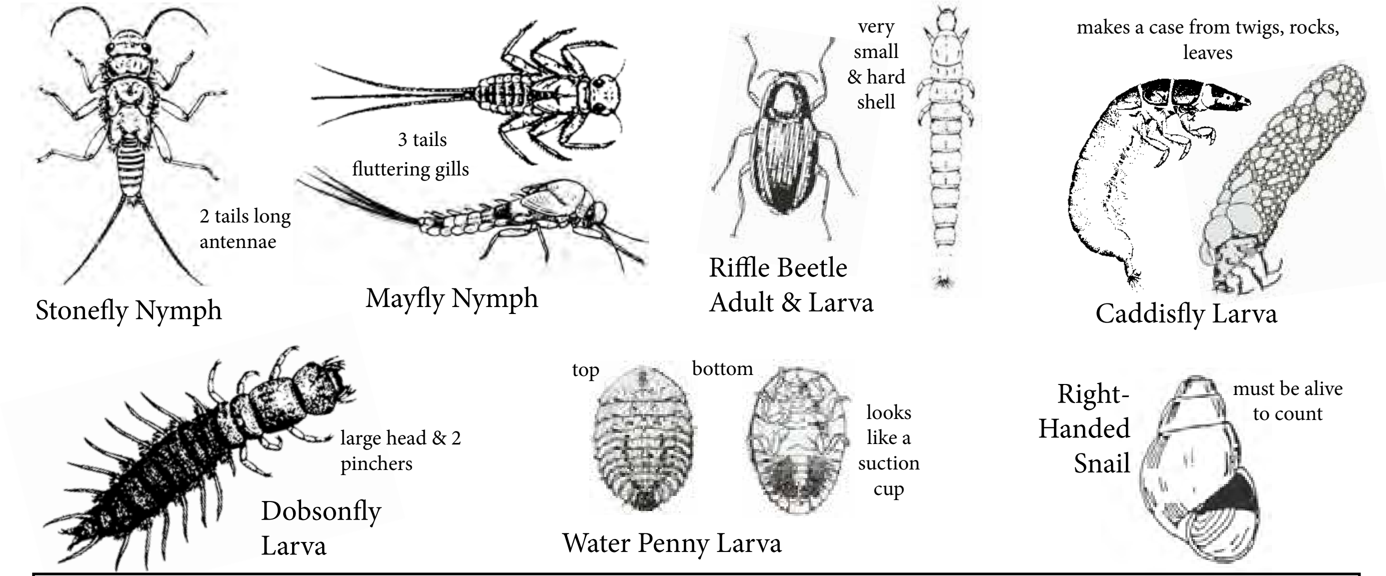
PTI Ratings	
Excellent	23 or More
Good	17 - 22
Fair	11 - 16
Poor	10 or Less

Please check other Biological Indicators you observed:

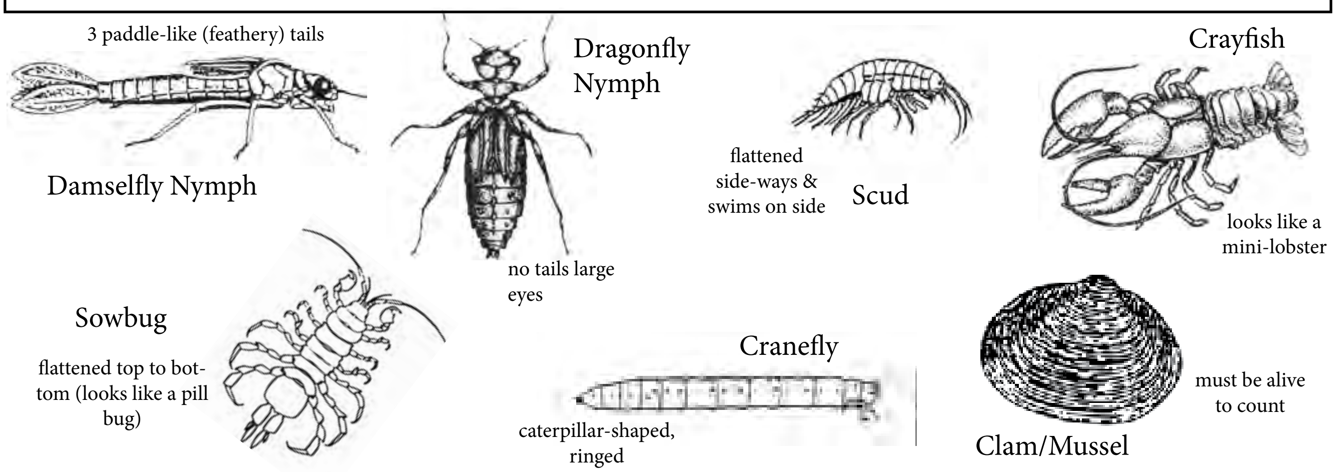
☐ Native Mussels ☐ Zebra Mussels ☐ Rusty Crayfish ☐ Aquatic Plants ____ % Algae Cover ____ Diversity Index

Macroinvertebrate Identification Key

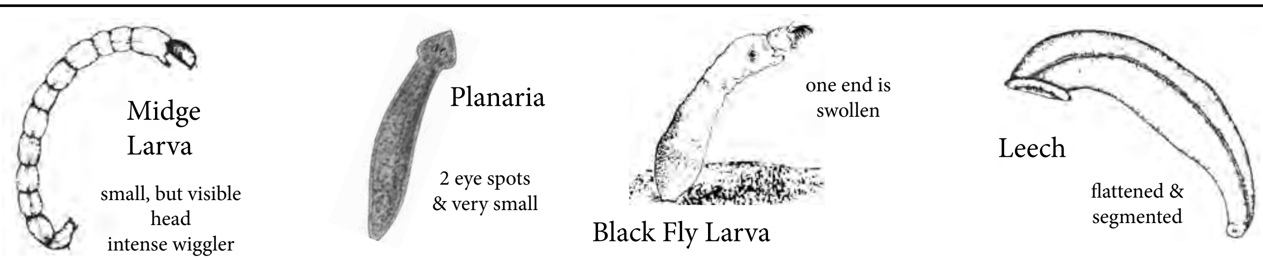
GROUP 1 – Very Intolerant of Pollution



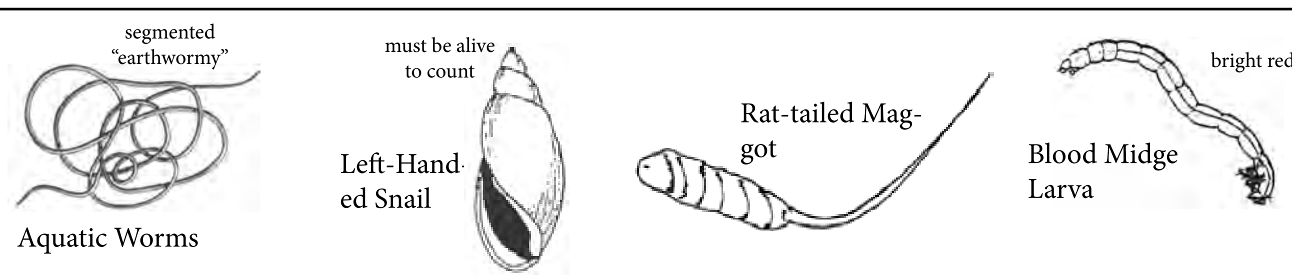
GROUP 2 – Moderately Intolerant of Pollution



GROUP 3 – Fairly Tolerant of Pollution



GROUP 4 – Very Tolerant of Pollution

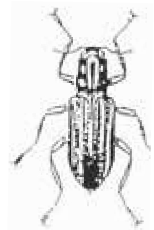


Macroinvertebrate Adults Key

GROUP 1 – Young are Very Intolerant of Pollution


Stonefly Adult


Mayfly Adult


Riffle Beetle Adult


Caddisfly Adult


Dobsonfly Adult

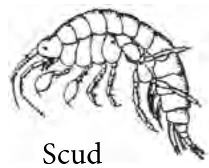
Water Penny Adult

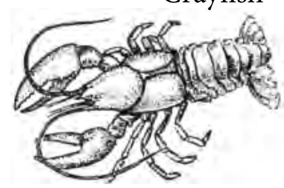

Right-Handed Snail


GROUP 2 – Young are Moderately Intolerant of Pollution


Damselfly Adult

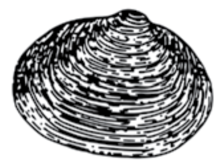

Dragonfly Adult


Scud

Crayfish



Sowbug


Cranefly Adult

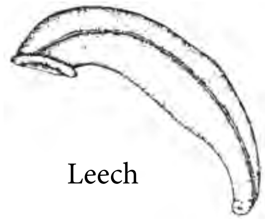

Clam/Mussel

GROUP 3 – Young are Fairly Tolerant of Pollution


Midge Adult

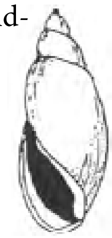

Planaria


Black Fly Adult


Leech

GROUP 4 – Young are Very Tolerant of Pollution


Aquatic Worms

Left-Handed Snail



Hoverfly
(Rat-tailed maggot adult)


Blood Midge Adult

Chapter 6 -
Aquatic Invasive Species (AIS)

What are aquatic invasive (or nuisance) species?

An "invasive species" is defined as a species that is non-native (or alien) to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm, or harm to human health (www.invasivespecies.gov/). Invasive species can be plants, animals, and other organisms, such as bacteria and viruses. This chapter addresses invasive species that can live in the aquatic habitats of Indiana, such as lakes, rivers and wetlands.

Why should we be concerned?

Invasive species problems are both a consequence of and an impact on the economic welfare of our nation. Most introductions of invasive species can be linked to the intended or unintended consequences of economic activities, such as trade and shipping. The Food and Agricultural Organization identified six types of economic impacts: (a) production; (b) price and market effects; (c) trade; (d) food security and nutrition; (e) human health and the environment; and (f) financial costs impacts. During the past 200 years or so, more than 50,000 foreign plant and animal species have become established in the United States. About one in seven has become invasive, with damage and control costs estimated at more than $137 billion each year.

New invasions of nuisance aquatic species could decimate fisheries and other aquatic resources, requiring funds for prevention, control and mitigation that could have been used for other purposes. Nuisance aquatic plant and animal invaders (such as zebra mussels, bighead carp, purple loosestrife, gizzard shad and sea lamprey) cost Hoosiers millions of dollars each year in control measures and lost natural resource value. For instance, University of Notre Dame researchers determined that it would be cost effective to spend $324,000 per year to prevent zebra mussel infestation of each lake associated with a power plant due to the high costs of managing their negative impacts on water withdrawals. A survey conducted by the Invasive Plant Advisory Committee of the Indiana invasive species council found that land owners and managers in Indiana spent $5.85 million in 2012 to manage invasive plants on their land.

Species of Interest

The following pages list just a few of the species of concern in Indiana. This is by no means a complete list, but these are species that you may have heard of. As Riverwatch volunteers, we ask that you keep your eyes open for anything that looks out of place. In an attempt to aid the public and water resource managers, DNR has posted 40+ aquatic invasive species fact sheets that aid in identification of plants, vertebrates, and fish at: www.in.gov/dnr/rules-and-regulations/invasive-species. If you think you have seen an exotic or invasive species, please report it. Visit the above website for more information and pictures of invasive species in Indiana, as well as instructions on how to report a sighting.

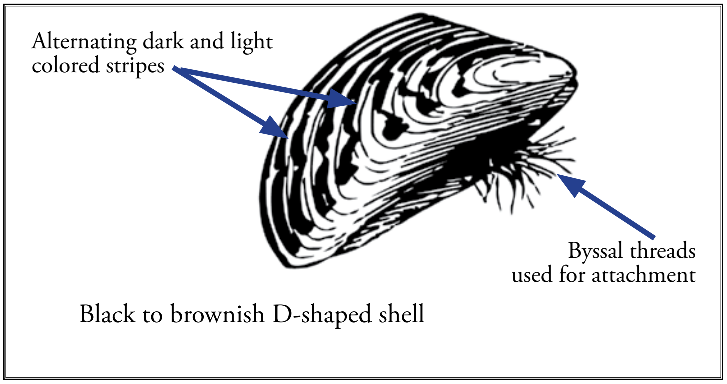
Exotic Invasive Mussels

The introduction of exotic invasive species such as the Asian clam (*Corbicula fluminea*), quagga mussel and the very prolific zebra mussel (*Dreissena polymorpha*) has had detrimental effects on many mussel species. Zebra mussels colonize on native mussels which can hamper their movements, including opening and closing their shells. Zebra mussels filter a large amount of water for such a small mussel (1 liter per day) and due to their large numbers they can take away a large portion of the food that the native species need. If zebra mussels are found, check the box on the Biological Monitoring Data Sheet.

What you can do to prevent the spread of Zebra Mussels:

- Learn to recognize zebra mussels.
- Inspect and remove aquatic plants, animals, and mud from boat, motor, and trailer.
- Drain water from boat, motor, livewell, bilge, and bait containers.
- Rinse boat and equipment with high-pressure and/or hot water (104ºF) especially if moored for over a day. OR
- Dry everything for at least five (5) days.
- Never introduce fish, plants, crayfish, snails, or mussels from one body of water to another.

Figure 32

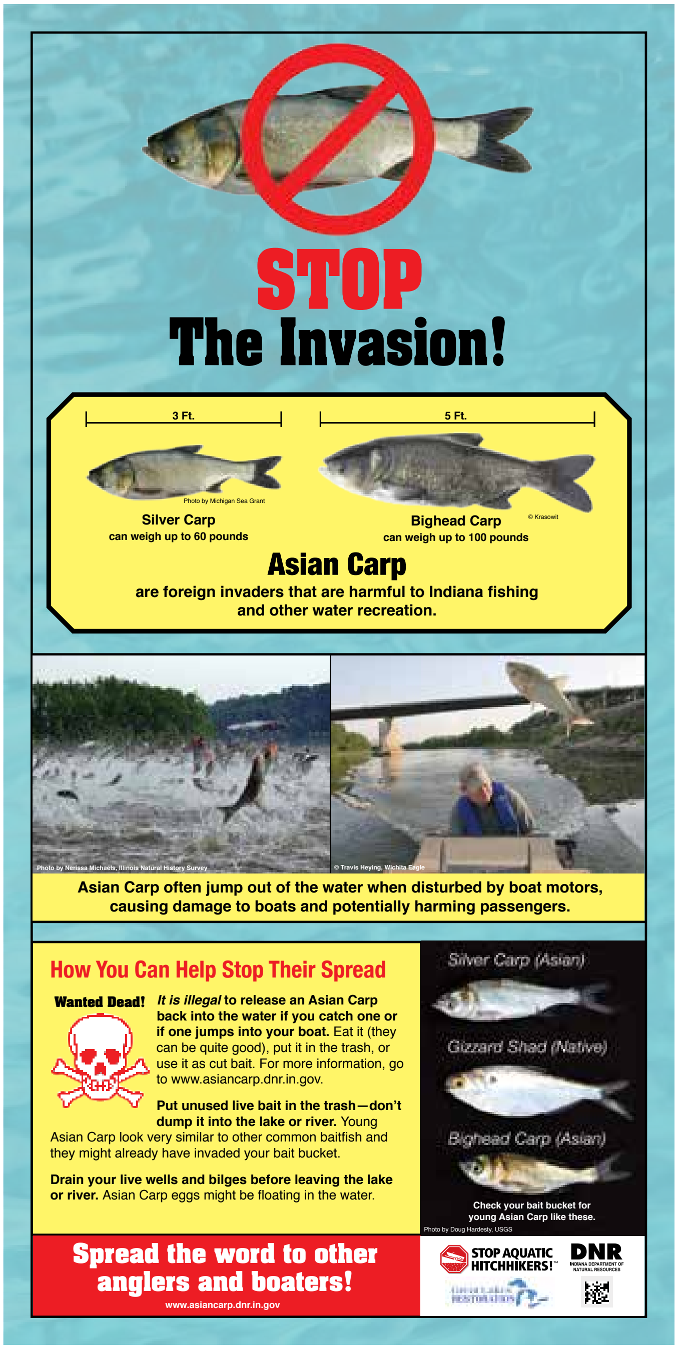


Description: Zebra mussels (Figure 32) have a triangular shaped shell that rarely exceeds 1.5 inches in length. Their shell is bivalve meaning it has two halves. Usually the shell will have alternating dark and light bands resembling the stripes of a zebra, hence their name. However, not all zebra mussels will have this characteristic coloring pattern, some may be entirely dark or light. The most distinguishing characteristic to look for would be the tuft of fibers called the byssal threads that grow from the foot and through the hinge of the mussel. These threads allow the mussel to attach to any hard surface. A similar species that may be confused with the zebra mussel is the quagga mussel, another exotic species.

Asian Carp

Asian carp (Figure 33) is a catchall name for species of silver, bighead, grass, and black carp from Southeast Asia. They were imported into the U.S. in the 1970s by Arkansas fish farms. Flooding in the area allowed them to escape and establish populations in the wild. At present, bighead carp have been found in the open waters of 23 states and silver carp in 17 states. Asian carp represent over 97% of the biomass in portions of the Illinois and Mississippi Rivers and are swiftly spreading northward up the Illinois River towards the Great Lakes. Voracious filter feeders, Asian carp consume up to 20% of their bodyweight per day in plankton and can grow to over 100 pounds. Plankton are small floating organisms that form the foundation of the aquatic food chain and are vital to native fish. The huge, hard-headed silver carp also pose a threat to boaters. The fish can leap out of the water when startled by boat engines, often colliding with people and causing injuries.

Figure 33



Invasive Aquatic Plants

Aquatic plants are indicators of clear water and stable substrate. They provide habitat and stabilize the stream bed during high flow conditions. They also produce oxygen and take contaminants out of the sediment via root absorption. *(From IOWATER Program Handbook)* However, exotic invasive plants can cause serious damage to an ecosystem. We need your help to identify and check for new invaders to Indiana's water, hydrilla and Brazilian elodea. If hydrilla or Brazilian elodea is discovered, please report immediately to the DNR Aquatic Invasive Species Coordinator at (317) 234-3883.

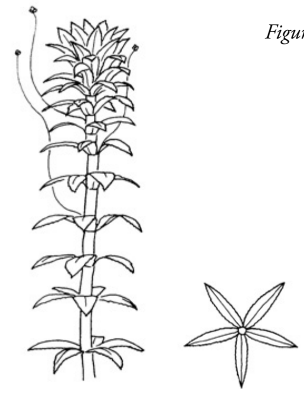


Figure 34

Hydrilla (*Hydrilla verticillata*): is an exotic and extremely invasive aquatic plant. Hydrilla typically has 5 leaves whorled around the stem although that number can range from 2 to 8. Leaves have distinctly serrated edges. Individual leaves can range from 1 to 2 cm. If nut-like tubers are found on the roots, the plant is definitely hydrilla. The other two plants described here do not form tubers. (Figure 34)

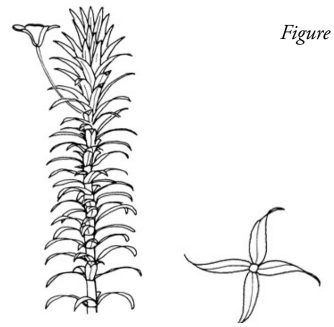


Figure 35

Brazilian elodea *(Egeria densa)*: Brazilian elodea is an exotic invasive aquatic plant. This plant has 3 to 5 leaves per whorl although 4 are most common. Serrated leaf edges are not visible. This plant can have leaves up to 4 cm, making it much larger than the other plants described here. Tubers do not form on the roots. (Figure 35)

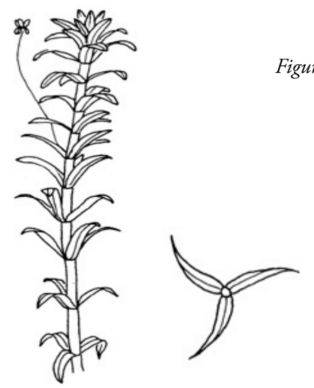


Figure 36

Elodea *(Elodea canadensis)*: is a **native** submersed aquatic plant. Elodea usually has 2 or 3 leaves per whorl. Serrated edges of the leaves are not obvious. Leaves can be up to 1.5 cm although they are usually much smaller. Tubers are not produced on the roots. **Elodea is a beneficial native plant**. Reports are not necessary if you discover this plant. (Figure 36)

Chapter 7 - Hoosier Riverwatch Database

Note: Database password is now case sensitive. Also, please omit all apostrophes (proper names, waterbody names, addresses) as these are misinterpreted and problematic in the database. Lastly, this database is a work-in-progress. We welcome your suggestions and ask that you communicate any problems encountered to us a soon as possible.

Introduction

The Hoosier Riverwatch online database has been in operation since late 2001. Since then it has undergone several updates and improvements; including the latest upgrades completed in summer 2021. Hoosier Riverwatch is interested not only in your monitoring results but also in having you share your findings with others in your area. Entering data online is a great way to begin doing so.

The database is accessible at www.HoosierRiverwatch.com. A key upgrade is that the database is now accessible via portable mobile devices in the field; assuming the internet is available at your location. Either way, it is a valuable tool allowing you to store, view, and retrieve tons of stream data. It also makes stream data available to the public, other volunteers, agencies, and anyone else interested in Indiana's water quality.

All are welcome to search, view, and download data from this database. However, only data collected by trained Riverwatch volunteers may be entered into the database. If you happen to have Indiana surface water data collected under another program, whether professionally or by volunteers, we invite you to enter and share it using the Secondary Data Portal at IDEM. This allows an even greater flexibility to store and share data with those working to assess and improve Indiana's watersheds.

Paper or Electronic: the Choice is Yours

Many of you will prefer using paper data sheets in the field and, then, entering your data later. Others may opt to enter data directly into the database using a tablet or other handheld electronic device.

If paper sheets are used, please keep them handy for a while so you can refer to them again, in case someone in your group or at IDEM wishes to clarify an entry. HRW staff try to conduct quarterly checks on what is entered into the database.

Database Home Page (Figure 37)

Welcome to the newly designed database. We think you will find it handy to use. You may access the areas discussed in this chapter via either the front screen itself or one of the drop down menus above.

Figure 37

Registering A New User

To enter your stream data, you first need to register yourself and your sites into the database. If sampling for one or more organizations, you can add them to the database also, if they are not already registered. You will need the database password, given during the workshop, to register and submit data.

Creating a new user in the Hoosier Riverwatch database is simple. (Figure 38) Please be sure to fill out all of the required fields as noted by the red * in front of the title. Hovering over or clicking the small gray "?" to the right of some entry fields will help clarify the information or format that is needed here, such as indicated in Figures 39 and 40:

Figure 38

You will only need to register as a user one time. The screen will momentarily affirm your registration and give you a User ID. You will get an e-mail confirmation of this as well and, if you forget to write it down, you can always look it up in the database itself, as you will see shortly.

Figure 39

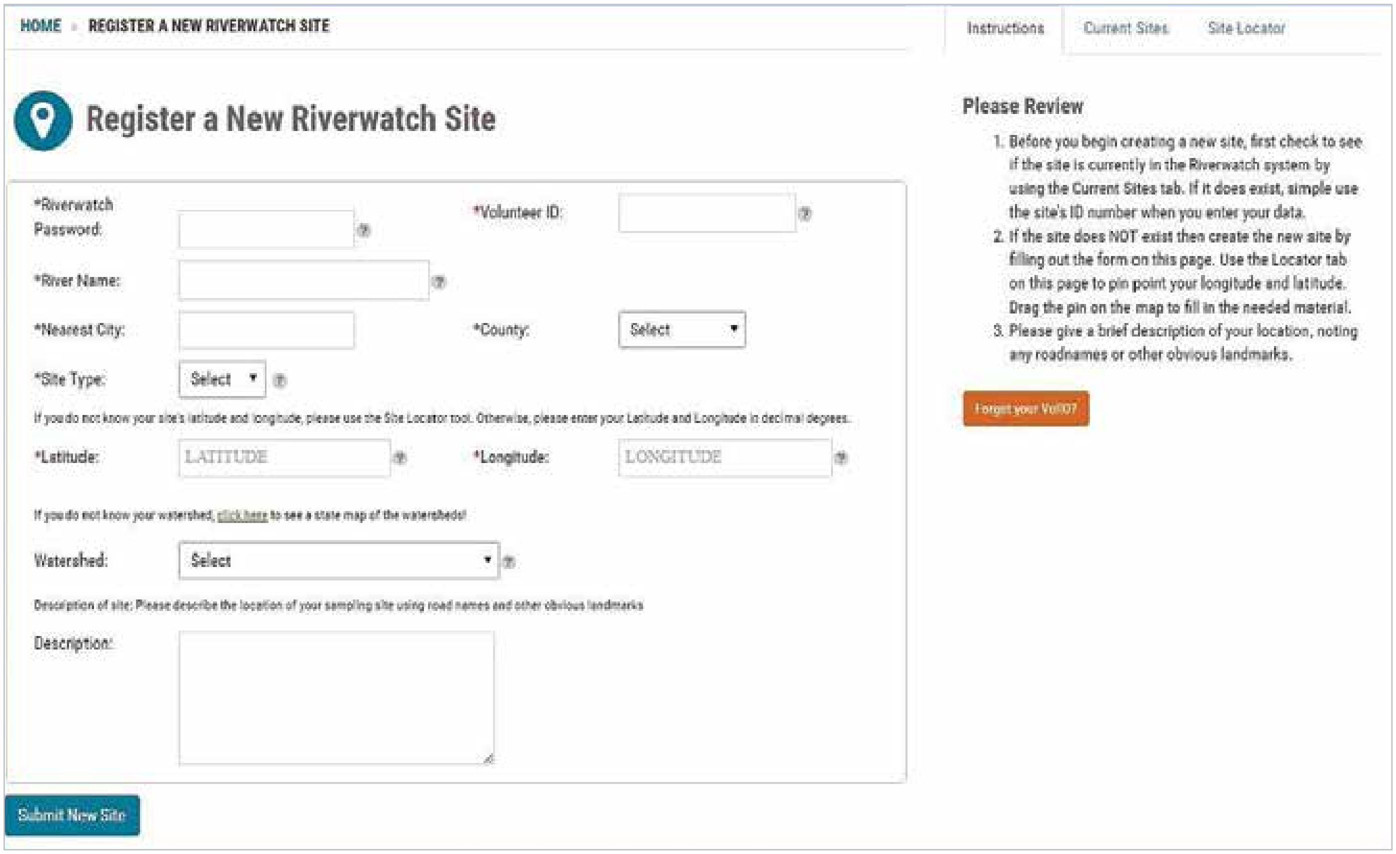
Figure 40

Users may collect data for any number of organizations, as several do. You will be given the opportunity to include an organization at the time of data entry.

Register a Monitoring Site (Figure 41)

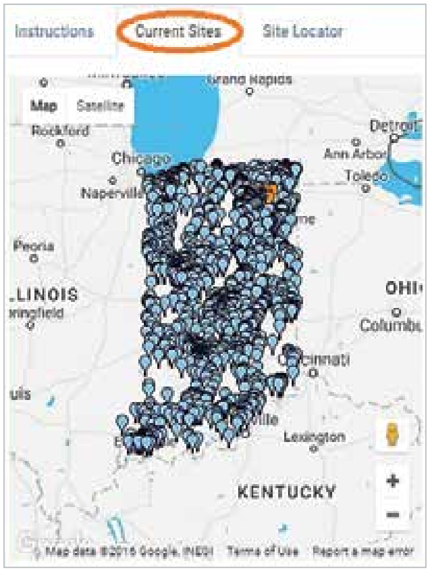
With nearly 2,000 sites recorded, it is possible that your site has been sampled already. Per the Instructions, please check the Current Sites tab on the right side of the registration page to find out (Figures 42 and 43). Zoom in to find your intended sampling location (Figure 44). If this location has been sampled before (as indicated by a blue pointer), simply record and use the same Site ID for your own monitoring efforts. If no Site ID exists for your location, use this page to create one.

Figure 41



You may use the Site Locator tab (Figure 45) on the page to find the correct coordinates for your new site. Be sure to grab and drag the red pointer with you as you scroll around the map, especially when you zoom in, as it will not do so automatically. The coordinates for wherever the pointer is resting will populate the latitude/longitude fields for you on the site entry page. When the pointer is in the correct position, simply complete and submit the form to register a site.

Figure 43

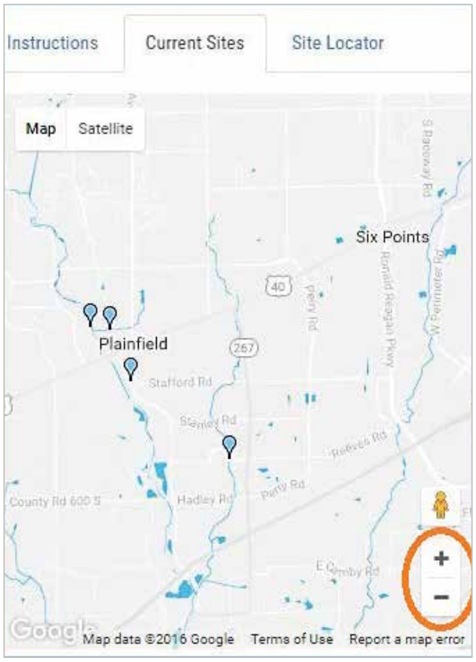


Otherwise, please use a GPS or other handy tool to determine the latitude and longitude of your site(s). Be sure to accurately convert these to decimal degrees and be very careful how you enter them. Reversing the order or forgetting a negative sign on the longitude field will make your site appear to be in another part of the world! Do the same for each site.

Figure 42

Please note that the HRW database is not georeferenced; meaning that selecting coordinates does not assign a county, watershed or even state to your sampling site. You must select each of these individually when registering a site (Figure 46). If selected incorrectly, it will make searching for and retrieving data for this site difficult. If you are unsure which watershed your site lies in, visit the Indiana Hydrologic Unit Code finder at: www.idem.IN.gov/cleanwater/indiana-huc-finder.

Figure 44



Before submitting, write a short description of the area around your site; referencing permanent structures (crossroads, bridges, parks) and distances /directions from these. This will aid in data retrieval and analysis, as well as allow for additional sampling by other volunteers at this location in the future. Please do not describe locally known or temporary information, such as Bob's house or the Keller farm; as these things change over time and will not aid others in finding this sampling site or using its data. Another helpful tidbit is to mention if you sampled upstream (u/s) or downstream (d/s) of the location described.

Click the Submit New Site button to register your site into the system and generate a Site ID. Please record this number or print the page for your records. You will need it to enter data. You should also receive an e-mail confirming each site registration with their respective Site IDs.

Registering an Organization

With the most recent database upgrade, organizational information was separated from volunteer/user information and now exists on its own. You may select the organization for whom you are sampling while you are entering stream data. At that time, you will be prompted to check whether the organization exists in the database (Figure 47). You will also be able to register it, if it is not yet in the database (Figure 48), and will be aided by the formatting and other hints described earlier in this chapter.

Figure 45

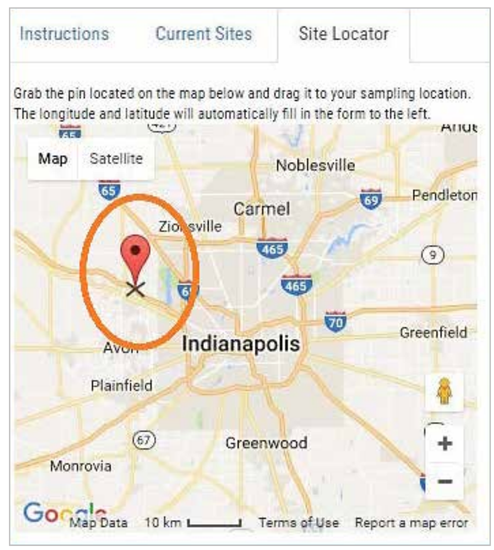


Figure 46

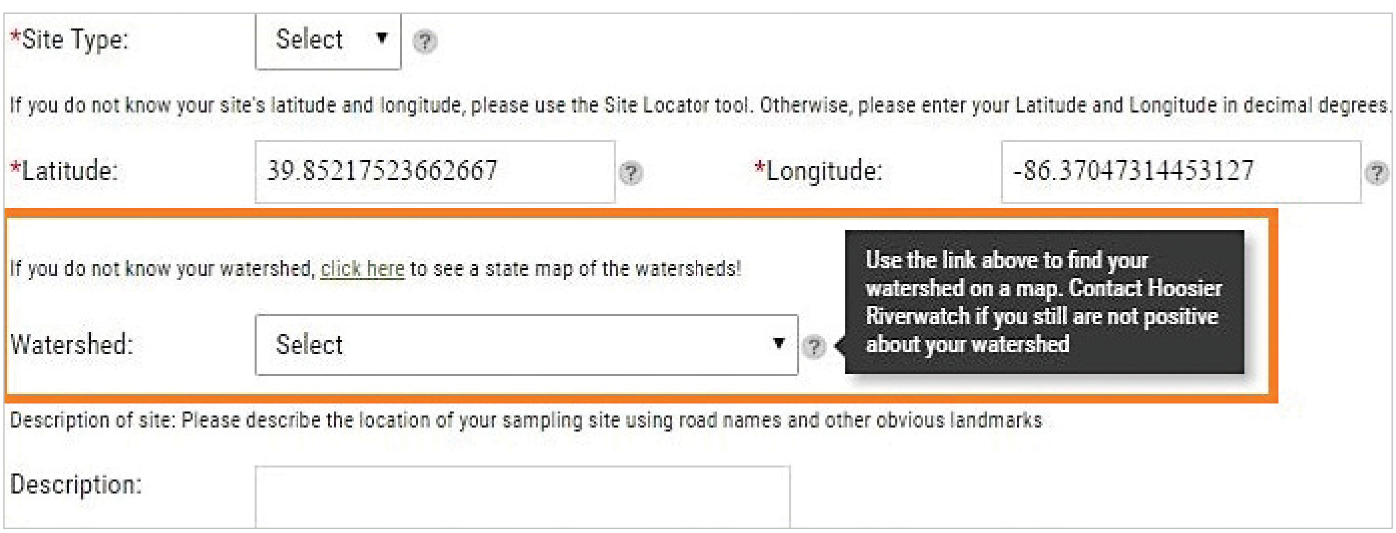


Figure 47

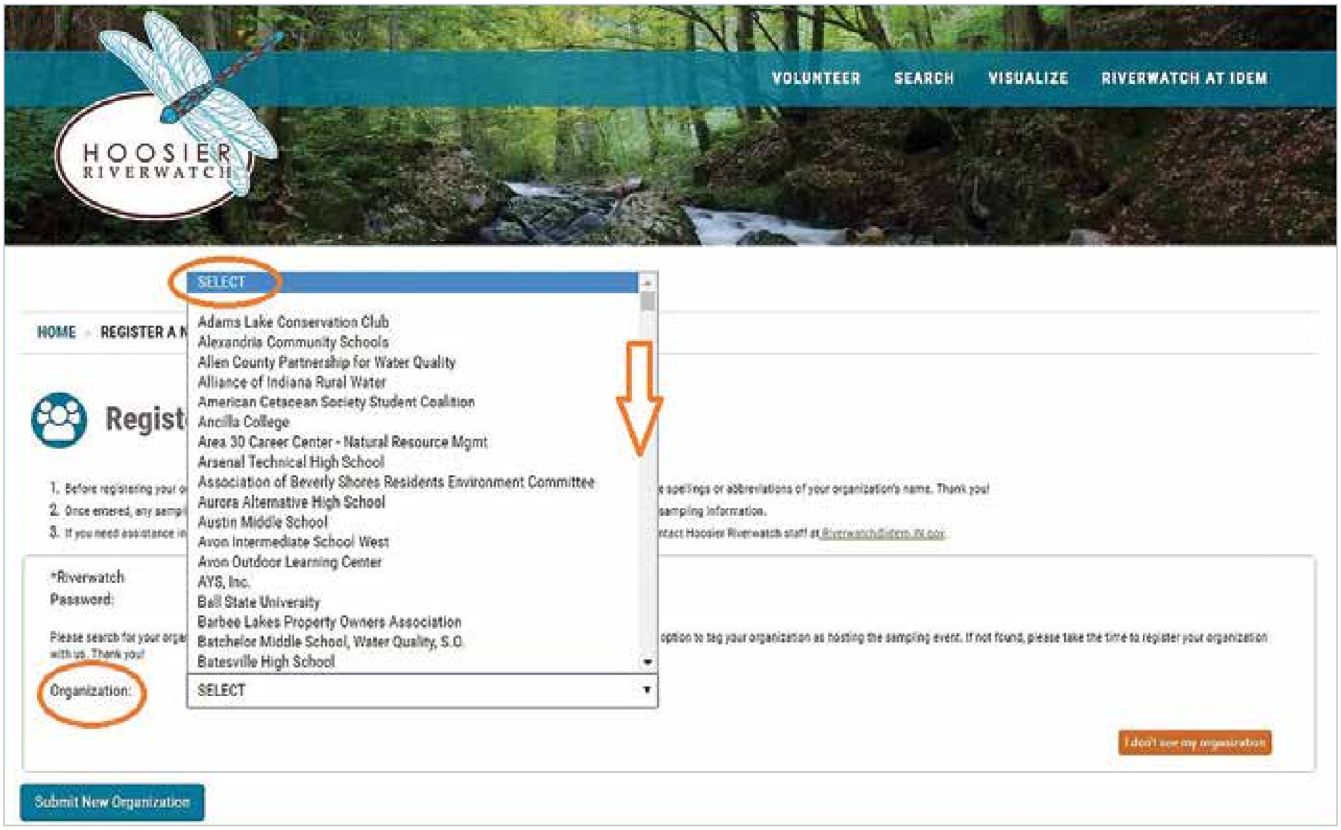
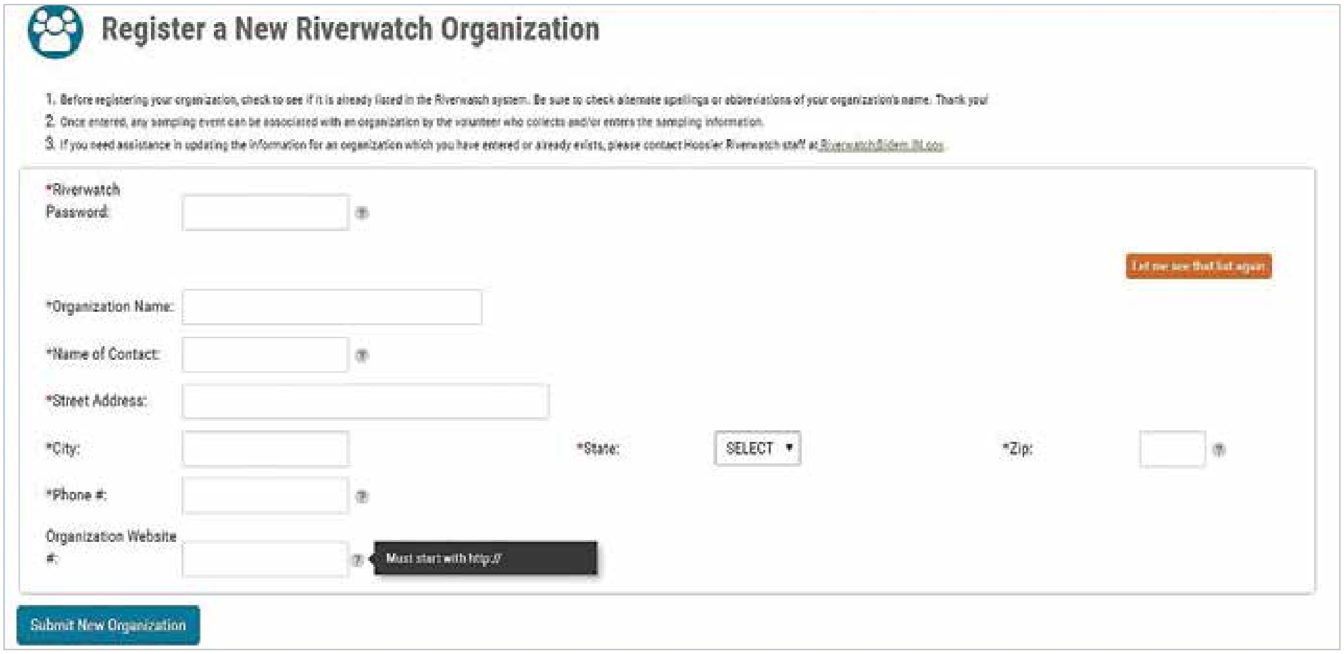


Figure 48



Entering Water Quality Data

Only those who have a valid Volunteer ID, Site ID and password may enter data into the Hoosier Riverwatch database. The data entry page (Figure 49) offers assistance in looking up these ID numbers via the tabs on the lower right side of the screen. Once entered, your first name and waterbody name will appear in the upper right corner of the screen (Figure 50). It will list the day of the week, date, hour of the day and time spent at the site. It will also graphically display the samplers and weather you entered for this event. If either of these are incorrect, you may have a typo in an ID number. If anything else is amiss you may see a pop up screen (Figure 51) advising you that something was entered incorrectly and should be double checked. Simply close that window, make the necessary corrections and carry on.

Figure 49

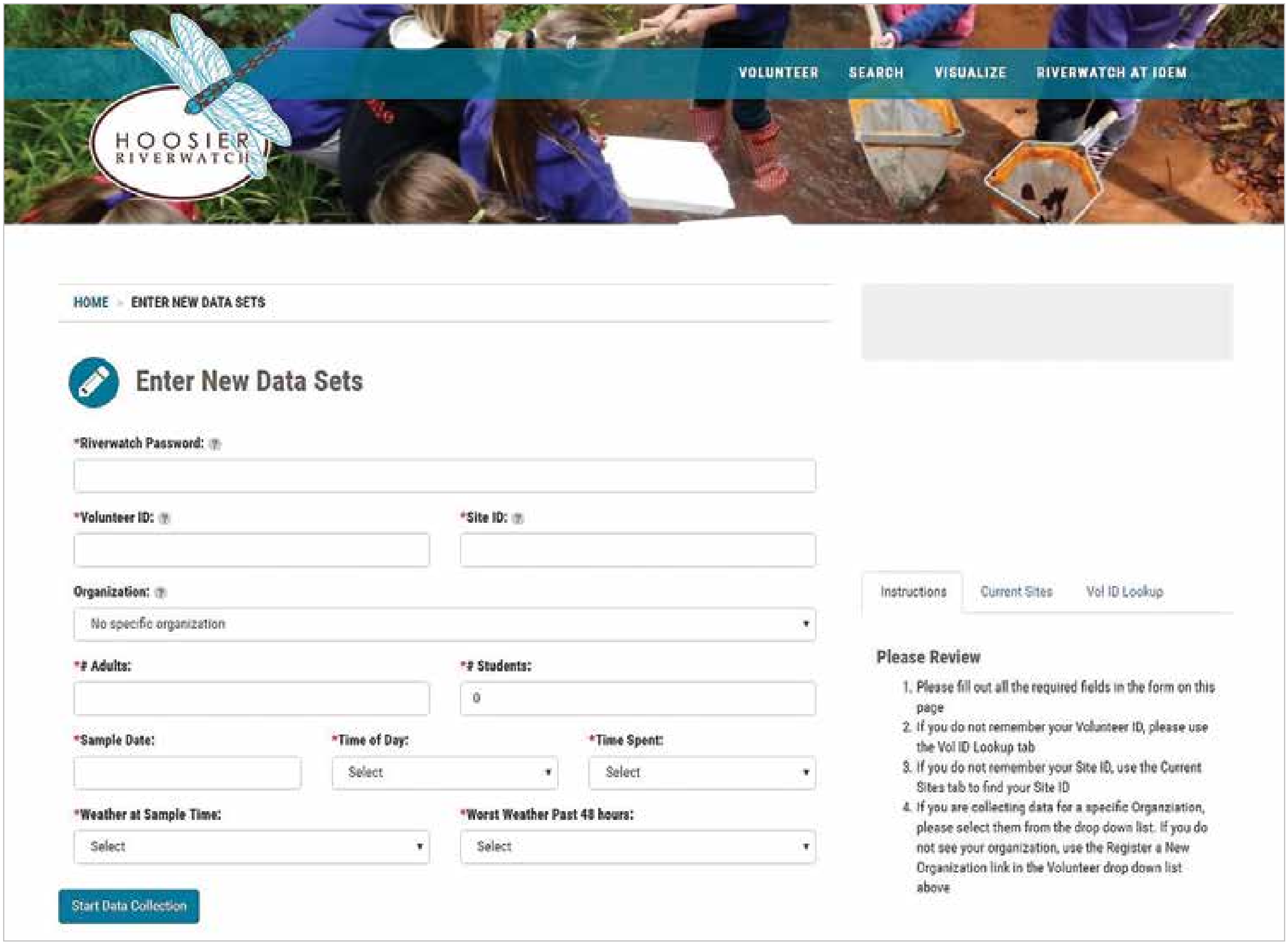


Figure 50

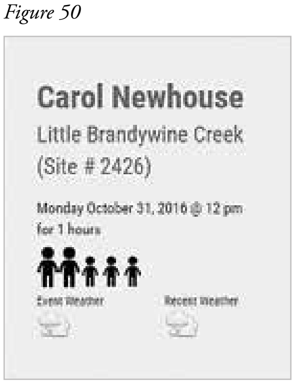
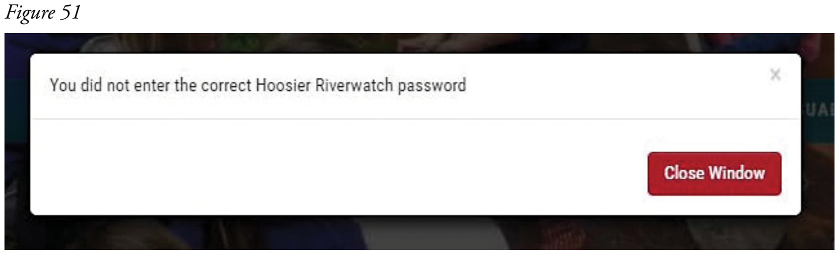


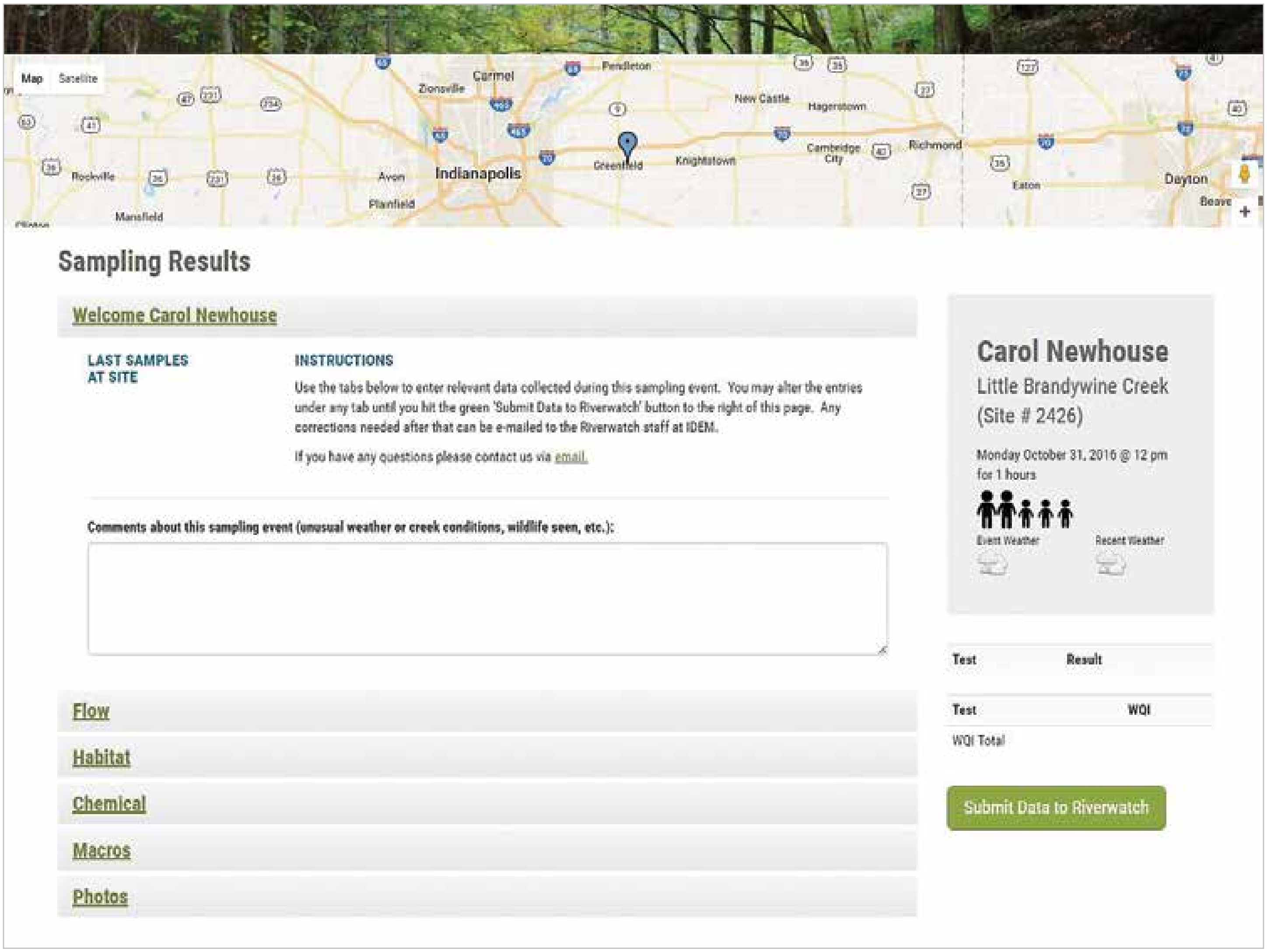
Figure 51



You will also be asked to provide basic information about your sampling event; such as number of adults and children on the sampling team, current and recent weather conditions, hour of the day, time spent sampling, and so on. Take good field notes during your sampling event, especially if you plan to enter the data on a later date. Although easily overlooked, having this information may add to a greater understanding of possible impacts effecting stream water quality on the day that you sampled.

Once finished, click the "Start Data Collection" button in the lower left. This will take you to the Sampling Results page (Figure 52). This is your keystone for data entry. It contains the Welcome, Flow, Habitat, Chemical, Macros and Photos tabs; which will be discussed in some detail below. Four of these tabs correspond directly to the data sheets used in the Hoosier Riverwatch program. This page also shows the last time you, personally, sampled this site (left side of the Welcome tab), a map of the site (header bar at top of page), and sampling conditions for the data you are about to enter (see Figure 48, again).

Figure 52



On the lower right hand side you will see scores and calculations occurring while you are entering data. Be advised that the database will no longer time you out. This allows ample time to complete your data entry. But it also warrants caution on your part to protect your work from unauthorized users.

The Welcome tab contains an area for comments. It is a handy place to record unusual things that occurred while sampling; who was there, animals, plants or unusual conditions that you observed, etc. There are also live links here to past sampling events, as well as e-mail contact for Hoosier Riverwatch staff.

Each of the data entry tabs opens with a Home tab, which contains basic descriptions or instructions for this portion of the data entry. Any one of the tabs listed here may contain charts with live data links to the database. Where pertinent, there will also be links to portions of the online training manual relevant to the topic you are in. There is also an orange bar (Figures 53 or 54) in the lower portion of each tab tracking calculations as you enter data. When finished, the scores for these may be seen on the right hand side of the Sampling Results page.

Figure 53

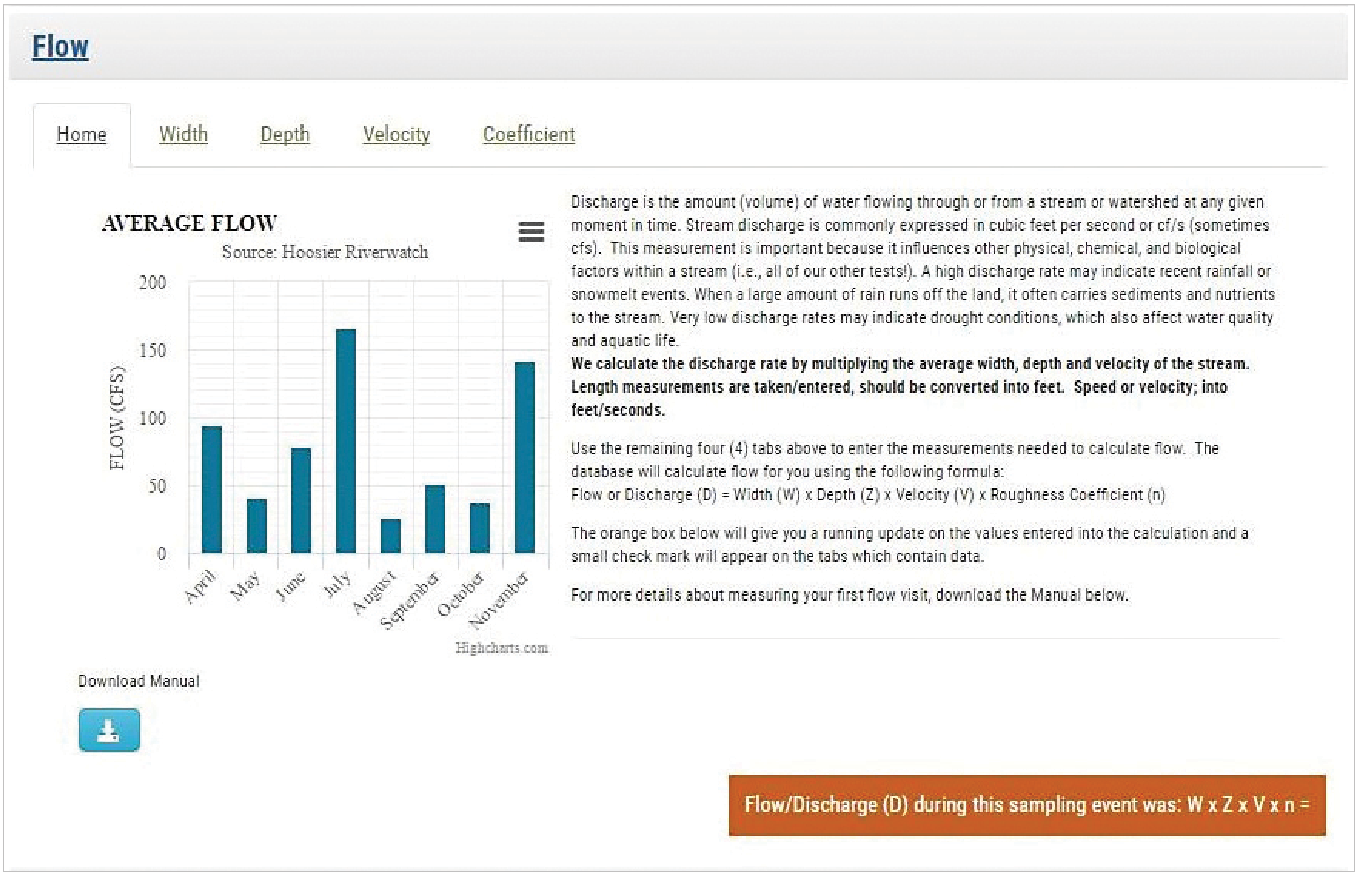
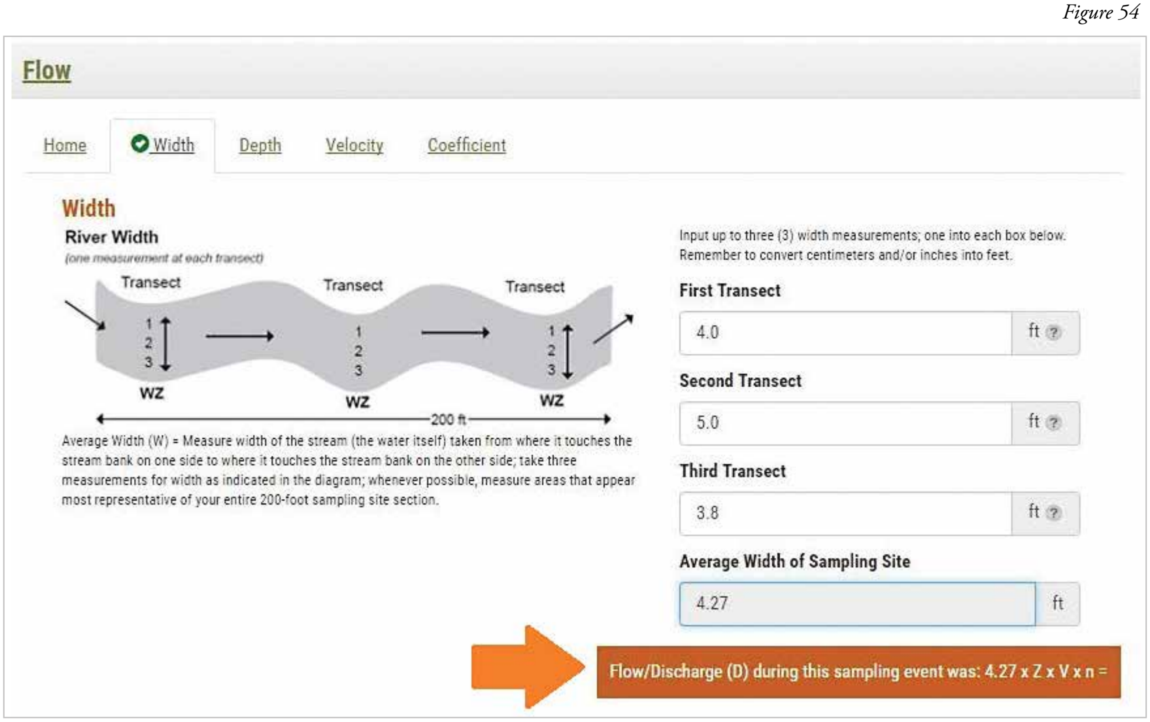


Figure 54



You only need to open and use the tabs for the data collected for this sampling event. Close one tab before opening the next to make viewing easier when using a mobile device. Otherwise, just keep scrolling! Again, the database will no longer time you out. However, attempts to close the page without clicking Submit will result in a pop up asking you to confirm whether or not you wish to leave the page. If you are satisfied with your data entry and resulting calculations, you are done and may leave. The database will save any data you enter, regardless of whether it is complete or partial. To add missed data or fix a data error, contact Hoosier Riverwatch staff.

Where indicated in each tab, select the method or equipment you used during your sampling event (Figure 55). In most cases, units of measurement have been preselected. Just be sure you enter the correct data for the given units for each parameter.

The Flow tab (Figure 53, again) contains individual tabs (left to right) for entering the Width, Depth, Velocity and Coefficient for your stream. Entry fields are provided for triplicate measurements (Figure 54, again). As you learned in the training workshop there are times when multiple readings are important and times when they are optional. Width needs three readings, as shown in the River Width/Transect diagram (Figure 54) below and page 30 of this manual.

Figure 55

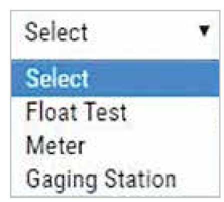


Figure 56

The Depth tab contains nine data entry fields, corresponding to three readings along each of the three stream transects. These are all in feet and tenths of a foot, as indicated by the preselected unit of measurement. As you enter data, you will see the average for each transect change, as will the overall average for the site in calculated (gray) fields and in the orange calculation bar lower down on the page. You will also note that a green check mark appears next to the name of each tab when data entry has been completed for that tab.

The same holds true for the Velocity and Coefficient tabs. When the last (or enough) of the data has been entered, the database will make the final calculation and display it on the right hand side bar on your screen (Figure 56).

Under the Habitat tab you will enter data collected for the Citizen's Quality Habitat Evaluation Index (CQHEI) score. The Home tab here shows the average for this site, as well as the watershed and the entire state. Subheadings under this category match the data sheet used and include Substrate, Fish Cover, Shape/Alterations, Forests/ Wetlands, Depth/Velocity (descriptive data, rather than measurements collected for Flow above), and Riffles/Runs. Follow directions under each tab to know whether to pick only choice or multiple choices. While there is no orange calculation bar at the bottom of these tabs, there is an area which shows your CQHEI score adding up.

Under the Chemical tab you will again see tabs for all of the parameters covered during training and included on the field/data sheets. Follow the instructions included under each tab and described above. The database will automatically make and display calculations for you. If/When enough parameters have been entered to determine a Water Quality Index score for this event, it will display on the right hand side of your page again (Figure 54). Otherwise, the database will simply store and show the data collected without a WQI score. Either one is fine.

A new feature to the database is the ability for you to enter any (and as many) additional samples you may have collected during a sampling event. Using the last tab, labeled "Secondary", you can select any number of parameters with their respective methods and add results to the database for these.

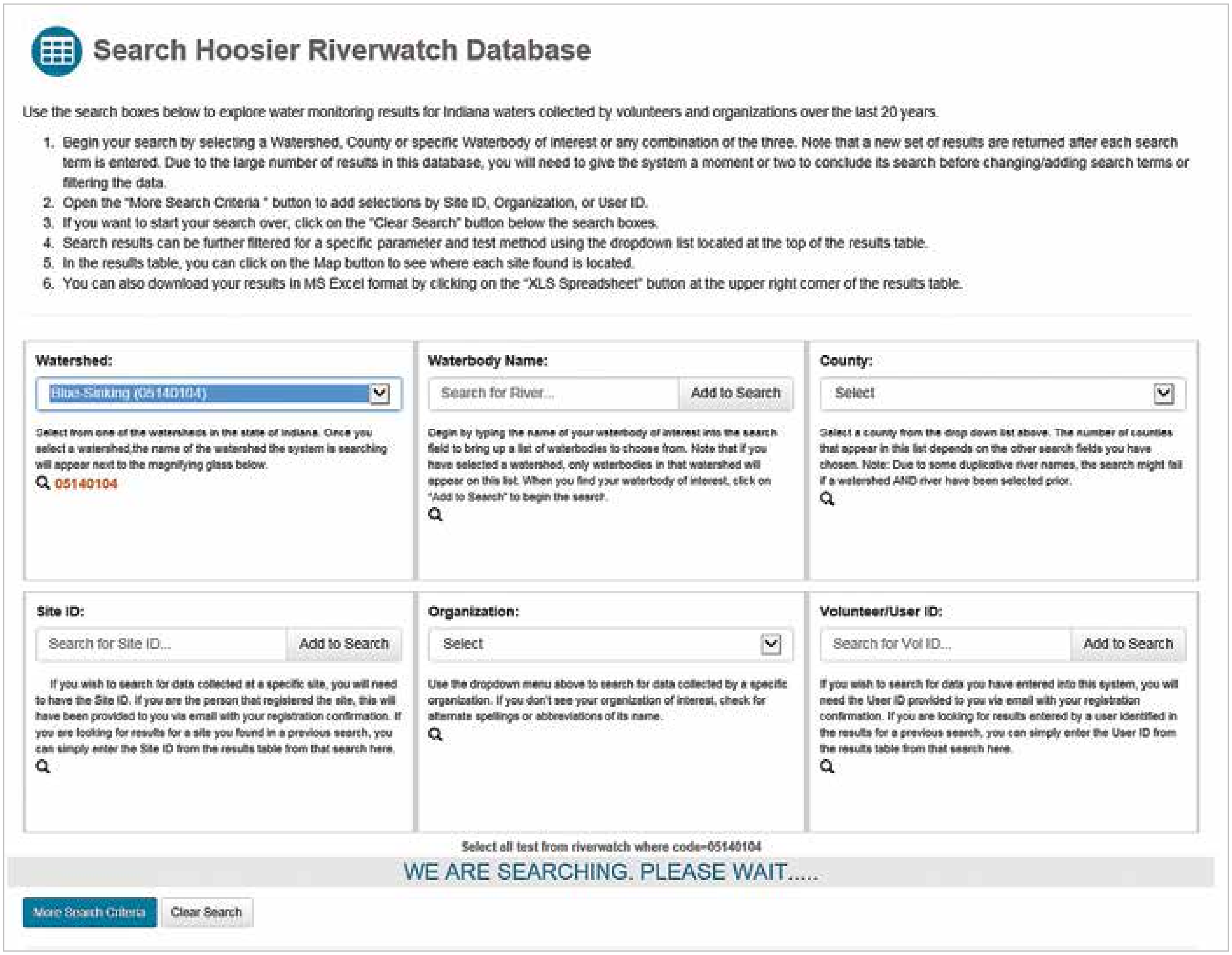
Data entry under the Macros tab works similar that for Habitat described above. The Photos tab is a new addition, allowing you to finally store that Site Map you drew or drop in a few key photographs of the site, unique plants or animals, and/or your sampling crew. When you are satisfied that your data entry is complete click the green Submit Data to Riverwatch button (also Figure 54) to finish. You may contact Hoosier Riverwatch staff to make any necessary corrections to your dataset, should it be needed.

Search the Database

With nearly 11,000 record sets in the Hoosier Riverwatch Database, finding data specific to your group, location or even to you as an individual can seem daunting. However, the Search and Visualize features will allow any user to find information quickly and easily.

Selecting Search in the title bar at the top of any page in the database will take you to the main Search page (Figure 57). Initially you will see three criteria boxes with which to begin your data search. Your first set of choices are Watershed, Waterbody Name and County. Clicking the blue More Search Criteria button at the lower left will toggle three addition criteria boxes on and off. These additional options include Site ID, Organization, and Volunteer/User ID.

Figure 57



You may search by any one of these criteria alone or sequentially. Give the database a moment to complete its search for the first criteria before adding the second and so on. While it is searching you will see the message (below the criteria boxes) which reads "We are searching. Please wait." You will also see the criteria you selected in orange text near the magnifying glass in each respective box.

When the search is completed the "Please wait" message will change to orange text and will state the numbers of individual test results and unique sampling trips found. The page will automatically scroll down to show the beginning of the data table below. There may be many pages in the data table, as the record for each parameter takes up its own row in the table (Figure 58).

Figure 58

Your search came back with 2785 test results in 200 unique sampling trips (Event ID). See the table below.

Select all test from riverwatch where code=05140104

More Search Criteria | Clear Search

Show 50 entries Filter by Test: Select Test Filter by Date: Select Date XLS Spreadsheet

Narrow Your Search:

Map	Watershed	Stream	Site ID	Date	Test	Result	Unit	Macro	Macro Count	Event ID	Vol ID	Org
Unique Trip												
Map	Blue-Sinking	Brock Creek	1691	2016/10/21	Invert Sampling			stonefly	2	1691125610212016	1256	Salem High School
Map	Blue-Sinking	Brock Creek	1691	2016/10/21	Invert Sampling			mayfly	9	1691125610212016	1256	Salem High School
Map	Blue-Sinking	Brock Creek	1691	2016/10/21	Invert Sampling			riffle	4	1691125610212016	1256	Salem High School
Map	Blue-Sinking	Brock Creek	1691	2016/10/21	Invert Sampling			dobsonfly	2	1691125610212016	1256	Salem High School
Map	Blue-Sinking	Brock Creek	1691	2016/10/21	Invert Sampling			damselfly	2	1691125610212016	1256	Salem High School
Map	Blue-Sinking	Brock Creek	1691	2016/10/21	Invert Sampling			sowbug	1	1691125610212016	1256	Salem High School
Map	Blue-Sinking	Brock Creek	1691	2016/10/21	Invert Sampling			crawfish	4	1691125610212016	1256	Salem High School
Map	Blue-Sinking	Brock Creek	1691	2016/10/21	Invert Sampling			leech	2	1691125610212016	1256	Salem High School
Map	Blue-Sinking	Brock Creek	1691	2016/10/21	Invert Sampling			maggot	2	1691125610212016	1256	Salem High School
Map	Blue-Sinking	Brock Creek	1691	2016/10/21	Pollution Tolerance Index Rating	28	PTI			1691125610212016	1256	Salem High School
Map	Blue-Sinking	Brock Creek	1691	2016/10/21	Flow	12.04	CFS			1691125610212016	1256	Salem High School

You may wish to filter the data further by Test or Date (which use drop down menus) or type in your own criteria where it says "Narrow Your Search". You can also sort the data from high to low, old to new, etc. by using the arrows in the column headers.

The blue pointer in the map column will show you the location of the sampling site. If a small blue icon appears in the Event ID column, clicking it will reveal any photos uploaded for this event.

You may also wish to download the data to your own computer/device using the "XLS Spreadsheet" button to the upper right of the table. This is a great way to work with and graph the data in the manner you choose for analysis or presentation to others. You can also use the Visualize tool to view preset graphs of the data you are interested in.

Visualize the Datasets

Visualize is a tool of the Hoosier Riverwatch database that allows a user to do some simple graphs and analysis of the data that has been entered. This tool begins at an entry screen (Figure 59) which asks the user if they wish to compare data from two different locations or look at data from a single location over time. Both options allow you to select and view the data by one or two: watersheds, counties, rivers or sites (Figures 60 and 61).

Figure 59

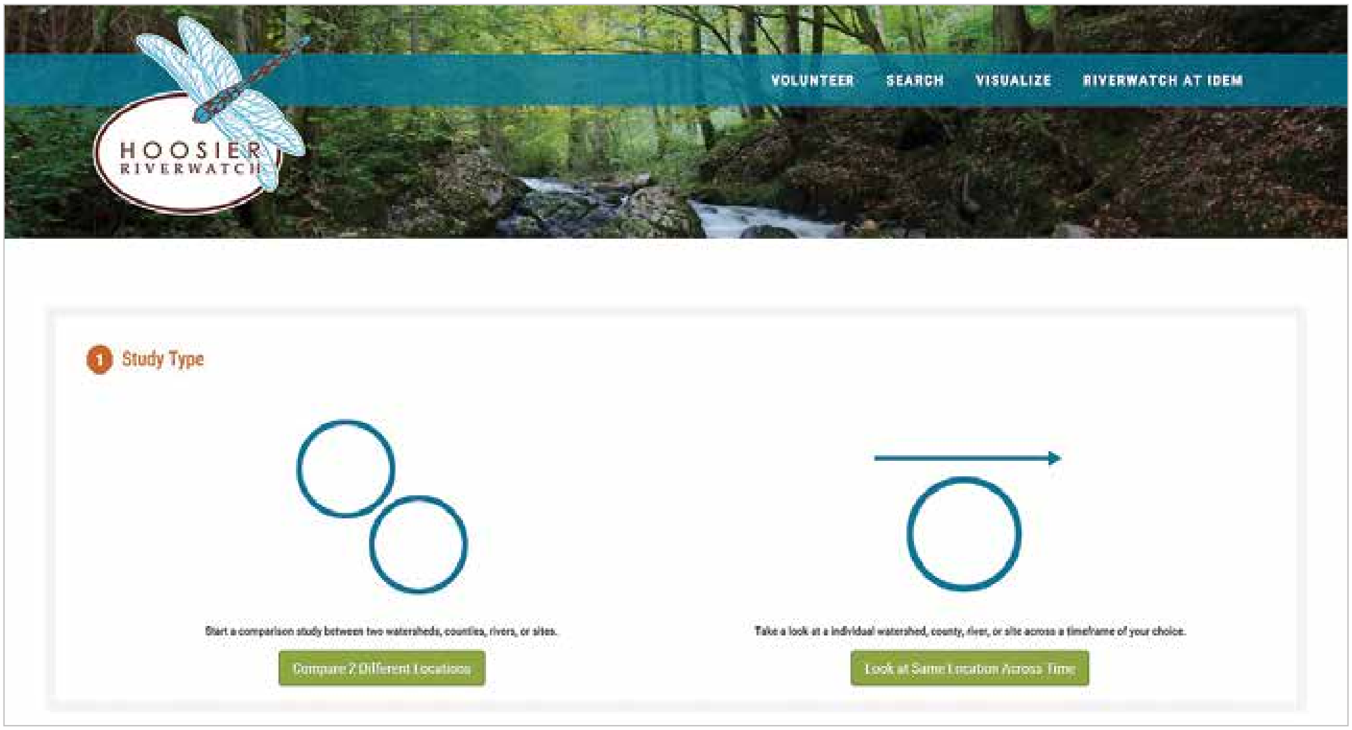


Figure 60

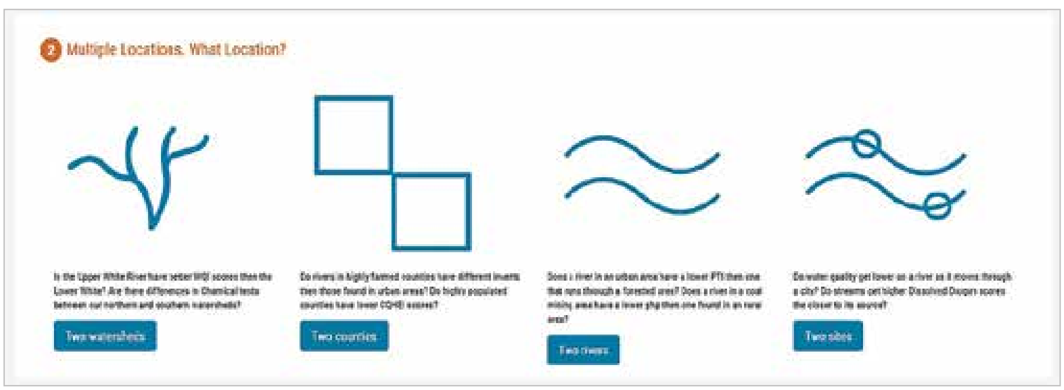
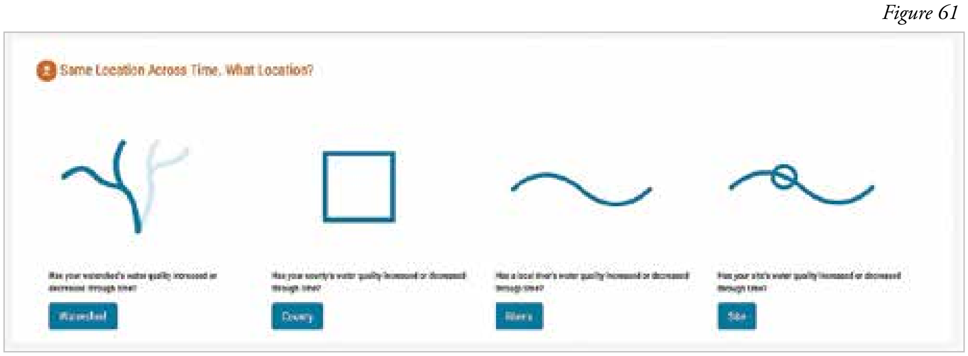


Figure 61



To view data by watershed you may click the correct watershed(s) on the map itself or select from one or two drop down menus (Figure 62). The same for making a county selection (Figure 63). After each selection click the teal button to confirm that "This is (or These are) your choice(s)."

Figure 62

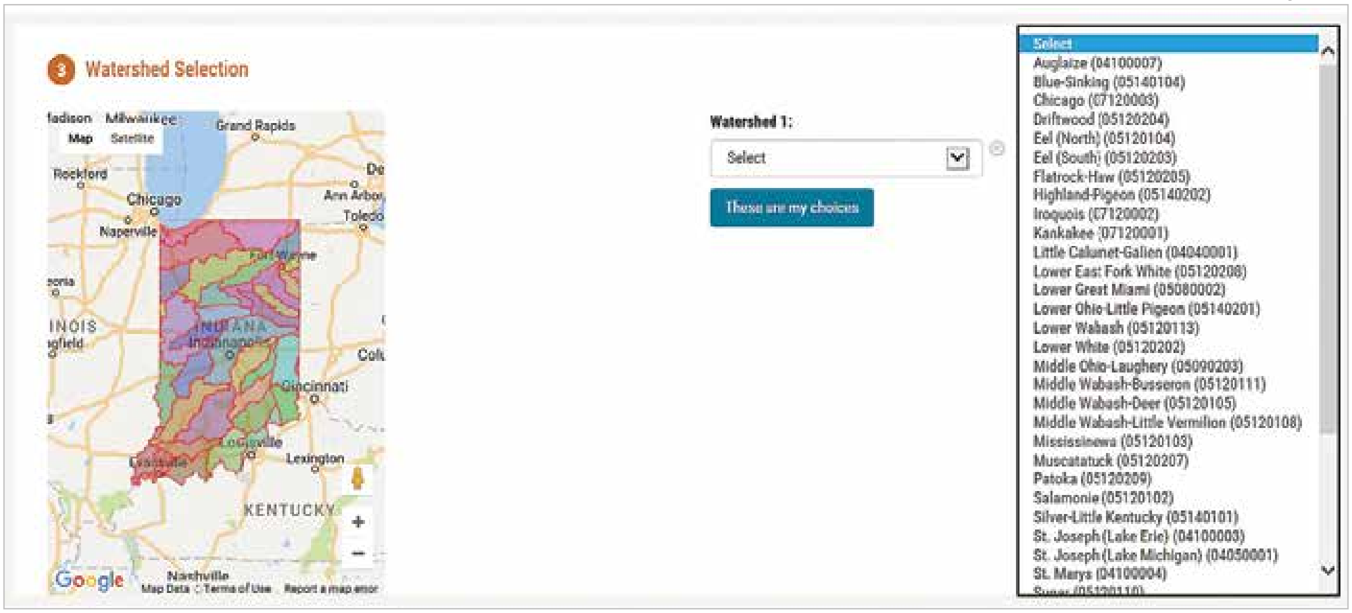
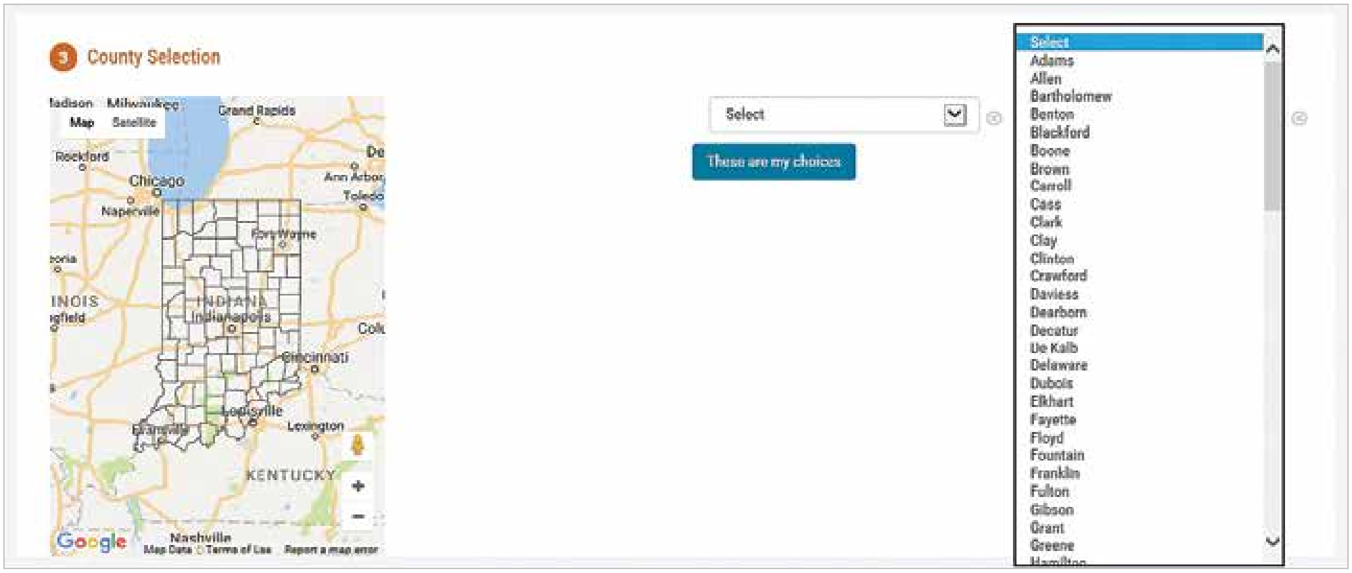


Figure 63



To view by river start by typing, where indicated, the name of the waterbody you are interested in. As you type, the list of possible entries in the database will appear. You may continue typing to narrow the possibilities or scroll down to make your selection (Figure 64).

To view by sampling site the database will present you with a map containing all sites (Figure 65). The light blue pins are Hoosier Riverwatch sites. (The orange pins are for other secondary data; collected outside of the IDEM Office of Water Quality's Watershed and Assessment Branch.) You can simply enter a Site ID or zoom in to locate and select the sites of interest to you. Clicking on a particular site will reveal its ID number, waterbody name, site description and 12-digit HUC code (Figure 66). As for above, click to confirm that those sites are your choices.

Figure 64

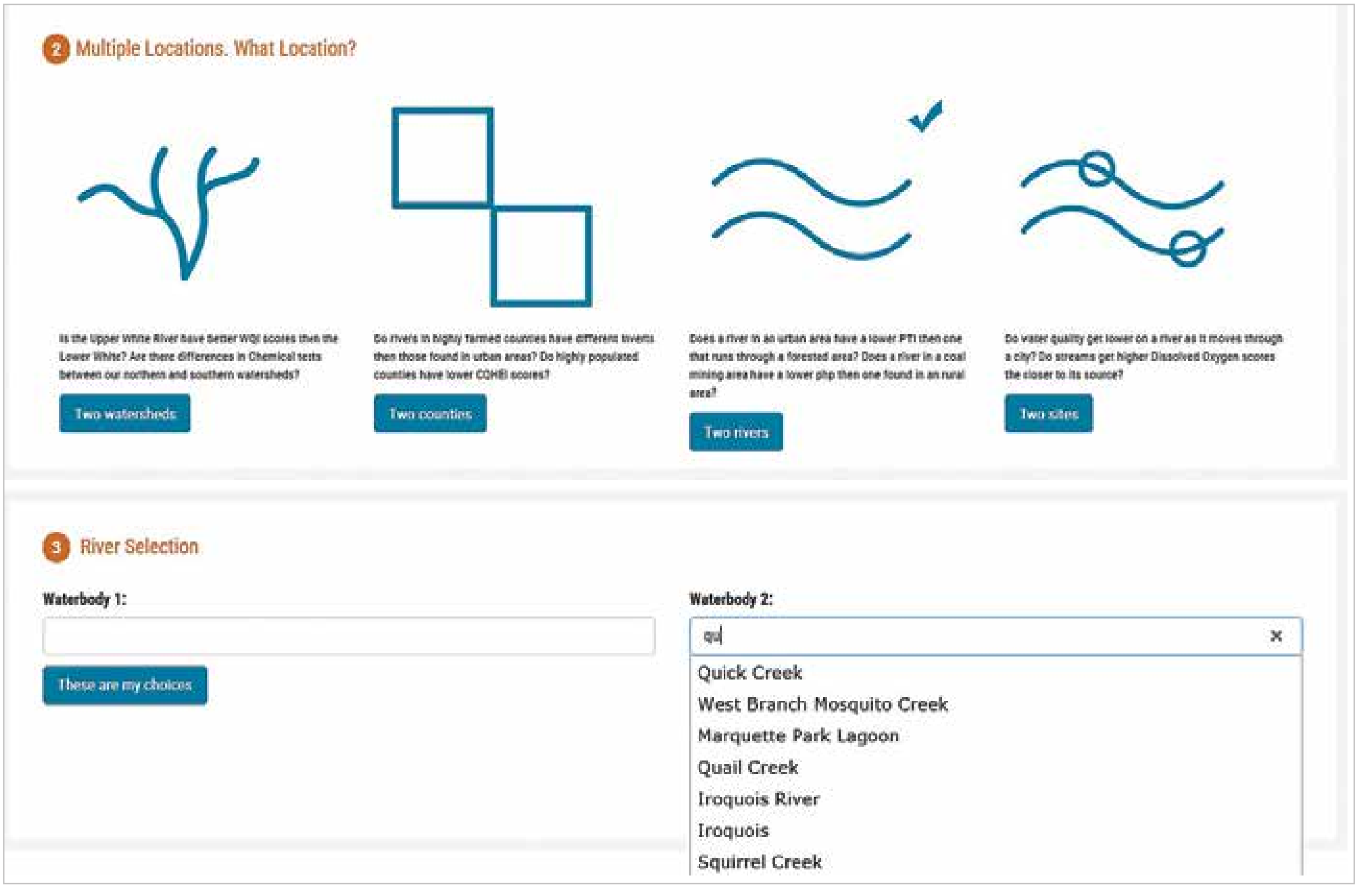


Figure 65

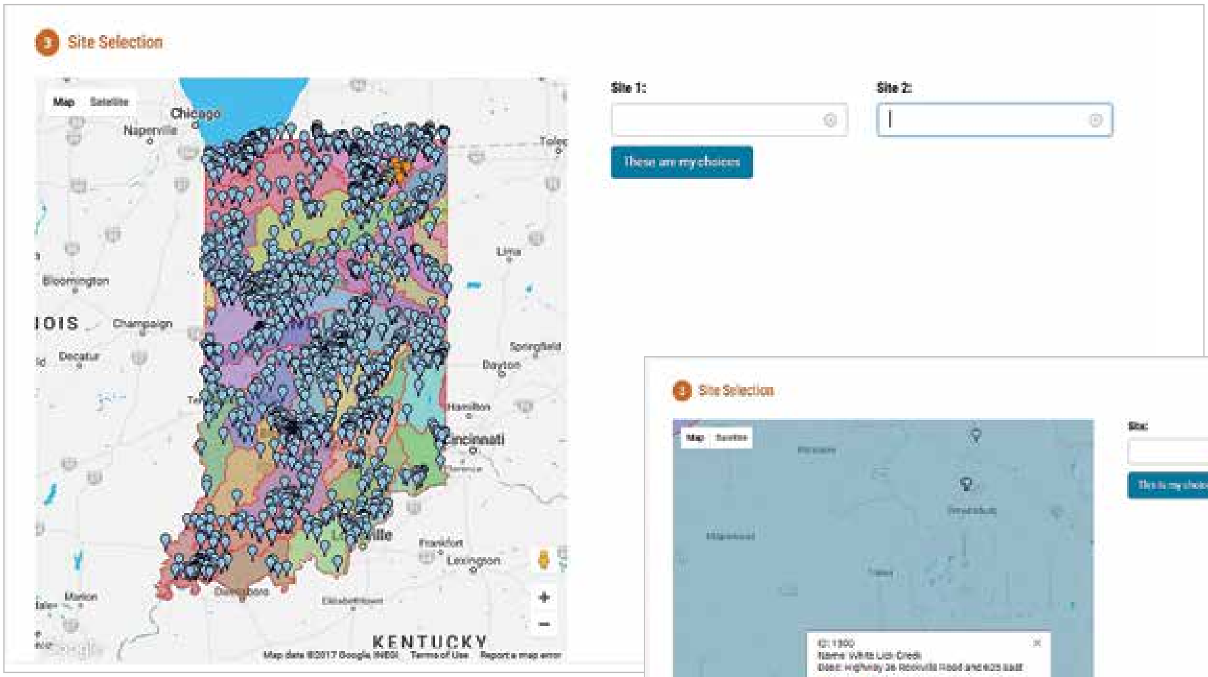
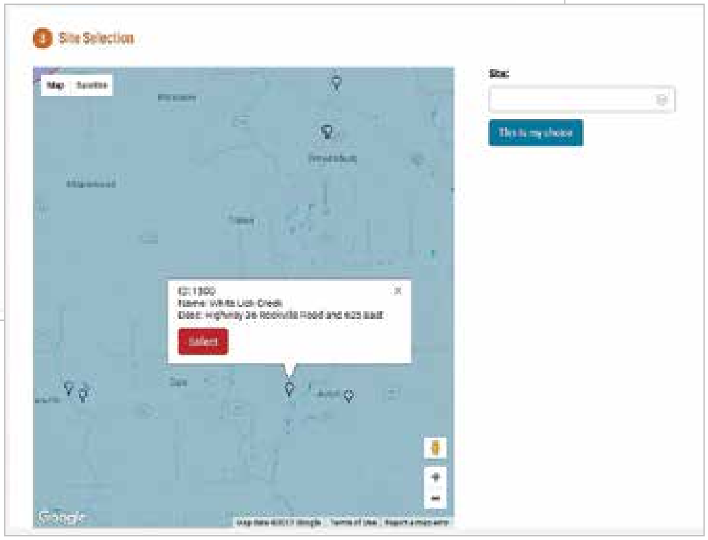


Figure 66



Parameter Selection

Once you make your selection above a window will open that says “Parameter Selection” (Figure 67). This may take a moment. Parameter names will appear where data exists. However, if no results appear below the header area, that means either the one or both datasets chosen contain no data. If that occurs, simply make another selection and try again. The arrows shown (as indicated in the key below the window name) are a general indication of whether the mean of the data appears to be higher or lower than the mean for the entire, statewide Riverwatch dataset.

Figure 67

Click on one or more of the parameters to view a bar chart (Figure 68), or modified pie chart in the case of macro-invertebrate samples (Figure 69), for the data associated with the watershed, county, river, or site that you chose earlier. The selected parameters will appear in a blue bar and charts will open below (Figure 68, again). Using the small ‘bars’ icon in the upper right of each graph will give you the option to print or download the chart (also, Figure 68). As before, hovering the cursor over an area of the chart will reveal a summary of the data behind that portion of the chart (Figure 69, right hand pie).

Figure 68

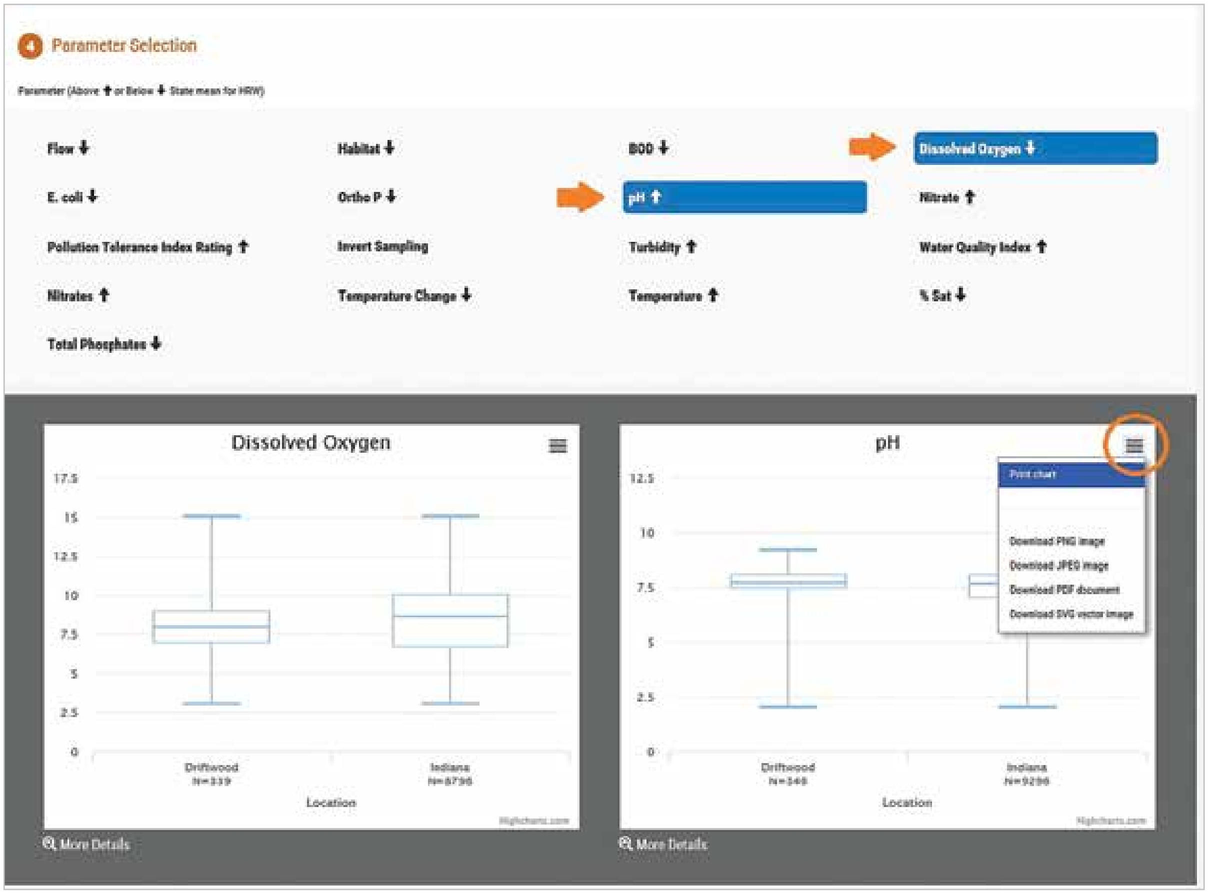
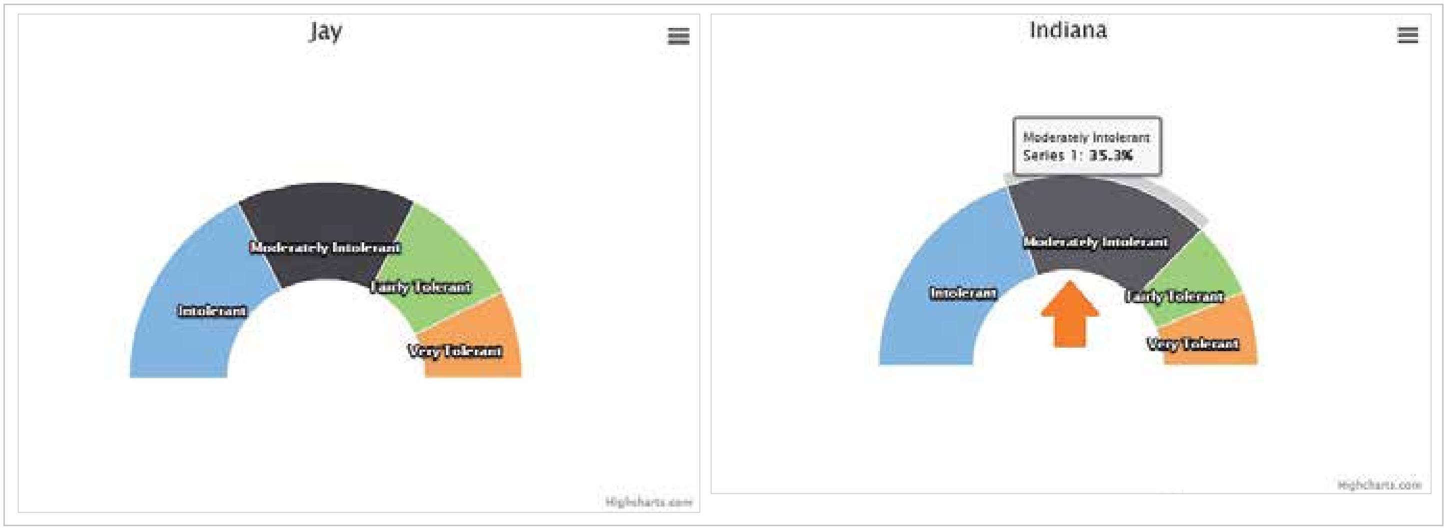
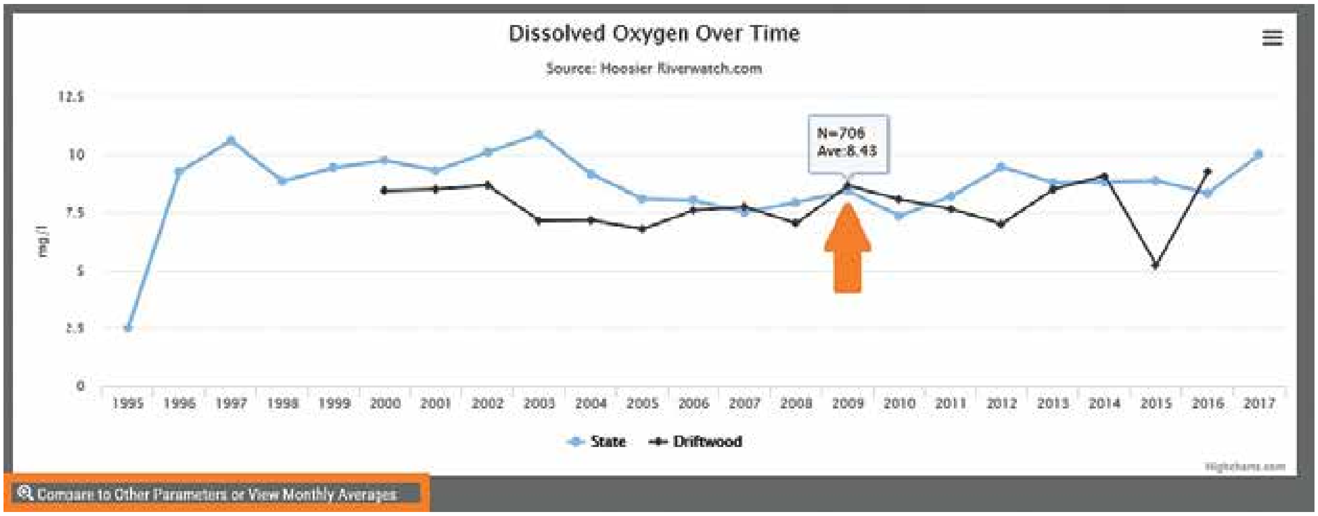


Figure 69



Clicking on "More Details" below the bottom left corner of each bar chart will open a line graph showing your selected data against the statewide average of all data for that parameter in the database (Figure 70). Again, hover the cursor over any data point on this graph to see the average value and sample size associated with a particular year.

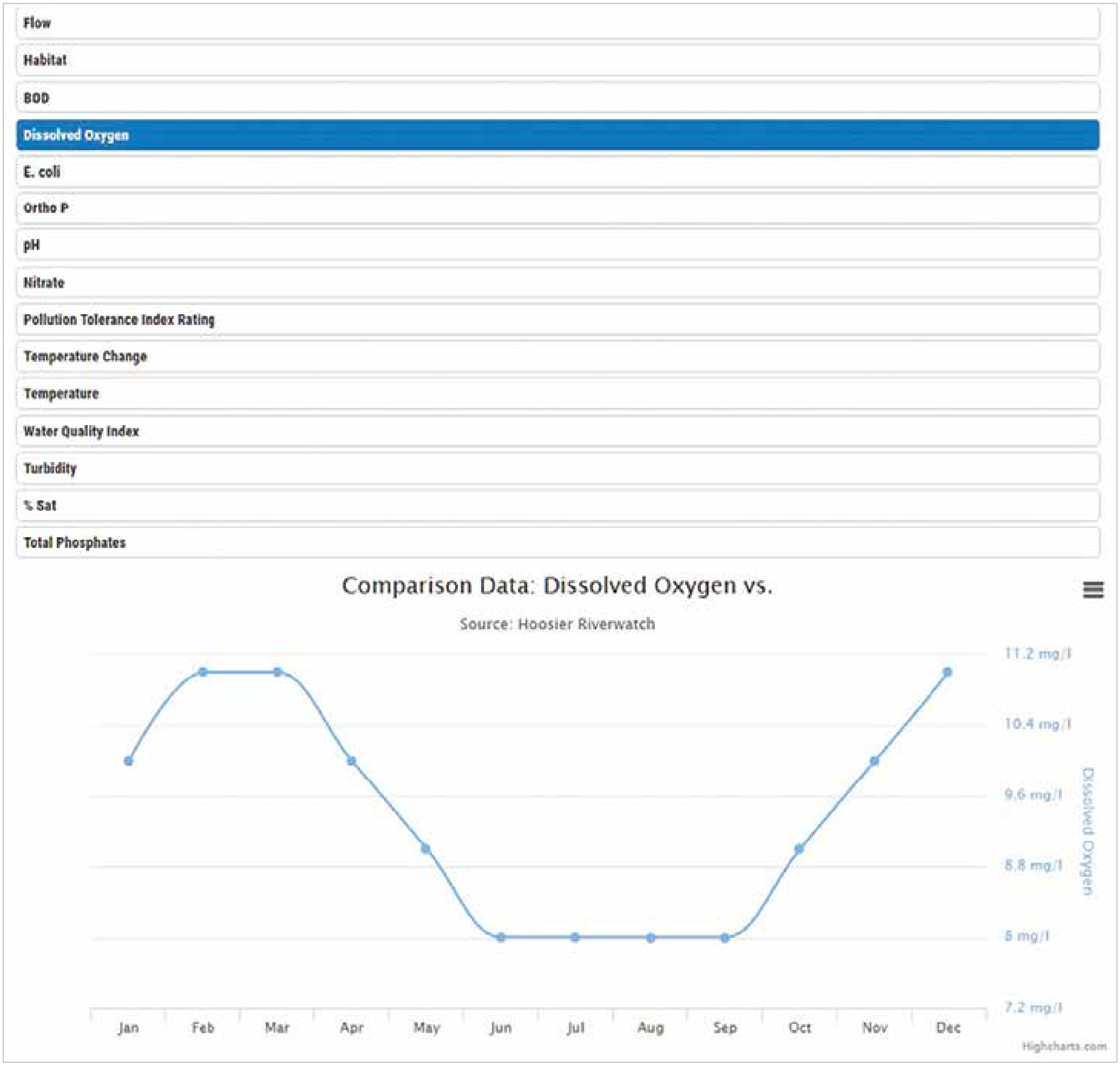
Figure 70



You can continue viewing the data in greater detail by clicking the "Compare to Other Parameters or View Monthly Averages" below the line chart (Figure 70, again). This will allow you to hone in on particulars about the data you are interested in. The monthly averages for only your selection (site, county, river or watershed) will appear, without a statewide average. From this point on, using Chrome or Firefox as your browser will often give you more satisfactory results.

That first click will open a parameter list different from the one you saw previously. It will also open a graph generated according to the parameter you originally keyed the open the comparison window (Figure 71). Clicking on or off any other parameter in this parameter list will generate an additional line on the graph comparing the two parameters from each other; such as in the Dissolved Oxygen vs. Temperature example shown (Figure 72). Note the differing scales (and their related line colors) on the left- and right-hand sides of the graph. You may toggle on any variety of two parameters to compare.

Figure 71



Pay attention to that previous statement. While it may seem easy to say "You may toggle on any variety of two parameters to compare"; the truth of the matter is, it is quite a powerful tool built into the database for your use. With this comparison window open, try turning on and off parameters alone or in pairs to look at the data. Simply graphing data to look for patterns is a great first step towards data analysis. You can see the relationship between water temperature and dissolved oxygen mentioned in Chapter 4 of this manual in Figure 72. Hovering the cursor over data points for a given month reveals both sets of data in this window.

Figure 73, for instance, shows that habitat scores are not always closely related to macroinvertebrate results. In fact the graph may be suggesting that simply finding and collecting aquatic insect samples during the winter months is a difficult task.

Figure 74, on the other hand, suggests that turbidity for any month might almost be predicted by the nitrate results from the previous month; perhaps owing to the time it takes algal growth to respond to the available nitrogen.

Figure 72

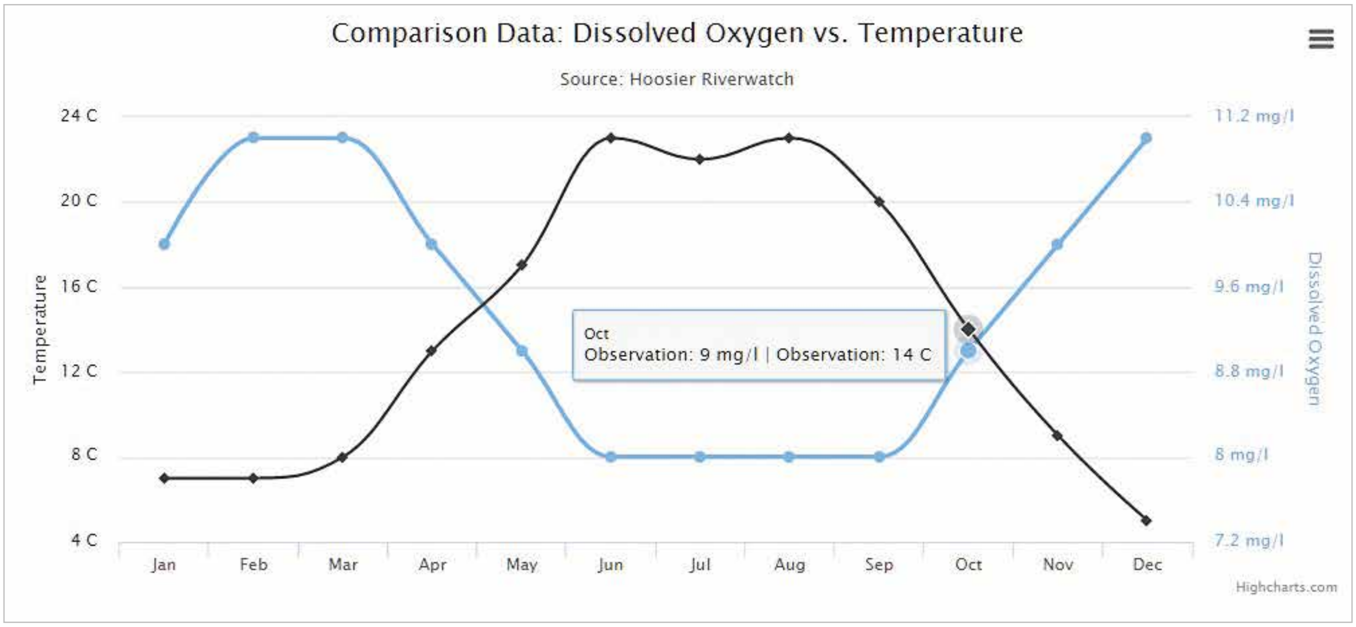


Figure 73

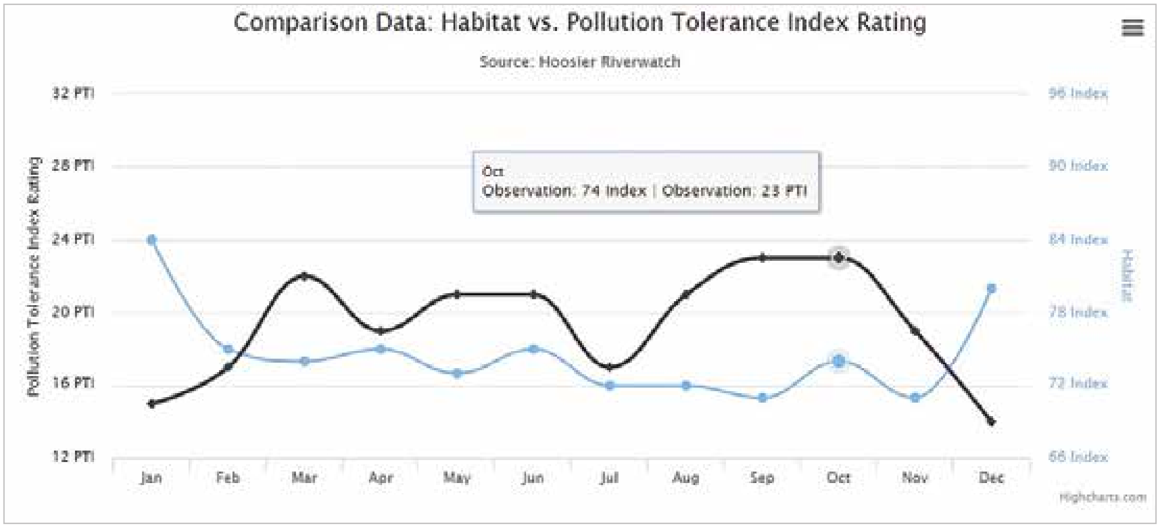
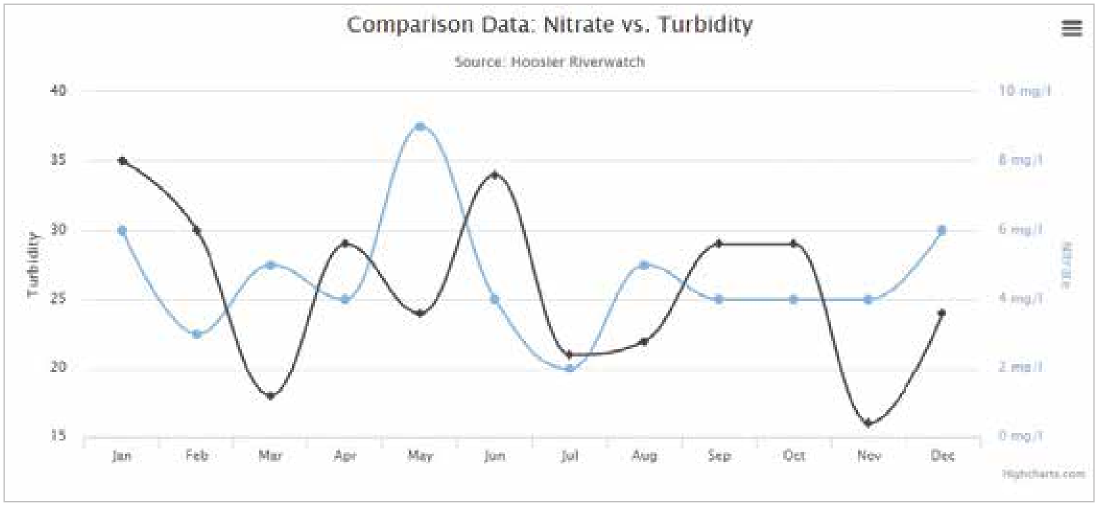
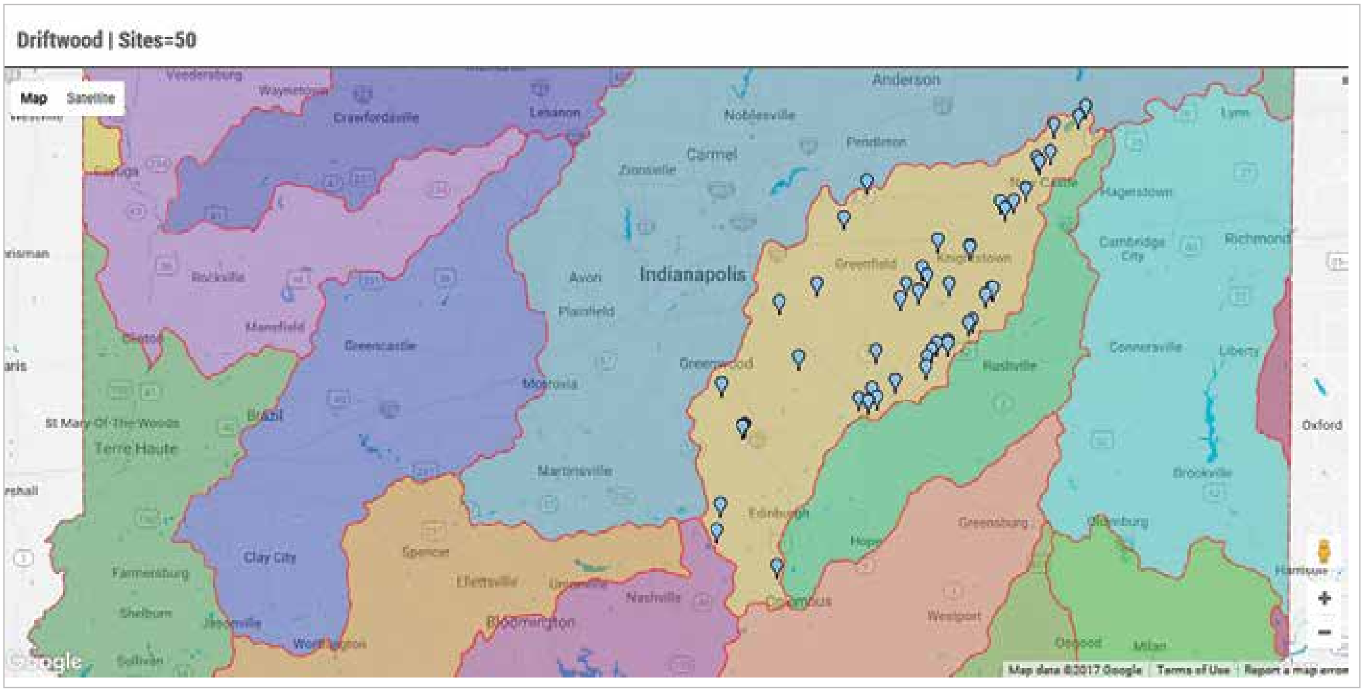


Figure 74



Another nifty item, displayed on the bottom of the Visualize page as soon as you select the "More Details" option above, is a map showing the sites from which the data is being pulled from (Figure 74). This is handy to have and gives you a relatively quick view of where in the state the data in the above charts and graphs was collected from. You will need to capture a screen shot of this, however, as downloading or otherwise saving it from the database is not an option. As in the Search and other screens, clicking on any site will reveal its ID, stream name and site description, as entered into the database.

Figure 75



A similar tool for viewing sample sites is available in the Search tool, as indicated by the blue Map and pin located in the leftmost column of the results table. However, clicking on this will show only one site at a time (Figure 75). Hovering your cursor over the brown magnifying glass next to the results for flow or habitat will reveal the average of the data entered as used to calculate the result (Figures 76 and 77).

Figure 76

Unique Trip

Map	Whitewater	Whitewater River	1077	2006/09/08	Flow	39.89	CF/SEC			10777682006-09-08 00:00:00	768	Hagerstown Jr. Sr. High School
Map	Whitewater	Whitewater River	1077	2006/09/08	Habitat	71	Index			10777682006-09-08 00:00:00	768	Hagerstown Jr. Sr. High School
Map	Whitewater	Whitewater River	1077	2006/09/08	Invert Sampling			bloodmidge	1	10777682006-09-08 00:00:00	768	Hagerstown Jr. Sr. High School
Map	Whitewater	Whitewater River	1077	2006/09/08	Invert Sampling			aquaticworms	3	10777682006-09-08 00:00:00	768	Hagerstown Jr. Sr. High School
Map	Whitewater	Whitewater River	1077	2006/09/08	Invert Sampling			blackfly	5	10777682006-09-08 00:00:00	768	Hagerstown Jr. Sr. High School

Figure 77

39.89	d:39.89,w:35.47,z:1.98,v:0.71,n:0.8	
71	Index	

Figure 78

39.89	CF/SEC	
71		

Substrate:20,Fish Cover:14,Stream Shape:3,Riparian Areas:14,Depth and Velocity:9,Riffles and Runs:11

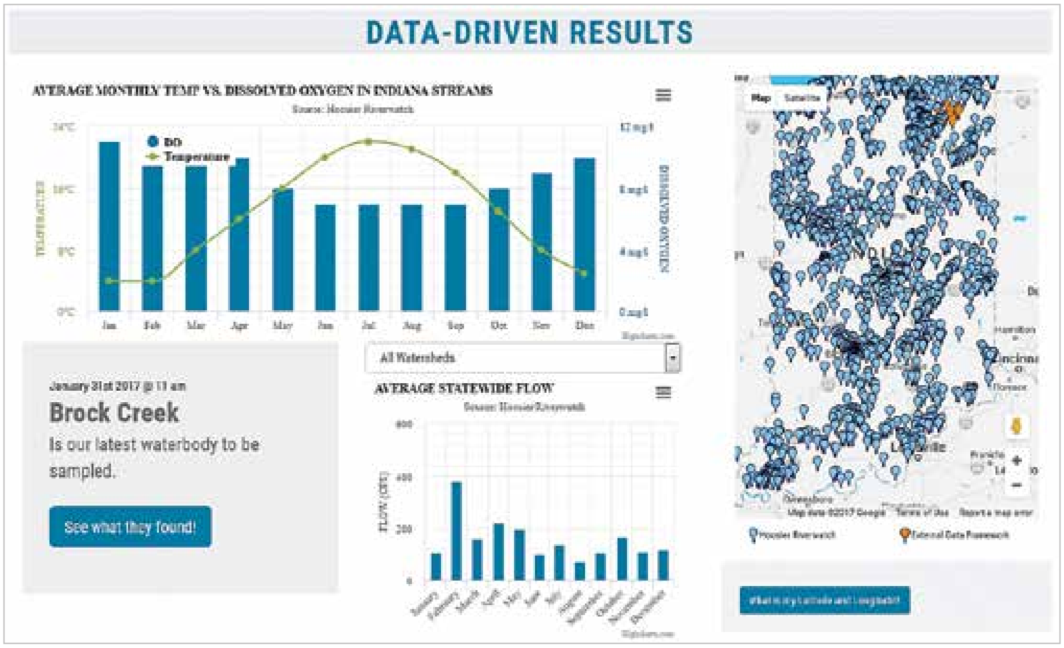
Test Your Database Skills

This database has been designed with you in mind. Hopefully you will use it often and find doing so enjoyable. Below are a few practice drills to show you how fun and easy it is to glean information from it. Perhaps they will help you think of similar questions you can ask to retrieve data useful to your own efforts. (Clues to finding the current answer are provided below each question in *italics.*)

- Where was the latest Hoosier Riverwatch sample taken from?

    While it may or may not be the latest sample 'taken', the latest sample entered into the database is shown on the lower left corner of the home page under "Data-Driven Results" (Figure 79).

Figure 79



- What is the highest flow ever recorded in the Driftwood Watershed? On what date did this occur?

    On the Search page, select Driftwood Watershed using first Search Criteria box. When results are returned (several thousand of them), use "Filter by Test" window and select Flow. When only Flow is shown on page, click arrows in the Result column header until the highest reading is at top. You can get the reading in Cubic Feet/Second and the Date from the top row of data.

- Which stream in the Patoka Watershed has the highest PTI (Pollution Tolerance Index) recorded? What Volunteer ID is associated with this sample?

    On the Search page, select Patoka Watershed using first Search Criteria box. When results are returned (a couple thousand), use "Filter by Test" window and select Pollution Tolerance Index Rating. When only the PTI scores are shown, click arrows in the Result column header until the highest reading is at top. You can get the reading in waterbody/stream name and the Volunteer ID from this top row of data.

• Is the dissolved oxygen average score for the Kankakee Watershed ranked higher or lower than the State average? How many samples were taken to get this average?

On the Visualize page, select One/Same Location Across Time as the Study Type, Watershed as the Location, and Kankakee as the Selection. Click "This is my choice" button. When parameters appear below, the arrow beside the words "Dissolved Oxygen" will indicate if the average results for the watershed are higher or lower than the state average. Selecting the Dissolved Oxygen parameter will open a bar chart below. The "N=" number on the chart will tell you how many samples are included in this average.

• Does Bartholomew County have a higher percent of pollution intolerant macroinvertebrates compared to the State average? What is the difference?

On the Visualize page, select One/Same Location Across Time as the Study Type, County as the Location, and Bartholomew as the Selection. Click "This is my choice" button. When parameters appear below, select the Invert Sampling parameter. If the pie charts do not open below, select any other parameter as a second choice and the pie charts will open along with the new selection. You only need the pie charts to answer this question. Hover your cursor over the blue "Intolerant" portion of each pie chart (Bartholomew and Indiana) and note which one has the higher percentage. Subtract the lower from the higher to find the difference between the two.

• Which month historically has the highest recorded temperatures in Lake County?

From the last screen, go back up and select Lake County as the Selection under #3. Click "This is my choice" button. When parameters appear, select Temperature. When the bar chart opens, click More Details below the chart. When the yearly average line graph opens, click "Compare toe Other Parameters or View Monthly Averages" below the graph. A monthly average temperature graph will open. Select the highest point on the graph to find the highest temperature. If more than one appears high, hover your cursor over these points to see the data behind them. Perhaps one is slightly higher or perhaps two or more months tie for the highest recorded temperature.

You can also view and sort temperature data for Lake County using the Search tool. However, even with only a hundred data points you would need to download this to your desktop so that you could manipulate and calculate monthly averages for yourself to answer this question. The Visualize tool does all this for you.

So, how did you do? Hopefully, great!

Notes:

Chapter 8 -
Data Analysis, Action & Evaluation

**Concepts in this chapter were modified from the GREEN Standard Water Monitoring Kit Manual. The process is detailed in the Earth Force-GREEN publication: Protecting Our Watersheds.*

Analyze

Analysis involves looking at data and trying to explain or understand what you've found. Often, collecting data over time reveals patterns and trends that are extremely useful in data analysis. Using graphs may help you see and understand these patterns. Tips on creating graphs in the database are provided on pages 97-98.

It is important to remember that the data you have collected are interrelated – habitat evaluation helps to explain macroinvertebrate presence, which depends upon chemical parameters, and so on. A simple but important question is: Do my results make sense? If not, what does not fit? How can this be explained? The following are also useful questions to ask during data analysis:

- Are there any noticeable patterns? (See graphing information on page 105)
- How do my results compare to the Indiana average values and typical ranges? (See Appendix D)
- What does macroinvertebrate sampling reveal that is not reflected in chemical testing? (Page 107)
- Do the results indicate sources of pollution in the watershed? (Pages 108-110)
- Do the test results seem to correlate to land use? (Page 111)
- Do the habitat (CQHEI), biological (Pollution Tolerance Index), and chemical (Water Quality Index) results make sense when analyzed as a group to describe the conditions at your stream site? (Page 112)

Take Action

Before starting a project, remember to contact Hoosier Riverwatch or your watershed specialist to see if they can provide any feedback or help. List any problems that you discovered during sampling. You may decide that you want to help resolve a problem that you have identified. First, you must define who or what is affected by the problem. For example, *E. coli* bacteria contamination impacts the stream community and is a threat to human health.

Second, determine the possible actions that you could take. You may choose to educate others by speaking to neighbors, at school, or by writing to the newspaper. You may choose to take direct action by making lifestyle changes, organizing a stream cleanup, or planting vegetation to stabilize stream banks. You may even consider taking political action by speaking at a public meeting or by writing or visiting public officials.

Third, create an action plan comprised of the actions you feel will best help solve the problem. Your plan needs to be realistic and achievable with available information, have a designated time frame, and yet still be challenging and interesting to you and your group. Work locally with people in your community.

Finally, implement your plan. Divide tasks among group members and interested participants and set timelines for each step, as well as an overall deadline. Record meetings and monitor your progress. We encourage volunteers to use their data to take action at a local level.

Evaluate the River Study

Evaluation of your river study is important, as it helps to identify successes and improve future monitoring efforts. Consider whether or not you were able to meet the goals you set prior to beginning stream monitoring. Was time a major limitation? Did you take on too many sampling sites? Did you feel comfortable using the equipment, or would another Hoosier Riverwatch training workshop be helpful? What did you learn? If you developed an action plan, was it successful?

In evaluating your stream or river study, you will likely come up with additional questions. Feel free to contact the Hoosier Riverwatch office at riverwatch@idem.IN.gov, as we want to help with the continued success of your volunteer monitoring project and the statewide volunteer stream monitoring program.

Data Analysis and Presentation Using Graphs

(Information from U.S. EPA Volunteer Stream Monitoring: A Methods Manual)

Analyzing and presenting numerical data is very difficult using tables filled with numbers. Graphs and charts are one of the best ways to summarize your findings and show the bottom line for each site (e.g., is it good or bad) and seasonal and year to year trends.

Graphs and Charts - Graphs can be used to display the summarized results of large data sets and to simplify complicated issues and findings. The three basic types of graphs that are typically used to present volunteer monitoring data are: bar graph, line graph, and pie chart. Bar and line graphs are typically used to show results (such as phosphorus concentrations) along a vertical or y-axis for a corresponding variable (such as sampling date or site) which is marked along the horizontal or x-axis. These types of graphs can also have two vertical axes, one on each side, with two sets of results shown in relation to each other and to the variable along the x-axis.

Bar Graph - A bar graph uses columns with heights that represent the value of the data point for the parameter being plotted. Figure 58 is an example using fictional data from Volunteer Creek displaying habitat data.

Line Graph - A line graph is constructed by connecting the data points with a line. It can effectively be used for depicting changes over time or space. This type of graph places more emphasis on trends and the relationship among data points and less emphasis on any particular data point. Figure 59 is an example of a line graph again using fictional data from Volunteer Creek displaying trends in phosphorus data.

Figure 58

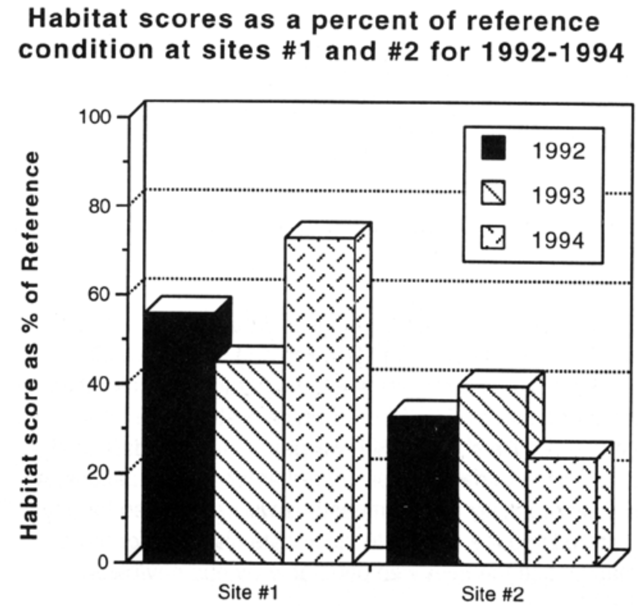
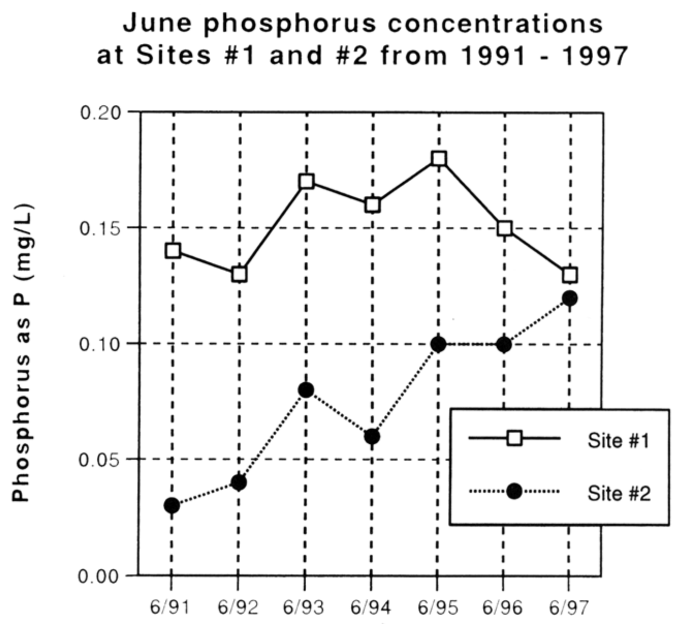


Figure 59



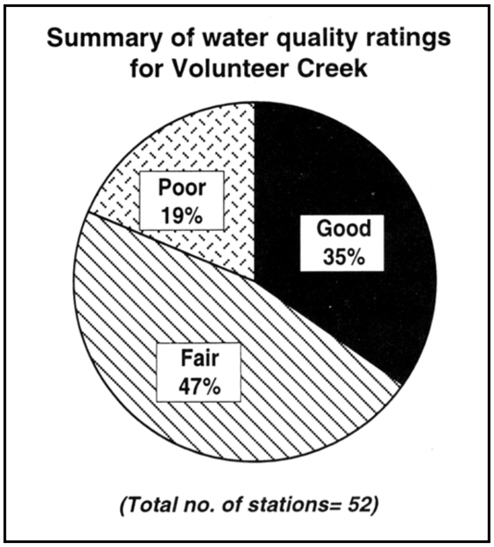


Figure 60

Pie Chart - Pie charts are used to compare categories within the data set to the whole. The proportion of each category is represented by the size of the wedge. Pie charts are popular due to their simplicity and clarity. Figure 60 (to the left) is a fictional summary of water quality ratings.

Graphing Tips

Regardless of which graphic style you choose, follow these rules to ensure you can utilize your graphics most effectively.

- Each graph should have a clear purpose. The graph should be easy to interpret and should relate directly to the content of the text of a document or the script of a presentation.

- The data points on a graph should be proportional to the actual values so as not to distort the meaning of the graph. Labeling should be clear and accurate and the data values should be easily interpreted from the scales. Label the X and Y axes. Do not overcrowd the points or values along the axes. If there is a possibility of misinterpretation, accompany the graph with a table of the data.

- Keep it simple. The more complex the graph, the greater the possibility for misinterpretation.

- Limit the number of elements. Pie charts should be limited to five or six wedges, the bars in a bar graph should fit easily, and the lines in a line graph should be limited to three or less.

- Consider the proportions of the graph and expand the elements to fill the dimensions, thereby creating a balanced effect. Often, a horizontal format is more visually appealing and makes labeling easier. Try not to use abbreviations that are not obvious to someone who is unfamiliar with the program.

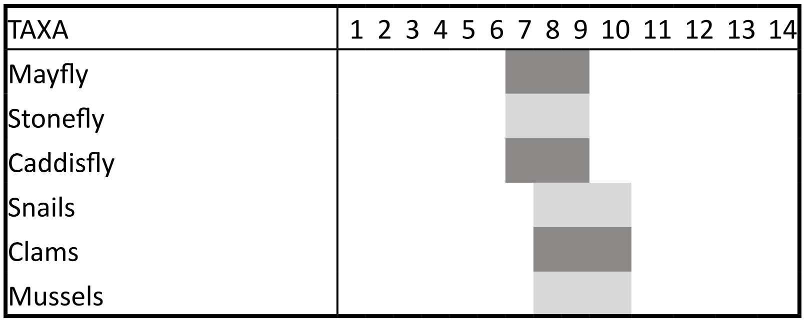
- Create titles that are simple, yet adequately describe the information portrayed in the graph.

- Use a legend if one is necessary to describe the categories within the graph. Accompanying captions may also be needed to provide an adequate description of the elements.

Habitat Parameters for Selected Macroinvertebrates*

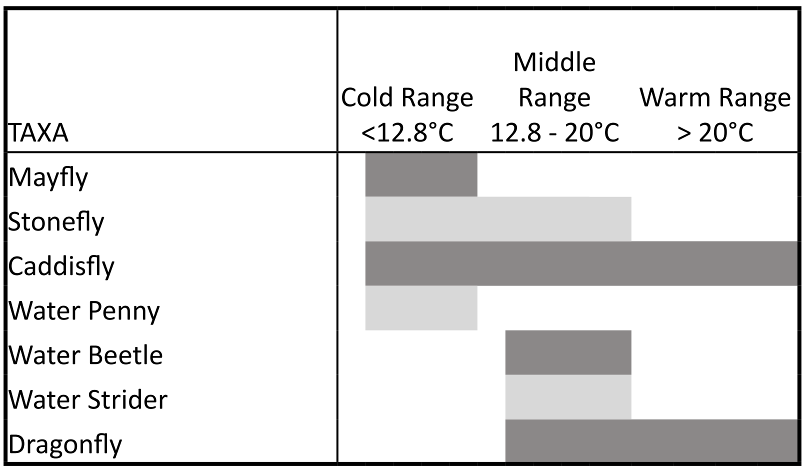
(from Globe Manual 1997)

pH Ranges for Selected Marcroinvertebrates*

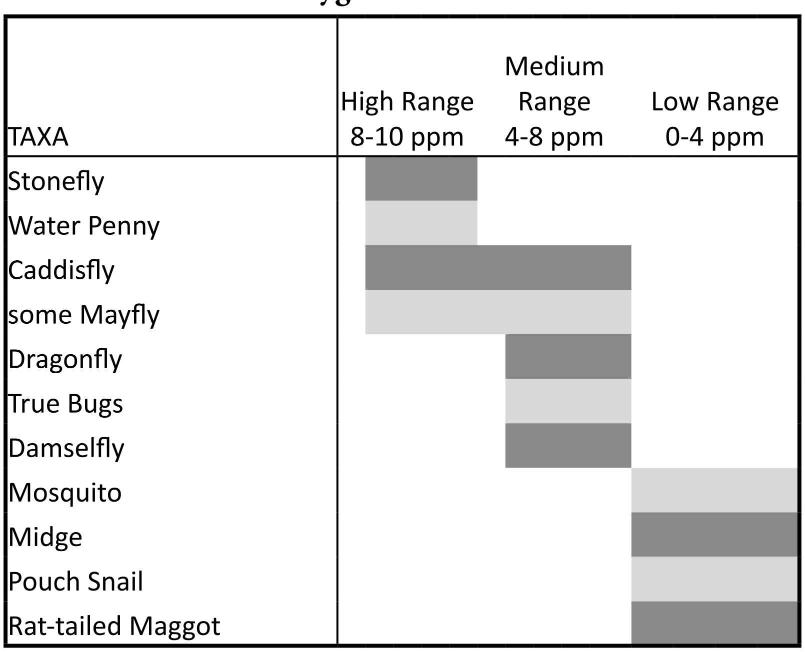


pH ranges 1-6 and 10-14 are unsuitable for most organisms

Temperature Ranges for Selected Macroinvertebrates



Minimum Dissolved Oxygen Levels for Selected Macroinvertebrates



** The values provided are preferred ranges for most species of these groups of organisms.*

LAND USE CONDITIONS

RURAL OBSERVATIONS	POSSIBLE ASSOCIATED PROBLEMS	POSSIBLE ASSOCIATED CAUSES
AGRICULTURAL Crop Production	Chemical runoff — pesticides, herbicides, insecticides	Poor farming practices causing excessive erosion of sediment and chemicals from fields
	Temperature increase in body of water adjacent to agricultural fields	Shade trees and shrubs removed from stream bank for irrigation or agricultural expansion, exposing the water to direct sunlight
	Natural flow of water impeded	Dams, dikes, and diversions for agricultural practices decrease flow rate of water, absorbing more heat from sunlight
	Reduced ability to contain suspended solids, chemicals, and excess water from runoff	Draining swamps and marshes for farmland
Manure Piles	Organic waste entering water from runoff	Improper containment of farm animal waste
Animal Grazing	Organic waste entering water from runoff	Direct discharge from farm animals with access to waterways or waste entering a body of water as runoff
RESIDENTIAL Housing	Excess water and chemical runoff, runoff from fertilized and impervious land	Urbanization leads to increasing numbers of buildings, homes, and roads on lands that previously were natural areas, runoff from driveways and lawn
	Reduction in vegetation shading body of water	Shade trees and shrubs removed from watershed for housing development, exposing the water to direct sunlight and increasing sediment and suspended solids entering a body of water from erosion
Septic Systems and Gray Water Fields	Human wastes and/or gray water leaking into groundwater	Leaking or failing septic systems
	Detergents	Household cleaning agents washing into water and sewage systems
Dumping	Trash	Litter washed into sewer systems
	Organic waste — once part of a living plant or animal (food, leaves, feces, etc.)	Pet wastes not collected and disposed of properly
		Grass, tree, and shrub clippings washed into sewer systems
SCHOOL	Runoff from fertilized and impervious land	Impervious land cover such as sidewalks, play grounds and parking lots causes excessive runoff
	Trash	Litter washed into adjacent waterways or sewer systems
COMMERCIAL/INDUSTRIAL	Reduction in vegetation shading body of water	Shade trees and shrubs removed from watershed for commercial/industrial development, exposing the water to direct sunlight and increasing sediment and suspended solids entering a body of water
	Organic waste	Wastewater treatment plants
		Discharge from food-processing plants, meat-packing houses, dairies, and other industrial sources
		Organic waste from fibers originating from textile and plant processing plants
	Runoff from fertilized or impervious land	Impervious land cover such as parking lots and sidewalks causes excessive runoff
	Industry and power plant discharge	Industrial cooling process; water returned to source body of water is at higher temperature than at initial intake point
		Industrial or mining drainage
CONSTRUCTION Buildings and Roadways	Sediment and suspended solids	Construction of new buildings, homes, and streets causes excessive erosion
		Paved roads cannot absorb chemicals, soil, and suspended particles in runoff
		Draining swamps and marshes for commercial or residential development reduces water catchment ability and filtering of silt and suspended solids
		Dredging waterways
	Temperature increase	Dams, dikes, and diversions for drinking water intake decreases flow rate of water, absorbing more heat from sunlight
PUBLIC USE Zoo	Organic waste	Direct discharge from mammals and birds as waste entering a body of water as runoff
Parks and Golf Courses	Runoff from fertilized and impervious land	Chemical runoff from golf courses and recreational parks entering a body of water as runoff
		Impervious land cover such as parking lots causes excessive runoff
Airports, Bus Stations, Train Stations	Runoff from impervious land	Impervious land cover such as parking lots causes excessive runoff
Marina or Shipping Port	Petroleum products	Chemical pollutants from point or nonpoint source pollution

MAKING WATER QUALITY CONNECTIONS

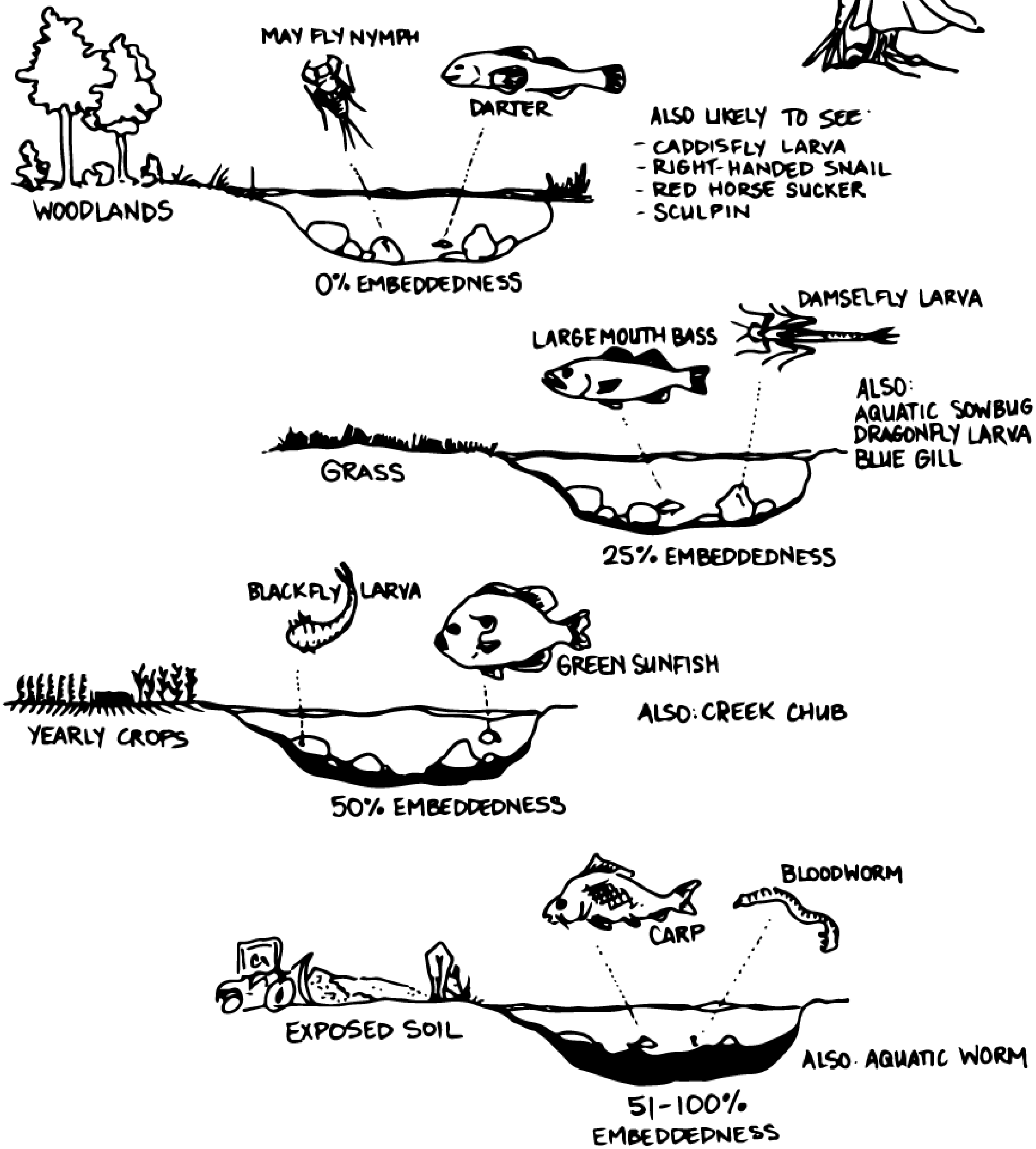
WATER QUALITY CONDITIONS

WATER QUALITY CONDITIONS OBSERVED	POSSIBLE ASSOCIATED PROBLEMS	POSSIBLE ASSOCIATED CAUSES
DECREASE IN DISSOLVED OXYGEN	Temperature increase	Reduction in vegetation shading body of water; increase in sediment or suspended solids; industrial cooling processes
	Organic waste — once part of a living plant or animal (food, leaves, feces, etc.)	Leaking or failing septic systems; waste from farms and animals (pets and feedlots); discharge from food-processing plants, meat-packing houses, dairies, and other industrial sources; garbage; industrial waste (organic fibers from textile, paper, and plant processing); sewage treatment plants, natural processes; grass, tree, and shrub clippings; urban runoff; agricultural runoff
	Chemical runoff — herbicides, pesticides, insecticides	Golf courses; residential lawns; agricultural lands; recreational parks
	Trash	Litter washed into sewer systems
	Lack of algae and rooted aquatic plants	Multiple sources of water pollution (e.g., chemicals, toxins)
	Low water levels	Climatic or weather change
FECAL COLIFORM BACTERIA *E. COLI* ENTEROCOCCI	Organic waste — feces from human beings or other warm-blooded animals	Leaking or failing septic systems; failing sewer systems
		Direct discharge from mammals and birds with access to waterways or waste entering a body of water as runoff
INCREASE IN TEMPERATURE (THERMAL POLLUTION)	Organic waste — once part of a living plant or animal (food, leaves, feces, etc.)	Natural processes; grass clippings; tree and shrub clippings; unnatural fish or animal kills
	Reduction in vegetation shading body of water	Shade trees and shrubs removed from stream bank for urban development, irrigation, and industrial and agricultural expansion, exposing the water to direct sunlight
	Industry and power plant discharge	Water returned to source is at higher temperature than at initial intake point
	Runoff from warmed urban surfaces	Impervious land cover such as paved streets, sidewalks, and parking lots
		Urbanization leading to increased numbers of buildings, homes, and roads on lands, that previously were natural areas and absorbed rain and snowmelt more efficiently
	Suspended solids	Removal of streamside vegetation; overgrazing; poor farming practices and construction causing excessive soil erosion
	Flow of water impeded	Dams, dikes, and diversions for agricultural, industrial, or municipal practices decrease flow rate of river, absorbing more heat from sunlight
		Dams created from beavers or log jams
TURBIDITY HIGH TOTAL DISSOLVED SOLIDS/ TOTAL SOLIDS	Suspended solids (ranging from clay, silt, and plankton, to industrial wastes and sewage)	Erosion from agricultural fields; construction sites; residential driveways, roads, and lawns; natural and accelerated erosion of stream bank; excessive algae growth
		Leaves and plant materials
		Wastewater treatment plant
		Runoff from urban areas
		Dredging waterways
		Waste discharge (garbage, sewage)
		Excessive population of bottom-feeding fish (such as carp) that stir up bottom sediments
EXCESSIVE PHOSPHATES	Human wastes	Leaking or failing septic systems; sewage treatment plants
	Organic waste — once part of a living plant or animal (food, leaves, feces, etc.)	Waste containers leaking; lack of waste storage facilities; animals have direct access to waterways
		Pet wastes not collected and disposed of appropriately
		Removal of natural vegetation for farming or construction practices, causing soil erosion
		Draining swamps and marshes for farmland or commercial/residential development
		Drained wetlands no longer functioning as filters of silt and phosphorous
	Runoff from fertilized land	Agricultural fields; residential lawns; home gardens; golf courses; recreational parks
	Industrial waste	Poorly treated sewage; broken pipes; farms; golf courses; sewage treatment facilities; industrial discharges
	Detergents	Household and commercial cleaning agents washing into water and sewage systems
	Natural events	Forest fires and fallout from volcanic eruptions
EXCESSIVE NITRATE	Runoff from fertilized land	Agricultural fields; residential lawns; golf courses; recreational parks
	Human wastes	Leaking or failing septic systems; sewage treatment facilities
	Animal wastes	Waste containers leaking; lack of waste storage facilities; animals (particularly ducks and geese) that have direct access to waterways
		Pet wastes not collected and disposed of appropriately
	Organic waste — once part of a living plant or animal (food, leaves, feces, etc.)	Natural processes; grass clippings; tree and shrub clippings; unnatural fish or animal kills
PH	Vehicles for transportation	Improper engine maintenance of vehicles (emissions systems)
	Industrial waste	Industrial or mining drainage; sewage treatment plants
	Runoff from fertilized land	Agricultural fields; residential lawns; golf courses; recreational parks
PH & ALKALINITY	Acid rain (beginning in neighboring regions)	Excessive air pollution from burning fossil fuels for automobiles, boats, planes, etc.
SALINITY	Salt and oil runoff	Paved roads cannot absorb substances, such as salts used on roads in winter; irrigation water picks up salts in soil
	Bodies of salt water mixing with fresh water	Water tables decrease in areas where water is being pumped (used) at levels exceeding replenishment capability
HIGH CONDUCTIVITY	Discharges into the water	Failing sewage systems
		High temperature
		Water used for irrigation
		Discharge of heavy metals into the water
LOW CONDUCTIVITY	Discharges into the water	Oil spill
		Low temperature

PHYSICAL CONDITIONS

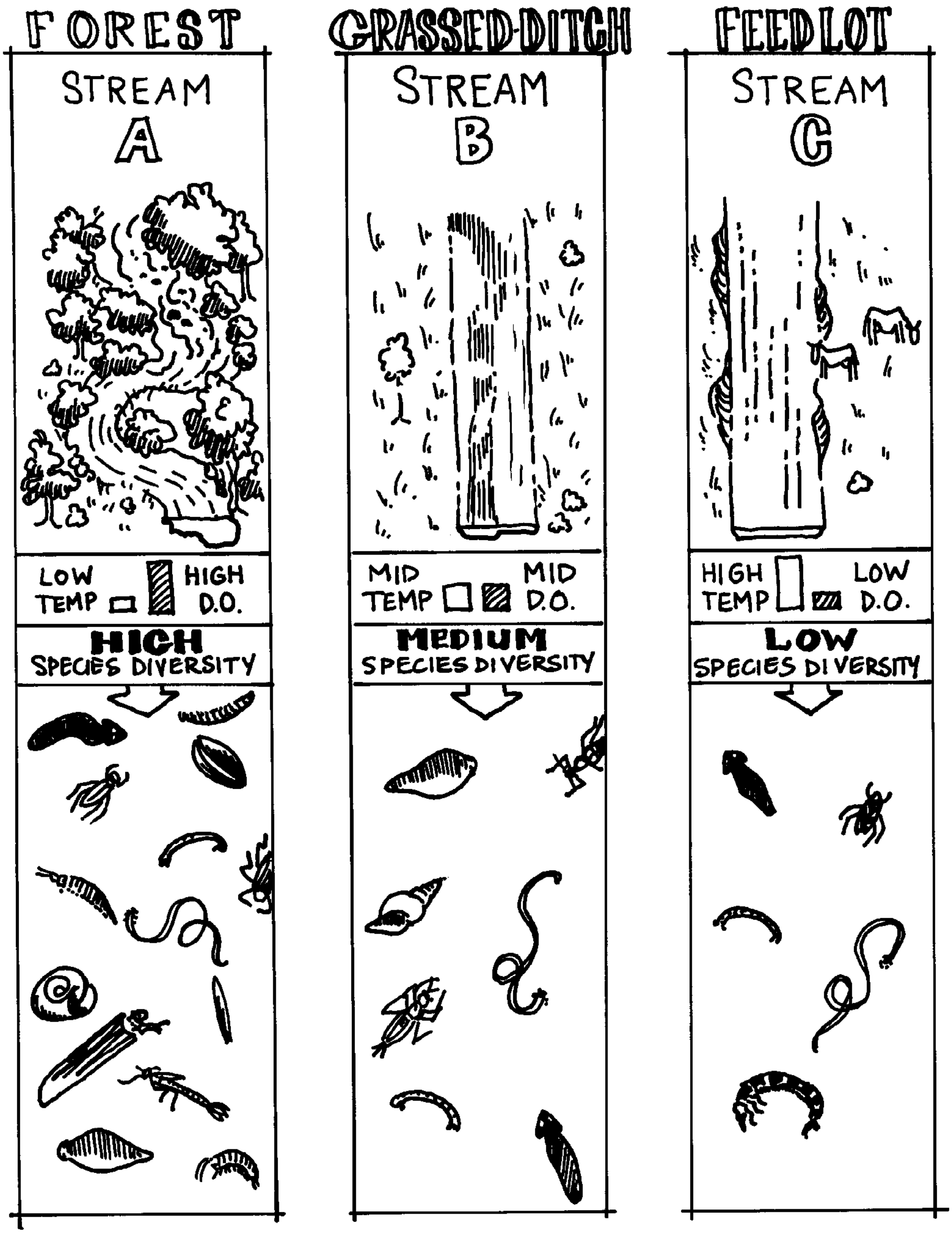
PHYSICAL CONDITIONS OBSERVED	POSSIBLE ASSOCIATED PROBLEMS	POSSIBLE ASSOCIATED CAUSES
WATER APPEARANCE		
Green, Green-Blue, Brown or Red	Indicates the growth of algae	High levels of nutrient pollution, originating from organic wastes, fertilizers, or untreated sewage
Muddy, Cloudy	Indicates elevated levels of suspended sediments, giving the water a muddy or cloudy appearance	Erosion is the most common source of high levels of suspended solids in water Land uses that cause soil erosion include mining, farming, construction, and unpaved roads
Dark Reds, Purple, Blues, Blacks	May indicate organic dye pollution	Originating from clothing manufacturers or textile mills
Orange-Red	May indicate the presence of copper	Copper can be both a pollutant and naturally occurring Unnatural occurrences can result by acid mine drainage or oil-well runoff
Blue	May indicate the presence of copper, which can cause skin irritations and death of fish	Copper is sometimes used as a pesticide, in which case an acrid (sharp) odor might also be present
Foam	May indicate presence of soap or detergent	Excessive foam is usually the result of soap and detergent pollution Moderate levels of foam can also result from decaying algae, which indicates nutrient pollution
Multi-Colored (oily sheen)	Indicates the presence of oil or gasoline floating on the surface of the water. Oil and gasoline can cause poisoning, internal burning of the gastrointestinal tract and stomach ulcers	Oil and gasoline pollution can be caused by oil drilling and mining practices, leaks in fuel lines and underground storage tanks, automotive junk yards, nearby service stations, wastes from ships, or runoff from impervious roads and parking lot surfaces
No Unusual Color	Not necessarily an indicator of clean water	Many pesticides, herbicides, chemicals, and other pollutants are colorless or produce no visible signs of contamination
ODORS		
Sulfur (rotten eggs)	May indicate the presence of organic pollution	Possible domestic or industrial wastes
Musty	May indicate presence of organic pollution	Possible sewage discharge, livestock waste, decaying algae, or decomposition of other organic pollution
Harsh	May indicate presence of chemicals	Possible industrial or pesticide pollution
Chlorine	May indicate the presence of over-chlorinated effluent	Sewage treatment plant or a chemical industry
No Unusual Smell	Not necessarily an indicator of clean water	Many pesticides and herbicides from agricultural and forestry runoff are colorless and odorless, as are many chemicals discharged by industry
EROSION	Sediment and suspended solids	Land uses that cause soil erosion include mining, farming, construction, unpaved roads, and deforestation
DUMPING	Decomposition of organic material or humanmade products, presence of chemical or metal pollutants in water, presence of oil or gasoline in water	Construction, urbanization
DISCHARGE PIPES	Organic wastes, detergents, chemical/industrial runoff, sewage, temperature increase in body of water	Improper industrial waste treatment, improper sewage or gray water treatment

THE RELATIONSHIP BETWEEN LAND USE & LIKELY AQUATIC LIFE



REPRESENTATIVE STREAMS

HABITAT & SPECIES DIVERSITY



Appendix A - Equipment

How to Clean and Care for Equipment

Nets

To ensure that no contamination occurs between sampling sites, make sure that all nets and organism collection equipment have been cleaned of all organisms and matter. Be sure to rinse them thoroughly with hot water before transporting to another location.

Transparency Tube

(From Minnesota Citizen Stream Monitoring Program, "Stream Reader" Spring 2000)

If you monitor a stream that is on the murky side, chances are the walls of your transparency tube have clouded up. Try cleaning the inside of your tube by filling it three-quarters full with tap water, add a couple drops of dish soap, and push a clean, soft rag or washcloth down the tube with the end of a broom handle, scrubbing the sides. If you take the stopper out of the bottom, be sure to fit it back into the tube securely. If your tube has a release tube and valve, it may become crimped. Try moving the position of the clamp on your release valve from time to time, and fully release the clamp between uses. By doing this, the tube won't break down and get crimped in any one spot.

***E. coli* Testing Supplies**

Store bottles of Coliscan Easygel in the freezer for up to one year. Thawed bottles can be refrozen. Do not freeze pre-treated petri dishes.

Store sealed Petrifilm plates in a refrigerator.

Chemical Testing Kits

Do not store kits in your car or anywhere they would experience extreme hot or cold temperatures. Bright light degrades the reagents in the CHEMetrics ampoules and color standards - do not leave them open in sunlight or indoors. Be sure to ***triple*** rinse bottles & tubes with distilled water immediately following tests to avoid staining and contamination, and always triple rinse with sample water before taking a stream sample.

Be sure your chemicals, test strips, and color standards are not expired! CHEMetrics color standards are good for 2 years, Water Works pH test strips are good for 2 years, and the Nitrate/Nitrite test strips expire after 20 months.

Equipment for Water Quality Monitoring

The following supplies may be useful in monitoring the water quality of your local river or stream:

Site Assessment

- ☐ Maps (e.g., 7.5” topographic map, assessor’s map indicating property boundaries) and aerial photos
- ☐ Compass and survey tape for marking boundaries
- ☐ Clipboard, writing utensils, and laminated copies of chemical, biological, and habitat data sheets
- ☐ Tape measure or twine marked in one-meter/foot lengths
- ☐ Stopwatch for measuring stream flow
- ☐ Apple, orange, or other biodegradable object that can be floated to measure stream flow
- ☐ Yardstick or other device to measure depth

Biological Assessment

- ☐ Kick seine net, D-net, hand rake, shovel, or other tools for collecting benthic macroinvertebrates
- ☐ Sieve and trays for sorting biological samples (white ice cube trays work well for sorting organisms)
- ☐ Tweezers, hand lens, magnifying glass, and possibly a microscope
- ☐ Glass vials or jars filled with isopropyl alcohol or white vinegar for storing insects (if so desired)
- ☐ Handmade Hester-Dendy substrate sampler or GREEN Leaf-pack bags to use in waterways too deep to enter on foot.

Chemical Assessment

- ☐ Chemical water quality testing equipment will vary with the type of monitoring you wish to pursue. Some of the tests most commonly performed include dissolved oxygen, *E. coli,* pH, BOD_5, water temperature change, total or ortho-phosphates, nitrates, turbidity, and total solids. Equipment for each test will vary in range, sensitivity, and cost depending on the use of chemical or electronic materials
- ☐ Handmade extension sampling rod (see page 117)
- ☐ Distilled water for rinsing sampling bottles and tubes
- ☐ Secchi disk or handmade turbidity tube
- ☐ Container with kitty litter for liquid waste (if using hazardous chemicals, need separate waste container)
- ☐ Safety Data sheets for every chemical being used

Safety

- ☐ Throw bag, life preserver or rope
- ☐ Rubber boots, hip boots or waders (***WARNING:*** Never put children in chest-high waders because they can fill with dangerous amounts of water if submerged.)
- ☐ Rubber gloves and protective eyewear
- ☐ First Aid kit that includes eyewash
- ☐ Washing water, antibacterial soap, and a towel
- ☐ Insect repellent
- ☐ Life vest

Other Supplies

- ☐ Drinking water
- ☐ Camera for documenting site
- ☐ Trash bags or other waste containers for a stream bank clean-up
- ☐ Folding card table
- ☐ Calculator
- ☐ Computer and Internet access for entry of water quality data

How to Make Your Own Equipment

Not all of your water monitoring equipment has to be purchased through a catalog or at a store. Nets and other sampling supplies can be made at home.

Kick Seine Net #1

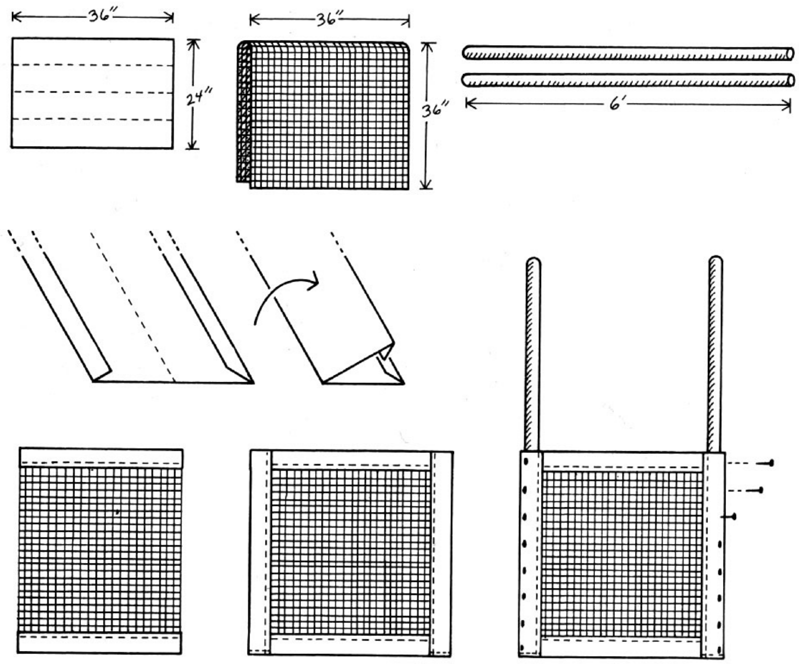
Materials:

☐ 3 foot by 6 foot piece of nylon or fiberglass screening (white, if you can find it)
☐ 4 strips of heavy canvas (6 inches by 36 inches)
☐ 2 broom handles or wooden dowels (6 feet long)
☐ finishing nails
☐ sewing machine and thread
☐ hammer
☐ iron and ironing board

Directions:

1. Fold screening in half (3 foot by 3 foot).
2. Fold edges of canvas strips under 1/2 inch and press with iron.
3. Sew 2 strips at top and bottom of screening, then use remaining 2 strips on the sides of the screening to make casings for handles. Sew bottom of casings shut.
4. Insert handles into casings and nail into place with finishing nails.

Kick Seine Net #1



Kick Seine Net #2

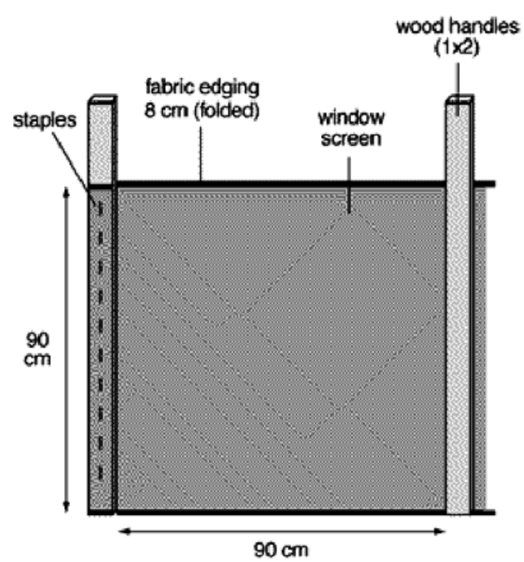
Materials:

☐ 3 foot by 4 foot piece of nylon or fiberglass screening (white, if you can find it)
☐ 2 strips of heavy canvas (6 inches by 36 inches)
☐ 2 broom handles or wooden dowels (6 feet long)
☐ Staple gun and staples
☐ sewing machine and thread

Directions:

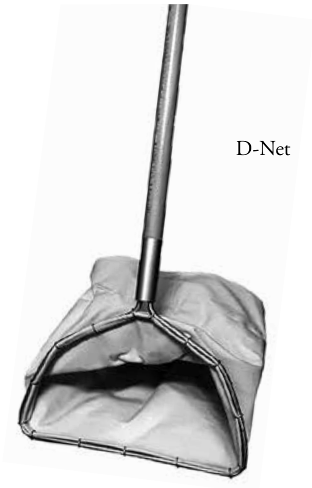
1. Fold one strip of fabric over one of the long screen edges and sew, reinforcing the edge.
2. Repeat for the other long edge.
3. Attach screen to poles with staples, making the poles even with the bottom of the screen and extending to form handles at the top.
4. Wrap screen around poles several times and staple again to reinforce the edges.

Kick Seine Net #2



D-Net

Materials:
- ☐ 2 pieces of 12 inch by 18 inch nylon or fiberglass screening (white, if you can find it)
- ☐ Strip of heavy canvas or fabric
- ☐ Broom handle or wooden dowel (48+ inches long)
- ☐ Duct tape, pipe clamp, 2 wire clothes hangers
- ☐ Sewing machine w/thread
- ☐ Drill and wire cutters



D-Net

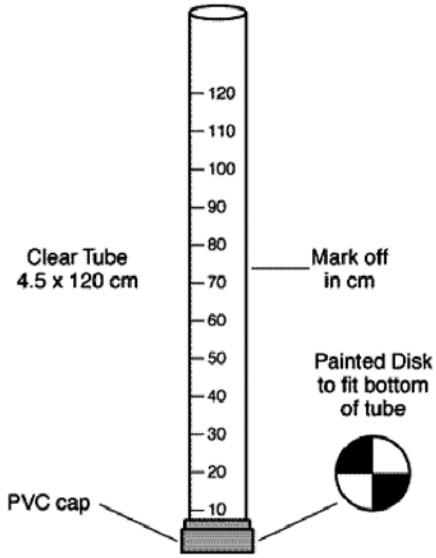
Directions:
1. Cut a net shape from the 36 x 53 cm pieces of nylon screen and sew them together leaving an opening.
2. Edge the open end of the net with heavy fabric, leaving an opening to form a casing to insert the hangers.
3. Cut hooks from hangers and untwist the wires.
4. Use duct tape to tape the hangers together to make your frame heavier.
5. Insert wire through the casing and twist ends back together at opening.
6. Drill a hole in the tip of the wooden handle large enough to insert the ends of the hangers into the hole in the pole. Secure the net to the pole by using the hook you cut from the hanger and using the pipe clamp or duct tape to secure the hook to the pole.

Turbidity Tube

For instructions on how to correctly use the turbidity tube see Chapter 4 on Chemical Monitoring.

Materials:
- ☐ Clear tube 4.5 cm diameter x 120+ cm length
- ☐ Tight fitting PVC end cap for tube/rubber stopper
- ☐ 4.5 cm diameter wooden or plastic disk
- ☐ Paint, permanent marker
- ☐ Glue
- ☐ Measuring stick/meter stick

Turbidity Tube



Directions:
1. Put a PVC cap over one end of a clear tube (a fluorescent light bulb tube cover works great). Cap should fit tightly so water cannot leak out. A rubber stopper also works.
2. Cut a disk from wood or plastic the same size as the tube diameter.
3. Divide the disk into four quadrants. Paint the alternating quadrants black and white. Seal the disk by laminating or painting with varnish to make it waterproof.
4. Glue the disk in the bottom of the tube, painted side facing up toward the open end of the tube.
5. Use a marker and meter stick to make a scale on the side of the tube, beginning at the disk with 0 cm or mark on a piece of tape and stick it to the outside of the tube.

Underwater Viewer

The underwater viewer can be used in shallow and slow moving streams to view under the surface.

Materials:

- Large metal coffee can with both ends cut out
- Plastic food wrap
- Lg rubber bands

Directions:

1. Stretch the plastic food wrap tightly over one end so that it is tight and smooth.
2. Secure the wrap with a rubber band, tape the rubber band to hold it securely in place.

Hester-Dendy Artificial Substrate Sampler

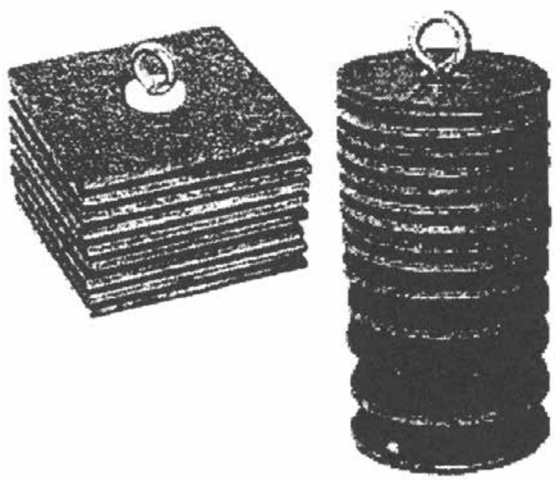
Materials:

- Nine 3x3 inch Masonite plates (hardest and most water resistant grade)
- Nylon spacers
- Stainless steel eye-bolt, extra long with nut

Directions:

1. Drill a hole in the middle of each masonite plate, so that the eye bolt will slide through each plate.
2. Place a nylon spacer between masonite plates.
3. Insert the eye bolt through the plates and the spacers (see picture to right). The width between each masonite plates can be varied by adding more spacers.

Substrate Sampler



Extension Sampler

(The following instructions were provided by John Rouch, Past-President of Water Watchers of Indiana.)

An extension sampler may be helpful for collecting stream water at monitoring locations where the water cannot be entered into directly (e.g., too deep, too fast , or too polluted).

Materials:

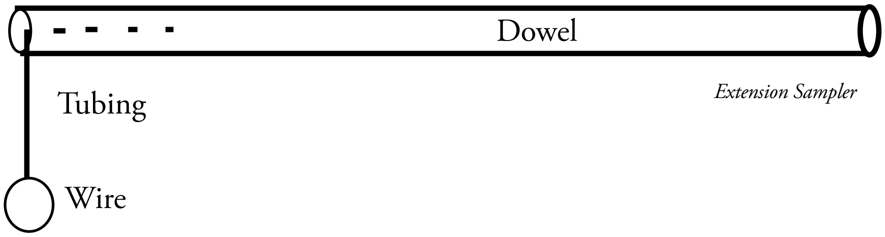
- 4-6 foot dowel rod, 1/2 inch or more in diameter
- Rubber inner tube, cut into 12 inch by 3 inch strips
- 6-inch length of picture framing wire (or other flexible wire)
- 6 small nails

Directions:

1. Nail the rubber tubing to the end of the dowel.
2. Hook the wire onto the end of the tube so that the wire forms a circle (see diagram below).
3. Nail the remaining four nails along the dowel so that the rubber tubing can secure different sizes of bottles for water collection.

For use:

Secure the sampling container against the dowel rod by wrapping the tube around the container and hooking the wire loop around one of the nails.



Extension Sampler

Where to Purchase Equipment

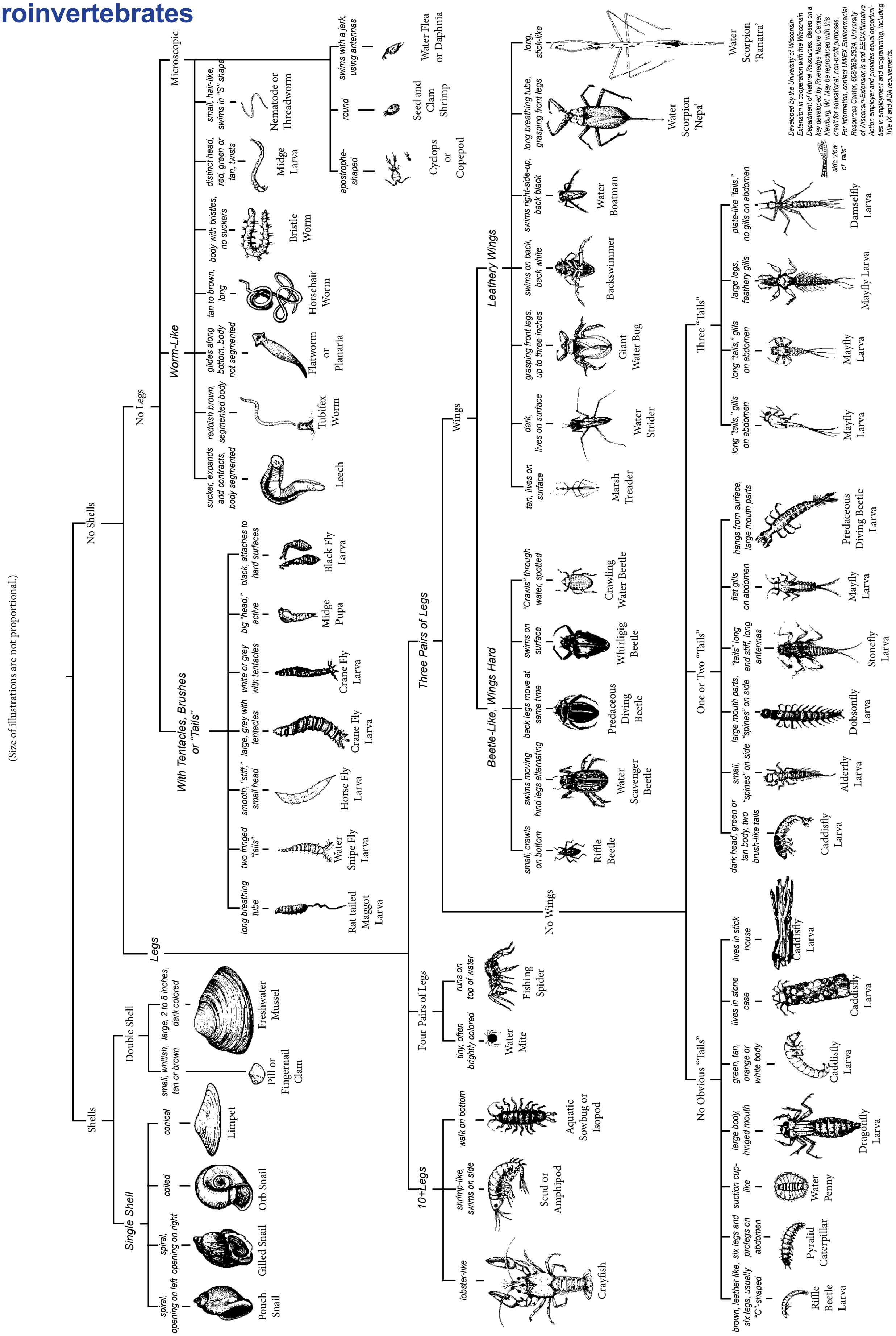
Product	Vendor	Website	Item Number	Price
Chemical Monitoring Supplies				
Dissolved Oxygen Test Kit	CHEMetrics	chemetrics.com	K-7512	$63.60
Dissolved Oxygen Ampoules	CHEMetrics	chemetrics.com	R-7512	$31.80
Dissolved Oxygen Comparator	CHEMetrics	chemetrics.com	C-7512	$22.70
OrthoPhosphate Test Kit	CHEMetrics	chemetrics.com	K-8510	$74.30
OrthoPhosphate Ampoules	CHEMetrics	chemetrics.com	R-8510	$30.20
OrthoPhosphate Color Comparator	CHEMetrics	chemetrics.com	C-8501 (0-1)	$15.70
			C-8510 (1-12)	$22.70
WaterWorks Nitrate strips (bottle of 50)	Industrial Test Systems	sensafe.com	480009	$19.99
WaterWorks pH strips (bottle of 50)	Industrial Test Systems	sensafe.com	481104	$10.49
BOD Bottle with stopper	Forestry Suppliers	forestry-suppliers.com	53868	$22.70
Thermometer	Forestry Suppliers	forestry-suppliers.com	89108	$13.95
Transparency Tube (60cm)	Forestry Suppliers	forestry-suppliers.com	77107 (60 cm)	$36.95
Biological Monitoring Supplies				
Dish pan for bug sorting	Retail store	-	-	$3.00
Set of large & small bug magnifiers	Forestry Suppliers	forestry-suppliers.com	53744 (small)	$2.95
			53745 (large)	$5.25
Elenco 2-way bug viewer	Amazon	amazon.com	-	$9.99
Yellow kick net (no poles)	Forestry Suppliers	forestry-suppliers.com	78012	$46.50
Aquatic D-nets (500 micron mesh)	Forestry Suppliers	forestry-suppliers.com	53755	$100.50
Golden Guide ***Pond Life*** book	Amazon	amazon.com	ISBN 1582381305	$6.95
Insect Identification Cards	Foresty Suppliers	forestry-suppliers.com	76609	$62.50
Life Cycle and Habitat Flash Cards	Foresty Suppliers	forestry-suppliers.com	76619	$71.75
E. coli Supplies				
Coliscan EasyGel/Petri Dishes (10 tests)	Micrology Labs	micrologylabs.com	25001	$35.15
Sterile Pipettes 1 mL (500)	Thomas Scientific	thomassci.com	1216H32	$133.01
Sterile Pipettes 3 mL (500)	Thomas Scientific	thomassci.com	1216H38	$134.15
3M™ Petrifilm™ E. coli/Coliform Count Plates (25 tests)	Carolina Biological	carolina.com	6404	$86.95
Thermal Air Hova-Bator	G.Q.F. Manufacturing	gqfmfg.com	1602N	$54.00
Other Resources				
Stream Survey Kit	Hach Company	hach.com	27120-00	$620.48
500mL wash bottle	Hach Company	hach.com	620-11	$11.14
Nitrate Standard, 1 mg/L (500 mL)	Hach Company	hach.com	2046-49	$35.49
Phosphate Standard, 1 mg/L (500 mL)	Hach Company	hach.com	2569-49	$36.39
A Guide to Common Freshwater Invertebrates of North America (Voshell)	Barnes & Noble	barnesandnoble.com	ISBN 939923874	$39.95
Aquatic Entomology (McCafferty)	Barnes & Noble	barnesandnoble.com	ISBN 867200170	$221.16
Field Guide for Water Quality Monitoring (Stapp and Mitchell)	Amazon	amazon.com	ISBN 757555462	$70.62
Volunteer Stream Monitoring: A Methods Manual	US EPA	epa.gov	EPA 841-B-97-003	Free Download

This list contains just a few of the many science equipment vendors available. It is not intended to be an endorsement of any product or company. Prices are as of April 2022 and subject to change.

Notes:

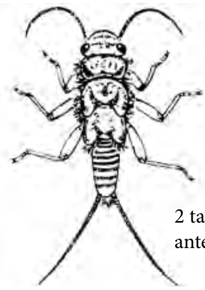
Key to Macroinvertebrate Life in the River

(Size of illustrations are not proportional.)



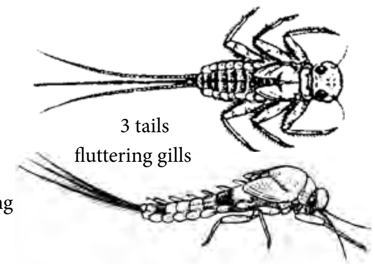
Macroinvertebrates Identification Key

GROUP 1 – Very Intolerant of Pollution



2 tails long antennae

Stonefly Nymph



3 tails

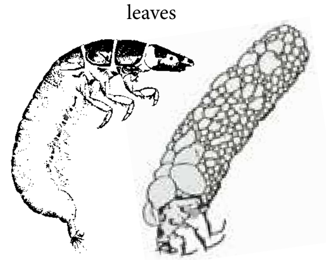
fluttering gills

Mayfly Nymph

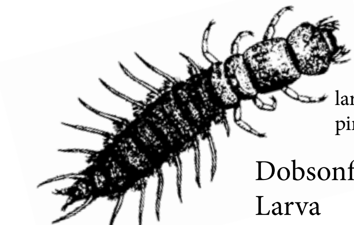
very small & hard shell

Riffle Beetle Adult & Larva

makes a case from twigs, rocks, leaves



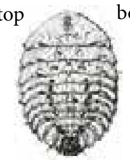
Caddisfly Larva



large head & 2 pinchers

Dobsonfly Larva

top



bottom

looks like a suction cup

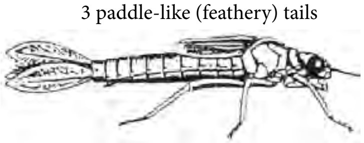
Water Penny Larva

Right-Handed Snail

must be alive to count

GROUP 2 – Moderately Intolerant of Pollution

3 paddle-like (feathery) tails



Damselfly Nymph

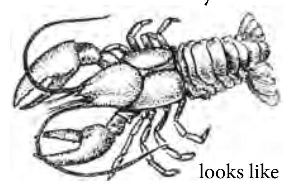
Dragonfly Nymph

no tails large eyes

flattened side-ways & swims on side

Scud

Crayfish

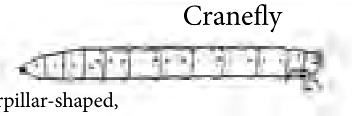


looks like a mini-lobster

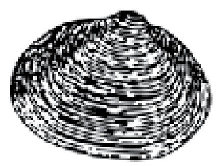
Sowbug

flattened top to bottom (looks like a pill bug)

Cranefly



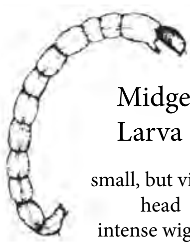
caterpillar-shaped, ringed



must be alive to count

Clam/Mussel

GROUP 3 – Fairly Tolerant of Pollution



Midge Larva

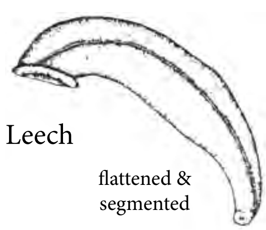
small, but visible head intense wiggler

Planaria

2 eye spots & very small

one end is swollen

Black Fly Larva

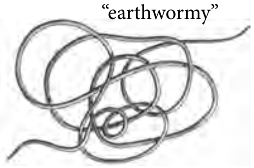


Leech

flattened & segmented

GROUP 4 – Very Tolerant of Pollution

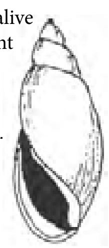
segmented "earthwormy"



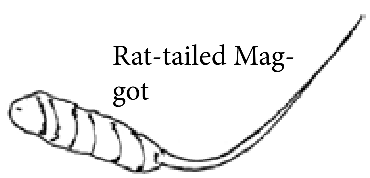
Aquatic Worms

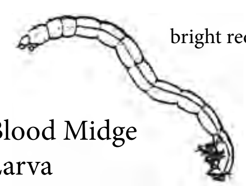
must be alive to count

Left-Handed Snail



Rat-tailed Maggot





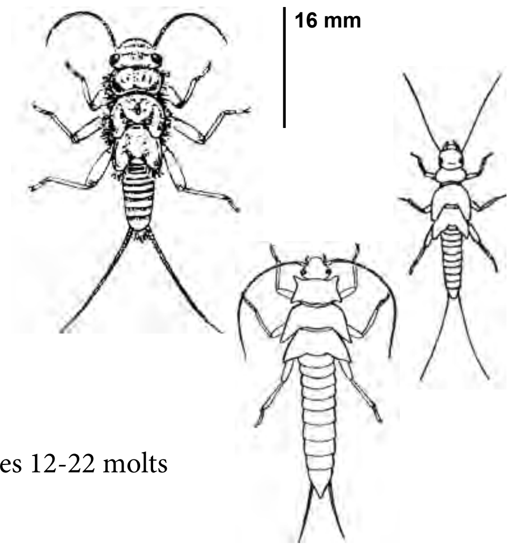
bright red

Blood Midge Larva

Group 1 - Intolerant to Pollution

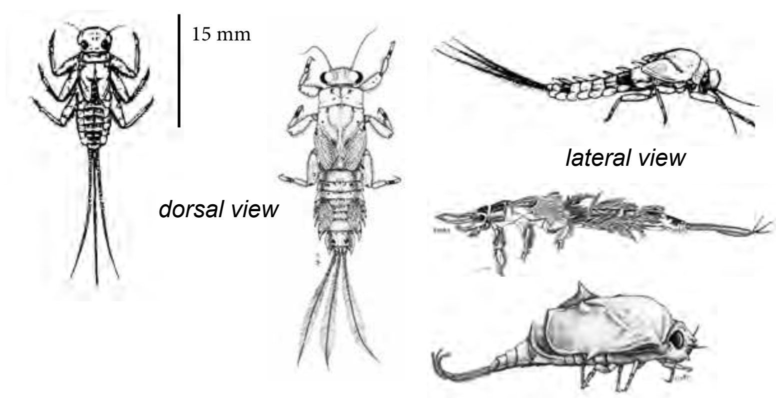
(Average Actual Size)

Stonefly nymph



Order	Plecoptera
Where to find	Underside of rocks, in debris, in algal mats
Body shape	Elongated, resembles adult
Size	5 - 35 mm
Feeding Group	Predator or shredder
Lifecycle	Incomplete metamorphosis Larval development: 3 months to 3 years, involves 12-22 molts
Distinguishing Characteristics	Abdomen ends in two hair-like tails No gills visible on abdomen 2 tarsal claws Antennae long (longer than head) Only found crawling on surfaces, <u>not</u> swimming **Distinguished from mayfly by two tails and lack of feathery gills*

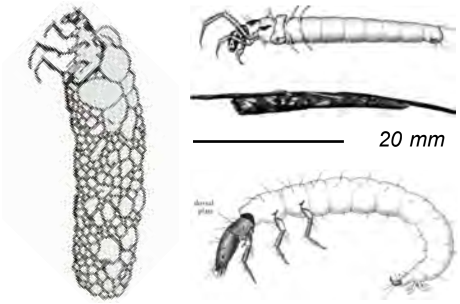
Mayfly nymph



Order	Ephemeroptera
Where to find	Underside of rocks and logs, some species free-swimming
Body shape	Elongated and flattened, resemble adults
Size	3 - 30 mm
Feeding Group	Gathering collector
Lifecycle	Incomplete metamorphosis, with additional sub-adult stage unique to mayflies Larval development lasts 3 months to 3 years Adults often form large mating swarms over water following emergence
Distinguishing Characteristics	Abdomen usually ends in three filamentous, hair-like tails (some species have two) Tails may appear webbed Tails are fragile and may break off during collection, examine carefully Feathery gills line sides of abdomen Often swim in collection bin – rather than crawling **Distinguished from stoneflies by presence of three tails and feathery gills*

(Average Actual Size)

Caddisfly larva



Order Trichoptera

Where to find Underside of rocks, on plant materials

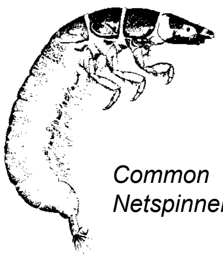
Body shape Usually cylindrical and "C"-shaped, 6 legs near head

Size 2 - 40 mm

Feeding Group Shredder

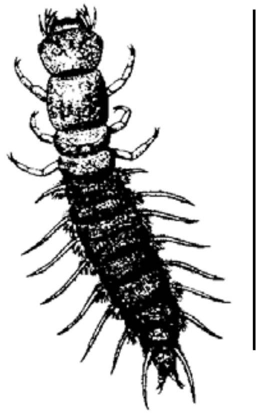
Lifecycle Complete metamorphosis, which occurs while sealed in "cases" or "houses"

Distinguishing Characteristics Often found in "houses" made of pebbles, wood, sticks, leaves, sand, or shells
Cases constructed using glue-like secretion from end of abdomen; leave holes in ends of "houses" to serve as breathing tubes prior to metamorphosis.
Abdomen ends in 2 prolegs, each with a claw. May have darker, harder plates on top of thorax. Move with characteristic wiggling – back and forth then up and down through the water.


Common Netspinner

Special Family of Interest – Hydropsychidae or "Common Netspinner Caddisfly" – do not build cases; they build fine mesh nets to filter food from the water current – are slightly more tolerant to pollution, especially organic wastes or nutrients, which they utilize for food have hair-like gills all along their abdomen, and are often green in color – important to distinguish family for use in multi-metric biotic index on pages 97,98.

Dobsonfly larva (Hellgrammite)



Order Megaloptera

Family Corydalidae

Where to find Soft substrate; soft, rotting logs and stumps; between rocks

Body shape Large, long and slightly flattened

Size 10 - 90 mm

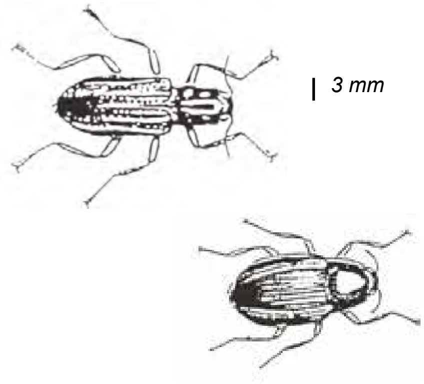
Feeding Group Predator

Lifecycle 2 – 5 years

Distinguishing Characteristics Large pinchers on head; 7 - 8 pairs of lateral filaments on abdomen; these are not legs
3 pairs of legs on middle portion of body (thorax) with tiny pinchers at the end of each
Abdomen ends in pair of <u>short</u>, spiny prolegs, each with 2 hooks

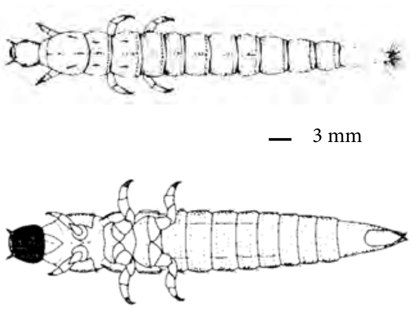
(Average Actual Size)

Riffle Beetle (adult)



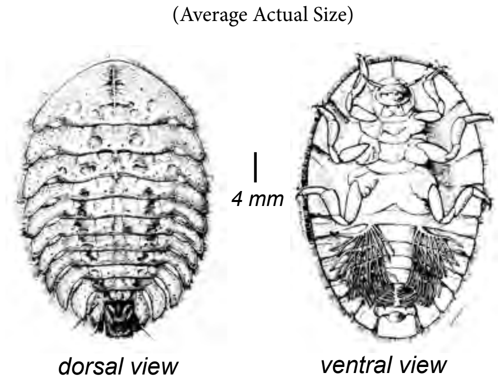
Order	Coleoptera
Family	Elmidae
Where to find	Crawling on stream bottom; often collected with kick seine in riffles
Body shape	Oblong, oval, hard
Size	1 – 6 mm
Feeding Group	Gatherer collector
Lifecycle	Complete metamorphosis Both adults and larvae are aquatic
Distinguishing Characteristics	Tiny Black in color Walks very slowly underwater Hardened, stiff appearance of entire body True “beetle” appearance with 6 legs Adult found more often than larvae

Riffle Beetle (larva)



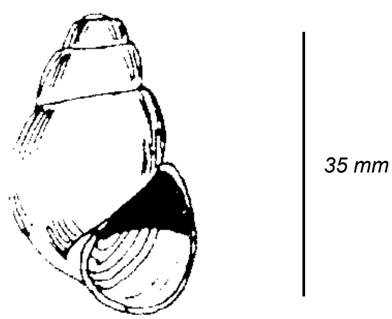
Order	Coleoptera
Family	Elmidae
Where to find	Crawling on stream bottom
Shape	Elongate, hard-bodied
Size	Usually 1- 6 mm
Feeding Group	Gatherer collector or grazer
Lifecycle	Complete metamorphosis Both adults and larvae are aquatic
Distinguishing Characteristics	Hardened, stiff appearance of entire body Resemble tiny torpedoes with circular rings around body Grey or brown in color White tuft of gills can be drawn-in, then protrude from end segment

Water penny beetle larva



Order	Coleoptera
Family	Psephenidae
Where to find	Stones and other substrate
Body shape	Disk (flat)
Size	3 - 5 mm
Feeding group	Grazer
Lifecycle	Complete metamorphosis; Lifecycle from 21 to 24 months
Distinguishing Characteristics	Round – resemble pennies Brown, black, or tan colored Often difficult to remove – resemble suction cups 3 pairs of tiny legs on underside of body

Right-Handed (Gilled) snail

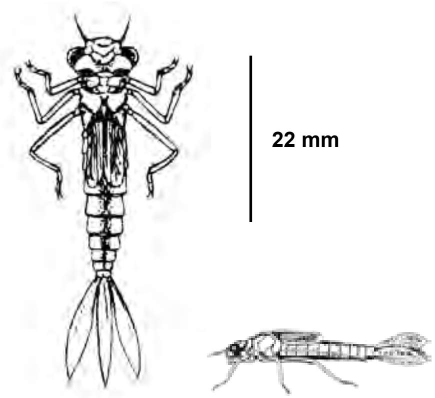


Phylum	Mollusca
Class	Gastropoda
Order	Mesogastropoda
Where to find	Grazing on a variety of substrates
Body shape	Hard, spiraled shell
Size	2 - 70 mm
Feeding group	Grazer
Distinguishing Characteristics	With point held up, opening (aperture) is on your right and faces you (right = good = gilled) Respire via gills, so require oxygenated water Plate-like covering over shell opening Shells coiling in one plane are counted as Left-Handed (Pouch) Snails (page 97) Only **live** snails may be counted in determining water quality

Group 2 - Moderately Intolerant to Pollution

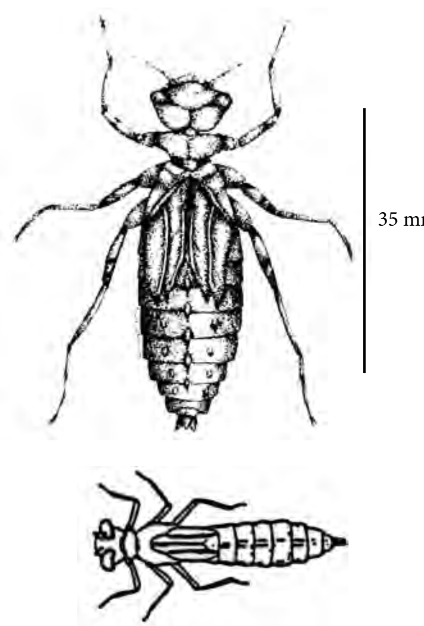
(Average Actual Size)

Damselfly nymph



Order	Odonata
Suborder	Zygoptera
Where to find	Overhanging/emergent aquatic vegetation
Body shape	Elongated, narrow, tapering rearward, resemble adults
Size	15 - 30 mm
Feeding group	Predator
Lifecycle	Incomplete metamorphosis, maturation in 1 to 4 years
Distinguishing Characteristics	No gills present on sides of abdomen Abdomen ends in 3 wide, oar-shaped gill-plates resembling tails Large eyes and long legs Grey, green, or brown in color **May be confused with mayflies, but damselflies have no abdominal gills and "tails" are more paddle-shaped or feather-shaped* **May be confused with dragonflies, but bodies are thin and narrow with long, spindly legs, and dragonflies have no tails*

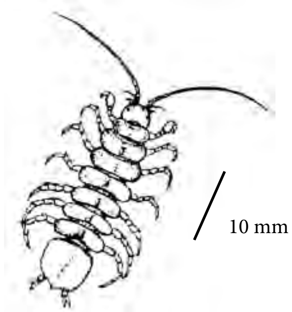
Dragonfly nymph



Order	Odonata
Suborder	Anisoptera
Where to find	Bottom substrate, mud, vegetation
Body shape	Wide abdomen, oval, flattened, robust, large eyes, resemble adults
Size	20 - 50 mm
Feeding group	Predator
Lifecycle	Incomplete metamorphosis, maturation in 1 – 4 years
Distinguishing Characteristics	Large eyes No external gills Distinct scooping mouthparts that extend to catch prey Grey, green, or brown in color Body is generally rough No tails **May be confused with damselflies, but distinguishable by wide, oval abdomen and no tails*

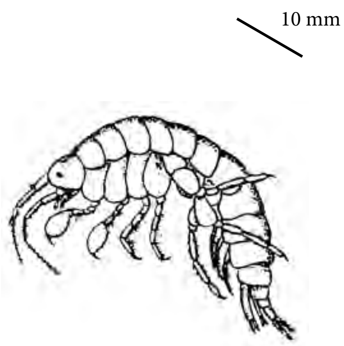
(Average Actual Size)

Aquatic sowbug



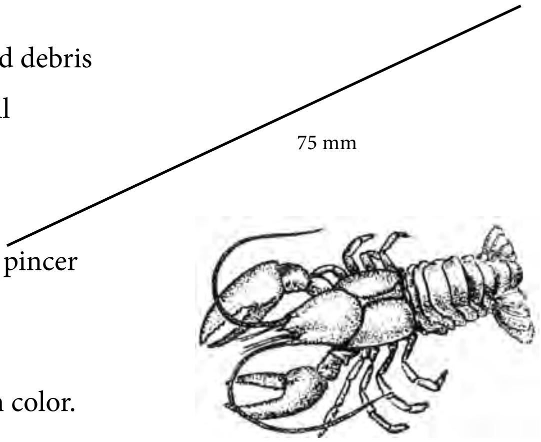
Class	Crustacea
Order	Isopoda
Where to find	Crawling on substrate, vegetation, and debris
Body shape	Hard bodied and flattened dorso-ventrally (top to bottom)
Size	5 – 20 mm
Feeding group	Collector **Looks like a pill bug or roly-poly. May be confused with scuds, but sowbugs are wider than high, and walk slowly along surfaces*

Scud



Class	Crustacea
Order	Amphipoda
Where to find	Aquatic vegetation
Body shape	Flattened laterally (side to side)
Size	5 – 20 mm
Feeding group	Filtering collector
Distinguishing Characteristics	7 pairs of legs and swims on side – often in pairs Shrimp-like, white to clear to pink in color with distinct black eyes **May be confused with sowbugs, but are taller than wide and they swim rapidly on their side*

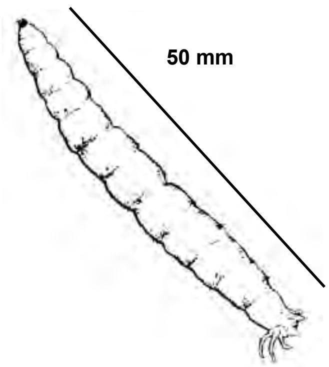
Crayfish



Class	Crustacea
Order	Decapoda
Where to find	Under stones, dense mats of vegetation, and debris
Body shape	Lobster-like, hard body with fan shaped tail
Size	3-15 cm
Feeding group	Grazer, predator
Distinguishing Characteristics	5 pairs walking legs, 1st pair enlarged with pincer claws. Looks like a small lobster Eyes on stalks; well-developed antennae Yellow, green, white, pink or dark brown in color.

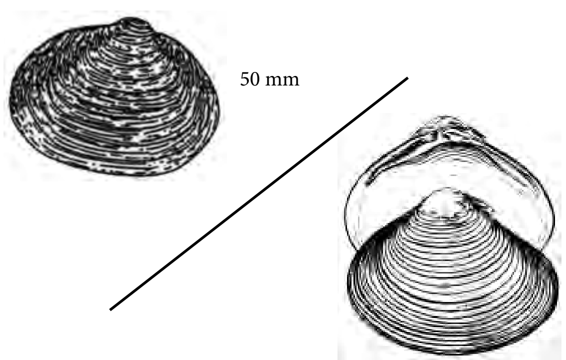
(Average Actual Size)

Cranefly larvae



Order	Diptera (True Flies)
Family	Tipulidae
Where to find	Under rocks, on aquatic vegetation, in leaf-packs
Body shape	Caterpillar-like, "juicy" and segmented
Size	10 – 100 mm
Feeding group	Shredder
Lifecycle	Complete metamorphosis, spends 6 weeks – 5 years in aquatic stage
Distinguishing Characteristics	No true legs or wing buds Milky, light brown, or greenish in color with digestive tract often visible Prolegs may be visible as small lobes **Distinguished from other fly larvae by finger-like appendages that extend from posterior end (if no appendages on hind end, probably a deer or horse fly larvae)*

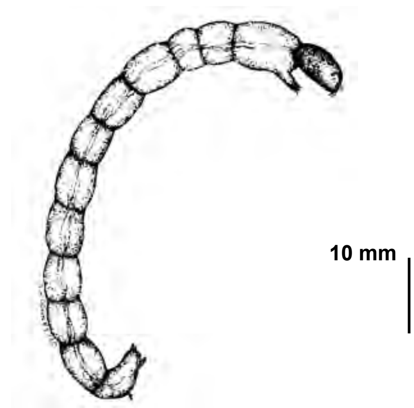
Clams and Mussels



Class	Bivalvia
Where to find	Substrate
Body shape	Two shells attached by a hinge
Size	Varies (very small to very large)
Feeding group	Filtering collector
Distinguishing Characteristics	Only **live** clams and mussels may be counted in determining water quality. If live native mussels or exotic zebra mussels are found, remember to mark the box at the bottom of the Biological Monitoring Data Sheet. In addition, remember to replace live native mussels exactly as you found them as described on page 70.

(Average Actual Size)

Midge larvae



Order Diptera (True Flies)

Family Chironomidae

Where to find Sediment, vegetation, leaf pack

Body shape Cylindrical, thin, soft, and often curled

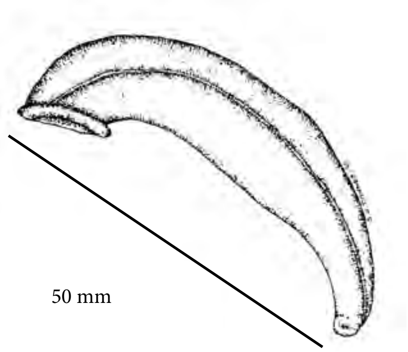
Size 2 - 20 mm

Feeding group Gathering collector or grazer

Lifecycle Complete metamorphosis

Distinguishing Characteristics No true legs, but very small anterior and posterior prolegs
Hardened head capsule
**Often confused with aquatic worms, but midge has small, but visible head and prolegs*
**Blood Midges (Very Tolerant to Pollution – Group 4) are a group of midges that are red in color –*

Leech



Phylum Annelida

Class Hirudinea

Where to find Sediment, leaf pack, vegetation, attached to host animal (maybe you!)

Body shape Flattened dorso-ventrally (top to bottom), many segments

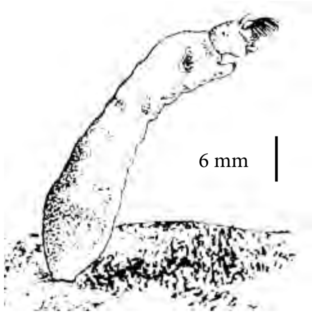
Size 5 – 100 mm

Feeding group Predaceous, collector

Distinguishing Characteristics Anterior and posterior suckers
Usually much wider than aquatic worm
Usually tan to brown in color, though can be patterned and brightly colored
**May be confused with planarians but are usually larger with segments and suckers*

(Average Actual Size)

Blackfly larvae



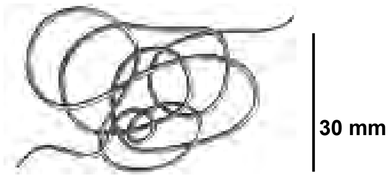
Order	Diptera (True Flies)
Family	Simuliidae
Where to find	In swift current on rocks, and submerged vegetation Often attached by disk on end of abdomen
Body shape	Bowling pin shaped with sucker on wide end
Size	3 - 12 mm
Feeding group	Filtering collector
Lifecycle	Incomplete metamorphosis
Distinguishing Characteristics	Soft body Single proleg directly under head - no true legs Fan-like mouth bristles may be present Head usually black, less often brown, tan, or green Move downstream by drifting on silken threads extended from abdomen **Distinguished from other fly larvae by swollen back end, which it will often stick to the bottom of your collection bin*

Planaria (Flatworm)

Class	Turbellaria
Order	Platyhelminthes
Where to find	Bottom of rocks, leaf litter
Body shape	Soft, flattened dorso-ventrally (top to bottom), arrow-shaped head
Size	Usually <1mm, range to 30mm
Feeding groups	Gathering collector, predator
Distinguishing Characteristics	Flat body Arrow-shaped head with white eyespots Body slides smoothly along surfaces **May be confused with aquatic worms or leeches, but slides along surfaces rather than moving end to end (leeches) or by stretching part of body and pulling the rest (worms) also, planarians are unsegmented*

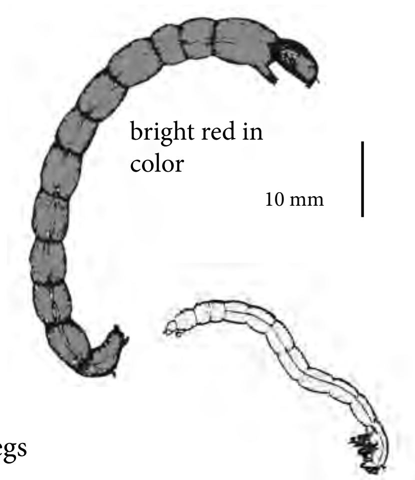
(Average Actual Size)

Aquatic worms



Phylum	Annelida
Class	Oligochaeta
Where to find	Silty sediment, organic debris
Body shape	Long, thin, cylindrical, segmented
Size	1 – 70 mm
Feeding groups	Shredder, collector, grazer
Distinguishing Characteristics	Often similar to earthworm in appearance Red, tan, black, or brown in color **Distinguished from leeches, midges, and planarians by long, thin body and worm-like movement (stretching and pulling body along)*

Blood Midge larva



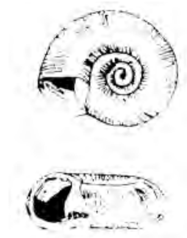
Order	Diptera (True Flies)
Family	Chironomidae
Where to find	Silty sediment, often in organically polluted water
Body shape	Cylindrical, thin, soft, and often curled
Size	2 - 20 mm
Feeding group	Collector gatherer
Lifecycle	Complete metamorphosis
Distinguishing Characteristics	Red in color No true legs, but very small anterior and posterior prolegs Hardened head capsule **Distinguished from red aquatic worms with small, but visible head and prolegs*

Left-Handed (Lunged) snail

(Average Actual Size)

50 mm

lunged snail



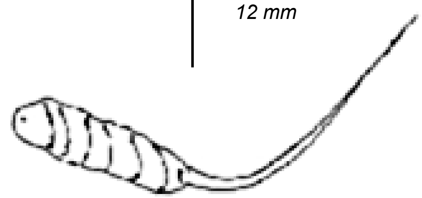
orb snail

also, limpets

Phylum	Mollusca
Class	Gastropoda
Order	Prosobranchia
Where to find	Grazing on a variety of substrates
Body shape	Hard shell usually spiral, but may be flattened
Size	2 - 70 mm
Food source	Grazer
Distinguishing Characteristics	With point held up and shell opening facing you, opening is on your left Snails with shells coiling in one plane (orb snail) are also counted as Left-Handed No plate-like covering over shell opening Respire via lung-like structures, so not dependent on dissolved oxygen in the water – they can obtain oxygen from the atmosphere Only **<u>live</u>** snails may be counted on Biological Monitoring Data Sheet

Rat-tailed maggot

12 mm

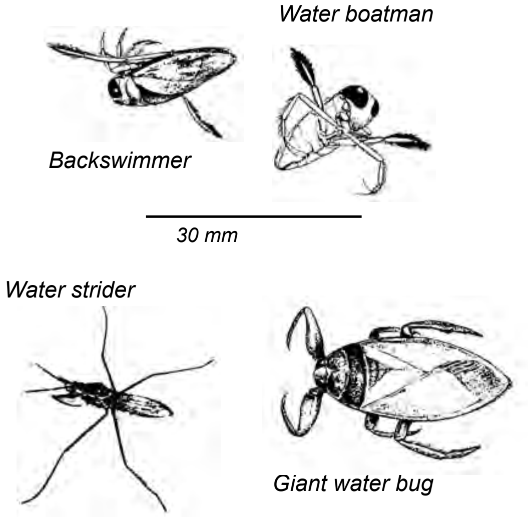


Order	Diptera (True Flies)
Family	Syrphidae
Where to find	Silty sediments of organically enriched water
Body shape	Soft, worm-like with long tail
Size	Usually 4 - 14mm, may exceed 70mm
Feeding group	Collector
Lifecycle	Complete metamorphosis
Distinguishing Characteristics	Maggot-like, wrinkled body Anglers call them "mousies" Long tail (can be 3 – 4x body length), which is actually a snorkel-like breathing tube Tail is extended above surface of the water allowing rat-tailed maggot to obtain oxygen from the atmosphere

There is a possibility that you will discover insects and other organisms that are not listed on the Pollution Tolerance Index (e.g., adult dragonflies, water striders, water bugs). They are not counted in the PTI. These organisms are not as useful as indicators of water quality because they are less dependent on local stream conditions for habitat requirements.

True bugs

(Backswimmer, Giant water bug, Water boatmen, Water strider)



Order	Hemiptera
Where to find	Often seen skimming or walking along water surface
Body shape	Hard, oval, and somewhat flattened
Size	1 – 65 mm
Feeding group	Predator. Injects chemicals that dissolve the internal parts of prey.
Lifecycle	Incomplete metamorphosis, adults and larvae are quite similar
Distinguishing Characteristics	Head and eyes often well developed 3 pairs of legs may be dissimilar (hindlegs may be flattened and hinged) Forewings, when at rest, are held close over the back and overlap Because adults are mobile, they are not a good indicator of water quality **May be confused with adult water beetle, but beetle's wings do not overlap*

Waterboatman - swims right side up, back is black

Backswimmer - swims on back, back is white

Water Strider - lives on surface, walks on water

Giant Water Bug - grasping front legs, up to three inches in length

Information in this section was modified from the following sources:

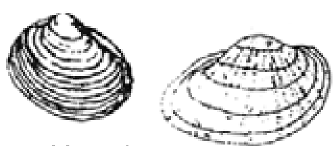
An Introduction to the Aquatic Insects of North America, Second Ed., Edited by R.W. Merritt and K.W. Cummins
Aquatic Entomology, Patrick McCafferty
Clinton River Watershed Council *Teacher Training Manual*, Michigan, Meg Larson
Field Manual for Water Quality Monitoring, 10th Ed., Mark K. Mitchell and William B. Stapp
Macroinvertebrate Identification Flash Cards, GREEN/Earth Force, Ann M. Faulds, et al.
Pond and Stream Safari, Karen Edelstein, Cornell Cooperative Extension
Save Our Streams Monitor's Guide to Aquatic Macroinvertebrates, Loren Larkin Kellogg

Taxonomic Key to Benthic Macroinvertebrates

The purpose of this taxonomic key is to assist volunteer monitors, who are not trained in taxonomy, with the identification of benthic macroinvertebrates found in Indiana. This key is a simplified version of more complex keys. The taxonomic level of this key is intended for use by citizen monitoring groups. When using this key please note that each couplet offers two or three options. Each couplet is numbered and the numbers in bold refer to the next couplet (the next set of numbers that you proceed to).

Please be aware that some macroinvertebrates may have missing body parts so you should look at more than one organism.

CHOOSE ONE:		GO BELOW TO:
(1)a	Has a shell(s)	**2**
(1)b	Has no shell	**5**
(2)a	Has a hinged double shell	**3**
(2)b	Has a single shell	**4**
(3)a	Adult under 2 inches long	**19**
(3)b	About 2-4 inches long	MUSSEL

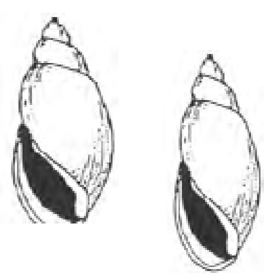


Mussel

(4)a	Right-handed opening	RIGHT-HANDED SNAIL

Right-Handed Snail

(4)b	Left-hand opening	LEFT-HANDED SNAIL

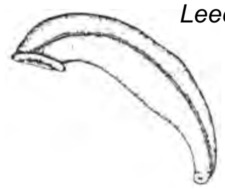


Left-Handed Snail

CHOOSE ONE:		GO BELOW TO:
(5)a	Has a segmented body or looks like a tiny tick	**6**
(5)b	Has an unsegmented body and has an "arrow shaped" head; 2 pigment spots (eyes)	PLANARIA

Planaria

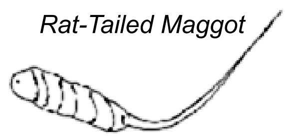
(6)a	No obvious legs	**7**
(6)b	Obvious legs	**12**
(7)a	Has no obvious appendages (long, tubular body)	**8**
(7)b	Has some appendages (small tubes, tiny bumps, or feathery structures)	**9**
(8)a	Has a smooth body and suckers	LEECH



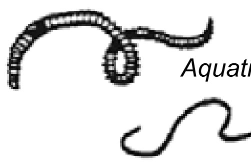
Leech

(8)b	Has a round body and a rat tail	RAT-TAILED MAGGOT

Rat-Tailed Maggot



(8)c	Has a rounded body	AQUATIC WORMS



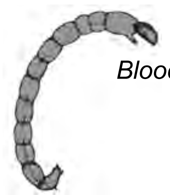
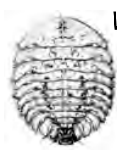
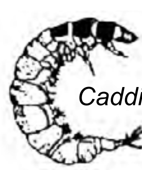
Aquatic Worms

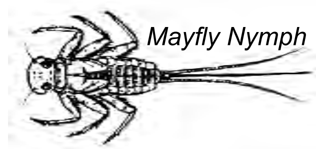
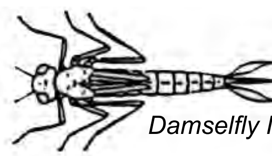
(9)a	Body black or brown; more than 1/3 inch long; plump and catepillar-like	CRANE FLY LARVA

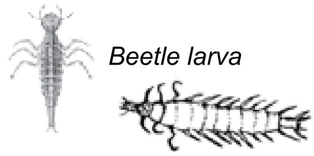
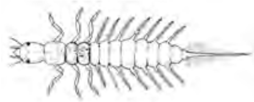
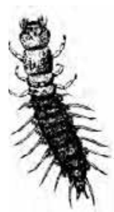
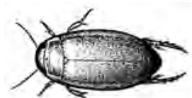
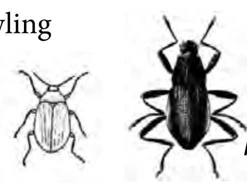
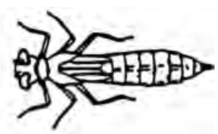
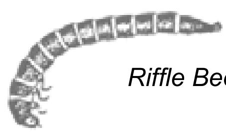
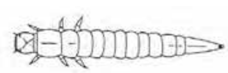
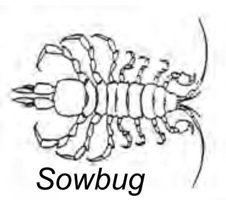
Crane Fly Larva

(9)b	Has a distinct head	**10**
(10)a	One end of body wider than other end; two tiny feather structures on smaller end	BLACK FLY LARVA

Black Fly Larva

CHOOSE ONE:		GO BELOW TO:
(10)b No difference in diameter along body		**11**
(11)a Bright red body	 *Blood Midge*	BLOOD MIDGES
(11)b Grey body		OTHER MIDGES
(12)a Has four pairs of legs	 *Water Mite*	WATER MITE
(12)b Has three pairs of legs		**13**
(12)c Has many pairs of legs		**26**
(13)a Has no wings or short wing pads on back		**14**
(13)b Has two pairs of wings that cover the abdomen		**23**
(14)a Has a flat, round body with legs underneath (wings are not obvious)	 *Water Penny*	WATER PENNY BEETLE LARVA
(14)b Not flat, has long body with legs		**15**
(15)a Lives in a tube or a case or has two hooks in its last segment and is green with 3 plates on back behind head. (The "green caddisfly" builds a net & tube, but will be washed into the kick net as "free living")	 *Caddisfly Larva* 	CADDISLY LARVA
(15)b Free-living		**16**

CHOOSE ONE:		GO BELOW TO:
(16)a Abdomen possesses lateral filaments similar in size to legs		**21**
(16)b Abdomen does not have "leg-like" filaments (may have feathery "gills")		**17**
(17)a Always with only two tail appendages and no abdominal gills	 *Stonefly Nymph*	STONEFLY NYMPH
(17)b Usually has three tail appendages		**18**
(17)c Tail has no appendages		**25**
(18)a Has long, bristle-like tail appendages, sometimes 2 or 3, and has gills on abdominal segments	 *Mayfly Nymph*	MAYFLY NYMPH
(18)b Lower lip formed into extensible scoop-like structure and has leaf-like tail appendages	 *Damselfly Nymph*	DAMSELFLY NYMPH
(19)a Small rounded shell (< 2 inches)		**20**
(19)b Small triangular shell with alternating cream and dark brown bands	 *Zebra Mussel*	ZEBRA MUSSEL (EXOTIC)
(20)a Numerous very fine concentric rows of elevated lines, white or cream colored, with smooth lateral teeth (ridge lines on inside near point)	 *Fingernail Clam*	FINGERNAIL CLAM
(20)b Numerous concentric elevated ridges, yellowish brown to black shell with serrated lateral teeth	 *Asiatic Clam*	ASIATIC CLAM (EXOTIC)

CHOOSE ONE:		GO BELOW TO:
(21)a Head narrower than widest body segments	 *Beetle larva*	BEETLE LARVA
(21)b Head as wide or wider than other body segments		**22**
(22)a Abdomen with single long filament at end	 *Alderfly*	ALDERFLY
(22)b Abdomen ending with a pair of tiny hooked legs, large head with pincer-like jaws	 *Dobsonfly Larva*	DOBSONFLY OR FISHFLY
(23)a Oval shaped body, legs with feathery swimming hairs	 *Water bug*	ADULT WATER BUGS AND WATER BEETLES
(23)b All legs smooth, without hairs, crawling	 *Riffle Beetle Adult*	RIFFLE BEETLE ADULT
(25)a Lower lip formed into scoop like structure	 *Dragonfly Nymph*	DRAGONFLY NYMPH
(25)b Looks like a tiny millipede	 *Riffle Beetle Larva* 	RIFFLE BEETLE LARVA
(26)a Flattened top to bottom, crawling looks like "roly-poly" or a "pill bug"	 *Sowbug*	SOWBUG
(26)b Flattened side to side, swimming looks like tiny shrimp	 *Scud or Side-swimmer*	SCUD

Appendix C - What Can You Do To Prevent Water Pollution?

"A man who is willing to undertake the discipline and difficulty of mending his own ways is worth more to the conservation movement than a hundred who are insisting merely that the government and the industries mend their ways."
~ Wendell Berry

At Home

- Properly dispose of household chemicals such as paint and cleaners at the local hazardous waste center (do NOT pour down sink or storm drains! Visit, the Association of Indiana Solid Waste Management Districts for more information at www.aiswmd.org/). Buy environmentally-friendly products: many safe yet effective cleaning solutions can be made from organic or non-toxic ingredients.
- Reduce the amount of solid waste you generate. Landfill space is becoming scarcer daily.
- Make sure your septic system is properly functioning https://secure.in.gov/health/eph/onsite-sewage-systems-program.
- Wash your car at a car wash or in your lawn. Do not wash it in your driveway with dirt and detergents flowing down a storm drain and into a local waterway.

Water Conservation

- Repair leaky faucets and toilets right away.
- Turn off the tap while brushing your teeth and washing the dishes.
- Run the washing machine and dishwasher only when they are fully loaded.
- Sweep off instead of hosing the driveway, patio or sidewalk.
- Install water-saving shower heads and high-performance, low-flush toilets.
- Water your lawn and garden only in the morning or evening.

In the Yard/Garden/Field

- Discontinue or minimize fertilizer usage on lawns, crops, etc., or use organic fertilizers.
- Test your soil to determine its nutrient needs before treating.
- Consider Integrated Pest Management principles
  (ask your Purdue Extension Educator, https://extension.purdue.edu/about#counties).
- Use the smallest amount of an appropriate pesticide at the proper time.
- Encourage natural pest predators such as certain birds and harmless insects.

On the Road/On the Water

- Fix motor vehicle leaks to prevent oil, antifreeze and other fluids from dripping onto streets, driveways and parking lots. These chemicals will mix with rain to produce polluted runoff.
- Recycle used motor oil and antifreeze.
- Boats and engines should be properly cleaned or allowed to dry after leaving zebra mussel infested waters.
- Check boat trailer for any "weeds" or fragments of invasive aquatic plants.

Wetlands

Wetlands filter pollutants such as sediment and nutrient runoff. Wetlands hold water and reduce flooding. Healthy functioning wetlands can actually reduce mosquito populations.

- Protect and preserve existing wetlands.
- Restore and create wetlands for landscaping and wildlife habitat.
- Be an advocate for wetlands and educate others about their importance.

Best Management Practices (BMPs)

Agricultural, urban/residential, and construction BMPs are systems or activities that are practiced to control and prevent erosion and nonpoint source pollution. They generally involve various combinations of the following approaches:

- Minimize mixing of rain and pollutants (e.g., animal waste management, fertilizer and pesticide/herbicide management, integrated pest management).
- Restrict water runoff, thereby restricting transportation of pollutants through the use of:
  - ¤ Porous pavement,
  - ¤ Ground cover management,
  - ¤ Conservation tillage (any tillage and planting system that covers 30% or more of the soil surface with crop residue after planting); and,
  - ¤ No-till (leaves the soil undisturbed from harvest to planting except for nutrient injection: Planting or drilling is accomplished in a narrow seedbed or slot created by special equipment. Weed control is accomplished primarily with herbicides).
- Trap/collect pollutants to prevent them from entering waterbodies or groundwater through the use of:
  - ¤ Silt fences,
  - ¤ Detention sedimentation basins,
  - ¤ Riparian buffer strips (streamside plantings of trees, shrubs, and grasses) and,
  - ¤ Grassed waterways (strips of grass seeded in areas of cropland where water concentrates and flows off a field).

Advocacy

Advocacy is the act of pleading for, supporting or recommending a cause or course of action. Becoming an advocate may require seeking out information about what laws exist and who is instrumental in deciding or enforcing those laws. Be sure you are well informed before pursuing a course of action. Get involved!

- To influence new or existing regulations, attend public comment meetings and participate in discussion (avoid opinionated comments, make articulate ones), write well-written letters, and/or arrange face-to-face meetings with rule makers (i.e. legislators, city/county council members, zoning board members).
- Participate in your neighborhood organization, watershed organization, land trust, local or state-wide river/stream/lake/wetland protection organization (or START one) (**see** http://www.idem.IN.gov/nps).
- Participate in storm drain stenciling programs (or START one!).
- Arrange and/or sponsor public presentations by respected experts.
- Serve on a decision-making board or run for office.

Appendix D -
Chemistry Ranges, Averages and Q-Values

Chapter 4 listed values representing the likely ranges into which your chemical data results may fall. These ranges were taken from the 2012 Monitoring Water in Indiana: Choices for Nonpoint Source and Other Watershed Projects or also known as the Environmental Indicators Manual. This manual can be accessed at https://engineering.purdue.edu/watersheds/monitoring/MonitoringWaterinIndiana.2012.1.pdf. Data from existing monitoring sites in Indiana have been compiled to provide a range. These ranges are provided to help you have a better idea of what is found in Indiana streams and lakes. This section relied on IDEM Fixed Station Data, compiled by IDEM staff or Purdue University. In addition, the Indiana water quality standards for rivers are included for each applicable parameter.

Typical range for DO =
1.2 to 22.3 mg/L

Indiana Average = 9.6 mg/L

State Water Quality Standard:
4.0 mg/L - 12.0 mg/L

Min: 6.0 mg/L in coldwater fishery streams

Min: 7.0 mg/L in spawning area of coldwater fishery streams

Typical range for *E. coli* =
2 to 1,204 K colony forming units/100mL

Indiana Average = 210 cfu/100mL

State Water Quality Standard for total body contact recreation: <235 cfu/100 mL (a single sample)
or
< 125 cfu/100 mL (Geometric mean of 5 samples equally spaced over 30 days)

Typical range for pH = 7.2 to 8.8 SU

Indiana Average = 8.0 SU

State Standard = between 6 - 9
Due to the state's limestone geology, Indiana surface waters will typically have a pH that is relatively basic (> 7).

Typical range for BOD_5 =
0.4 to 33 mg/L

Indiana Average = 2 mg/L

The maximum temperature rise at any time or place above natural temperatures shall not exceed State Water Quality Standard:

< 5° F (approximatively 2.8° C)

< 2° F (approximatively 1.1° C) for trout streams

Typical range for NITRATE (NO_3)
= 0 to 36.08 mg/L

Indiana Average = 12.32 mg/L

EPA recommends 1.5 mg/L as the dividing line between mesotrophic and eutrophic streams.

Typical range for Turbidity:
0 to 2150 NTU

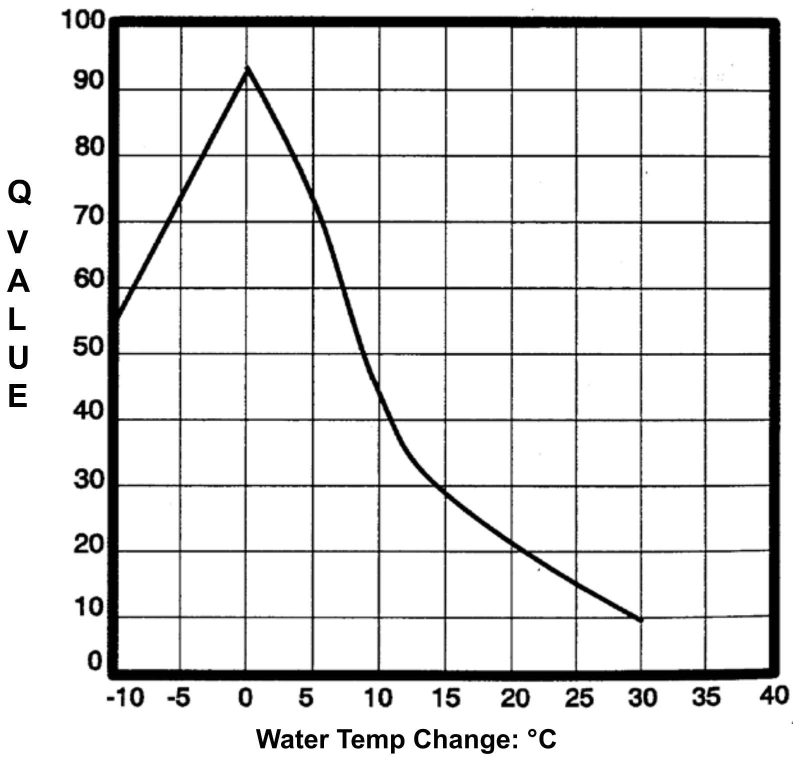
Indiana Average = 15 NTU

U.S. EPA recommends 10.4 NTU

There are no state water quality standards for Orthophosphate.
Total Phosphate typical range:
(0 to 0.85 mg/L) and average (0.05 mg/L).

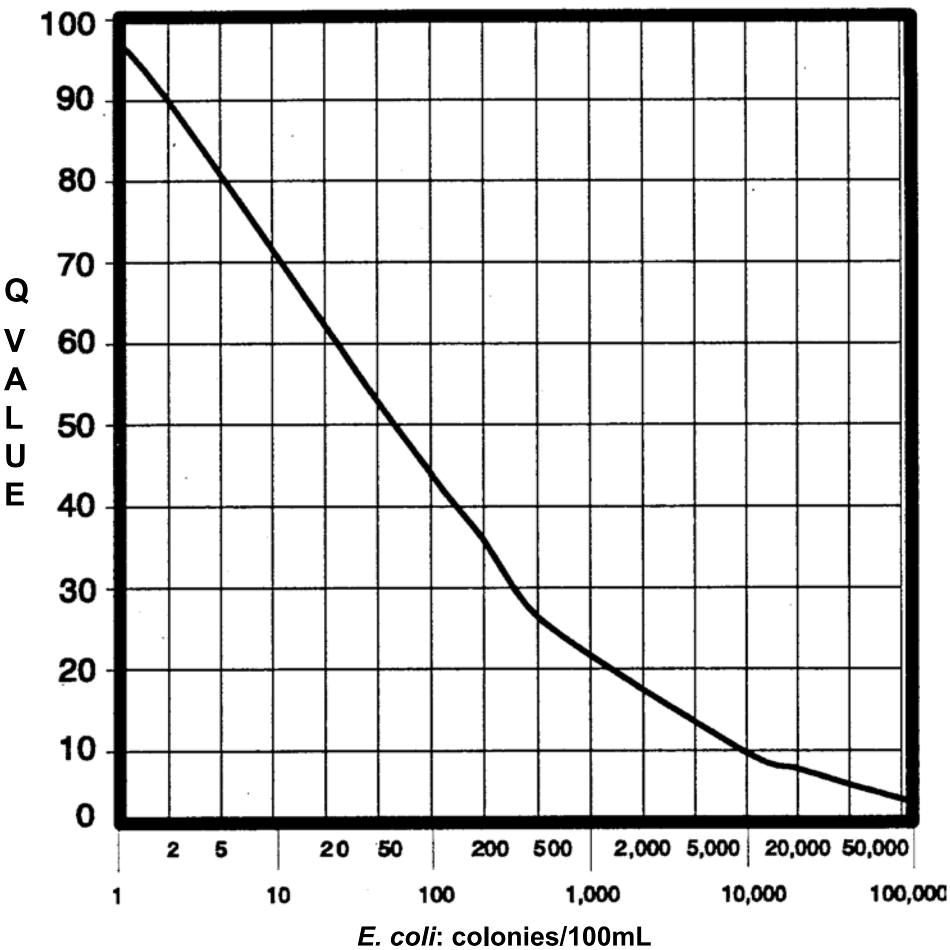
We generally expect orthophosphate to be less than total phosphate, since orthophosphate is but one component of total phosphate.

Temperature Change Q-Values



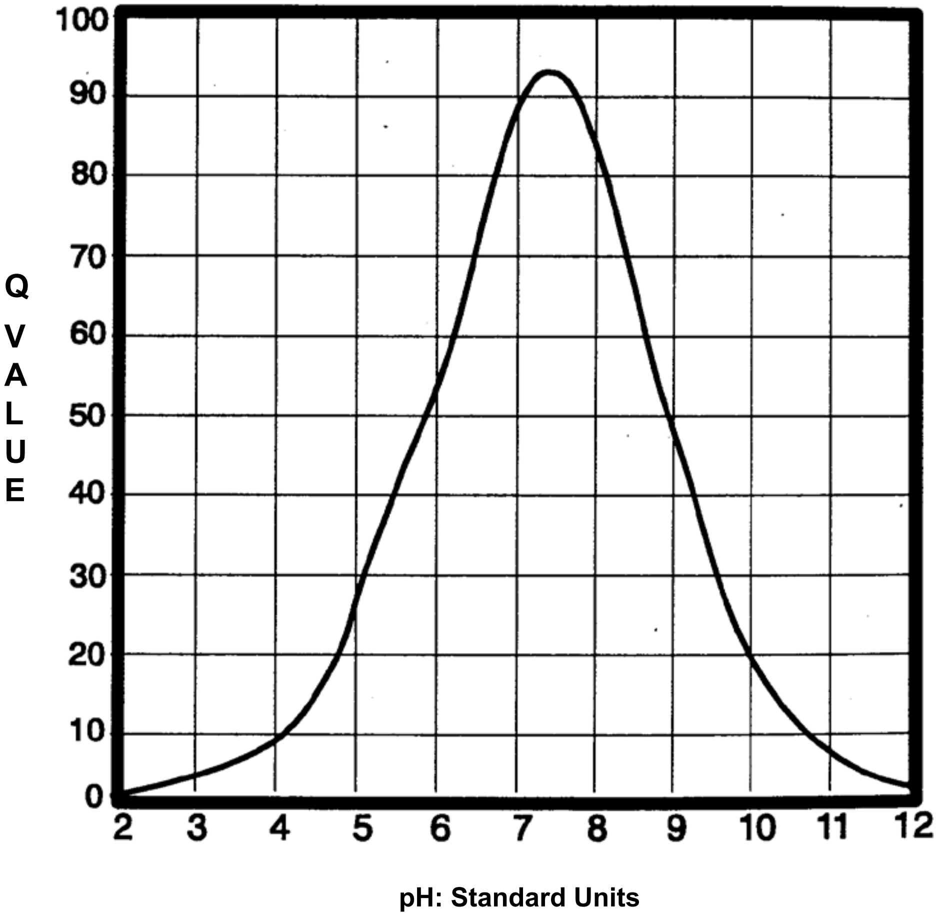
Change in Temp. (°C)	Q-Value
-10	56
-7.5	63
-5	73
-2.5	85
-1	90
0	93 (max)
1	89
2.5	85
5	72
7.5	57
10	44
12.5	36
15	28
17.5	23
20	21
22.5	18
25	15
27.5	12
30	10

E. coli Q-Values



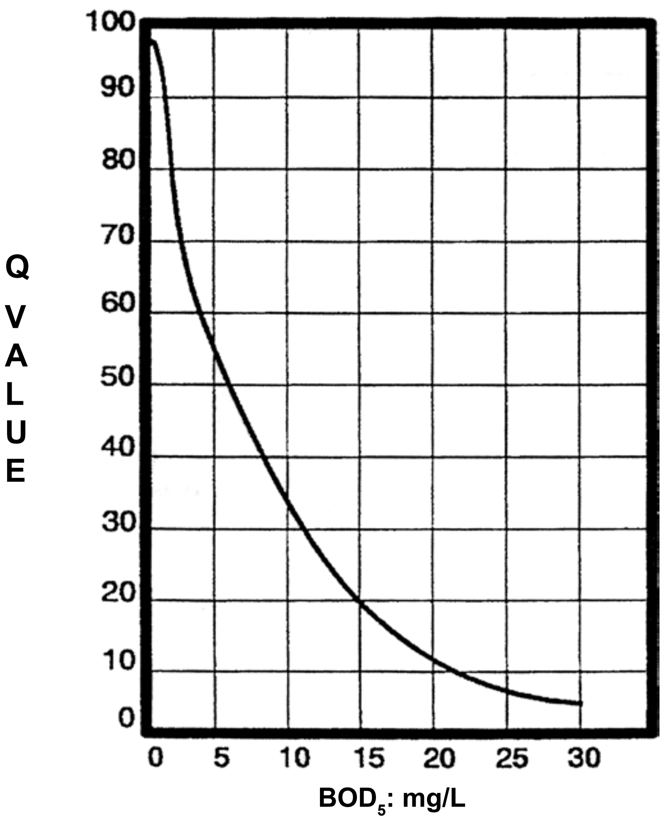
E. coli (colonies/100mL)	Q-Value
0-1	98
2	89
5	80
10	71
20	63
50	53
100	45
200	37
500	27
1,000	22
2,000	18
5,000	13
10,000	10
20,000	8
50,000	5
100,000	3
>100,000	2

pH Q-Values



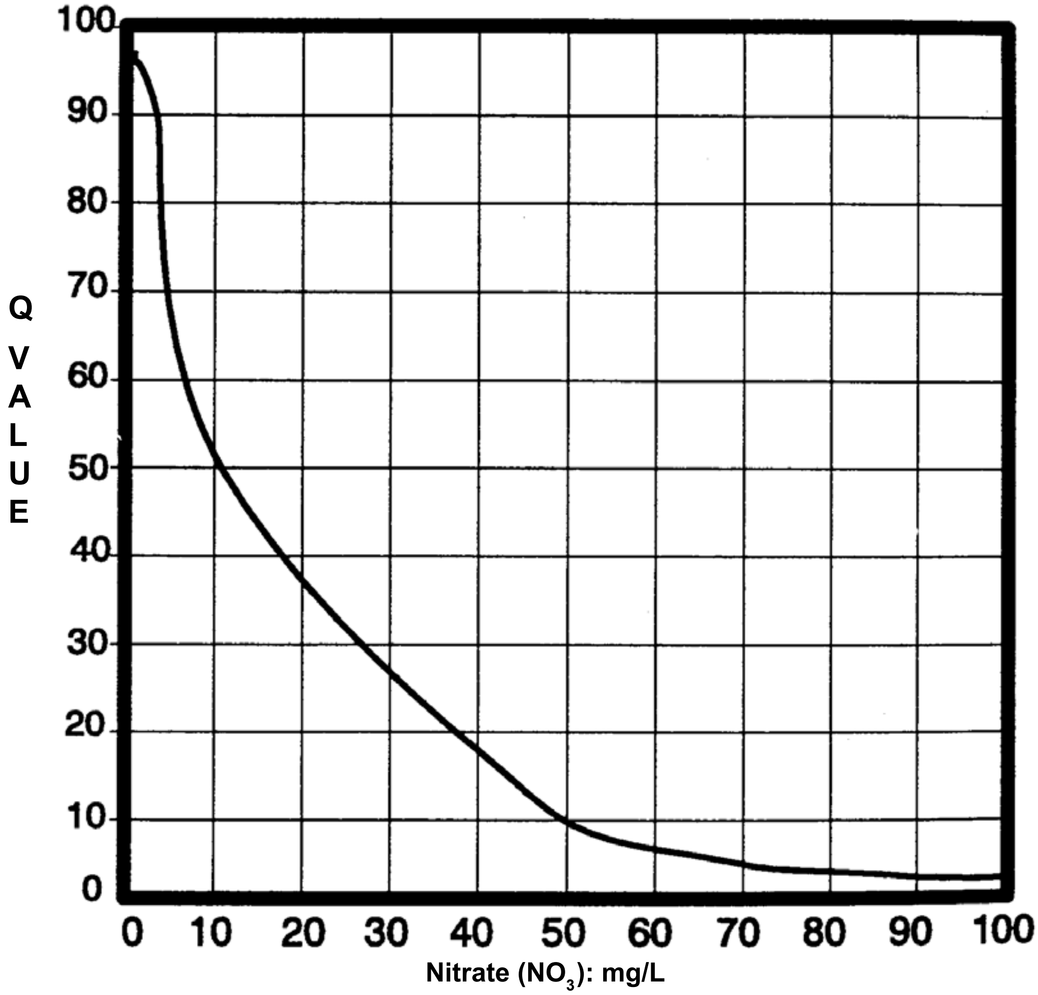
pH (SU)	Q-Value
<2	0
2	2
3	4
4	8
5	24
6	55
7	90
7.2	92
7.5	93 (max)
7.7	90
8	82
8.5	67
9	47
10	19
11	7
12	2
>12	0

BOD_5 Q-Values



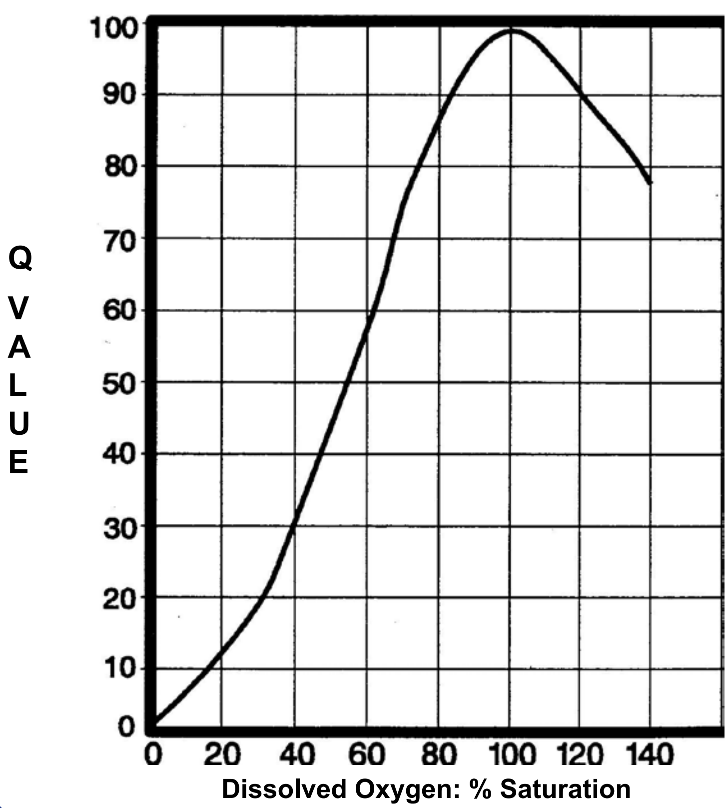
BOD_5 (mg/L DO)	Q-Value
0	96
1	92
2	80
2.5	73
3	66
4	58
5	55
7.5	44
8	40
10	33
12.5	26
15	20
17.5	16
20	14
22.5	10
25	8
27.5	6
30	5
>30	2

Nitrate (NO_3): Q-Values



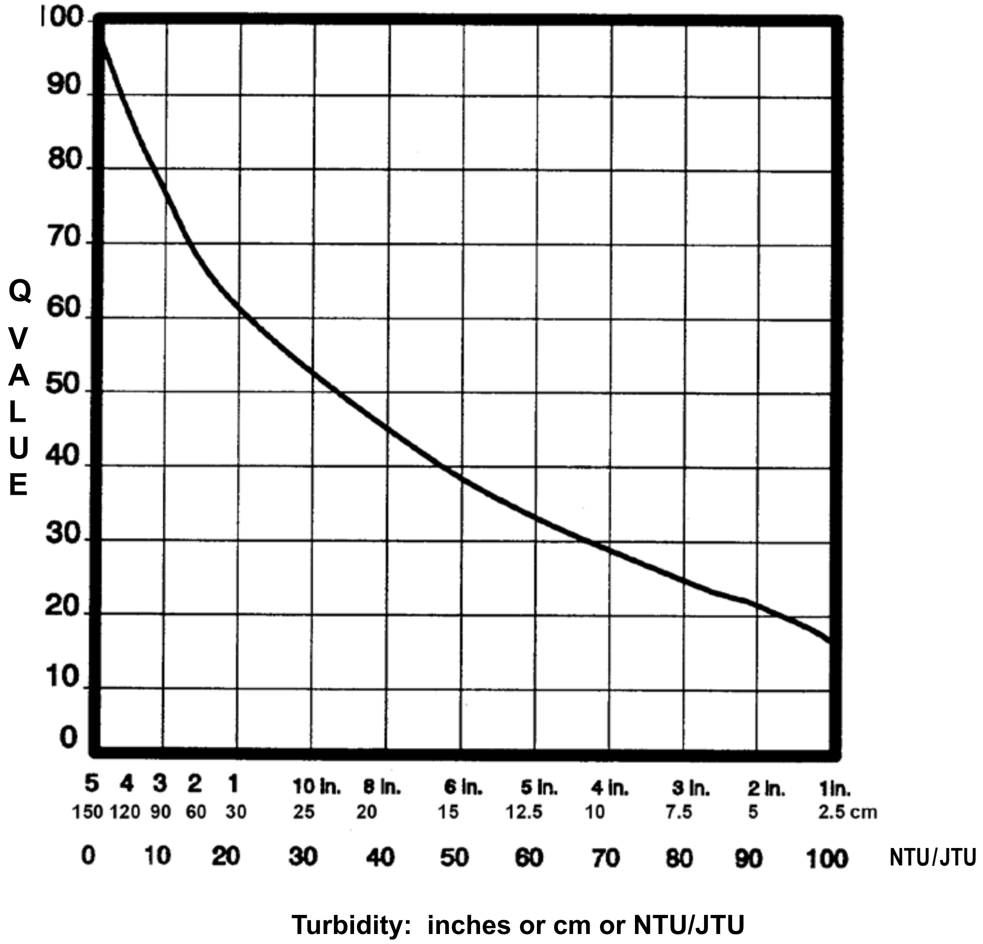
Nitrate (mg/L NO_3)	Q-Value
0	98
0.25	97
0.5	96
0.75	95
1	94
1.5	92
2	90
3	85
4	70
5	65
10	51
15	43
20	37
30	24
40	17
50	7
60	5
70	4
80	3
90	2
100	1
>100	1

Dissolved Oxygen Q-Values



DO (% Saturation)	Q-Value
0	0
10	8
20	13
30	20
40	30
50	43
60	56
70	77
80	88
85	92
90	95
95	97.5
100	99
105	98
110	95
120	90
130	85
140	78
>140	50

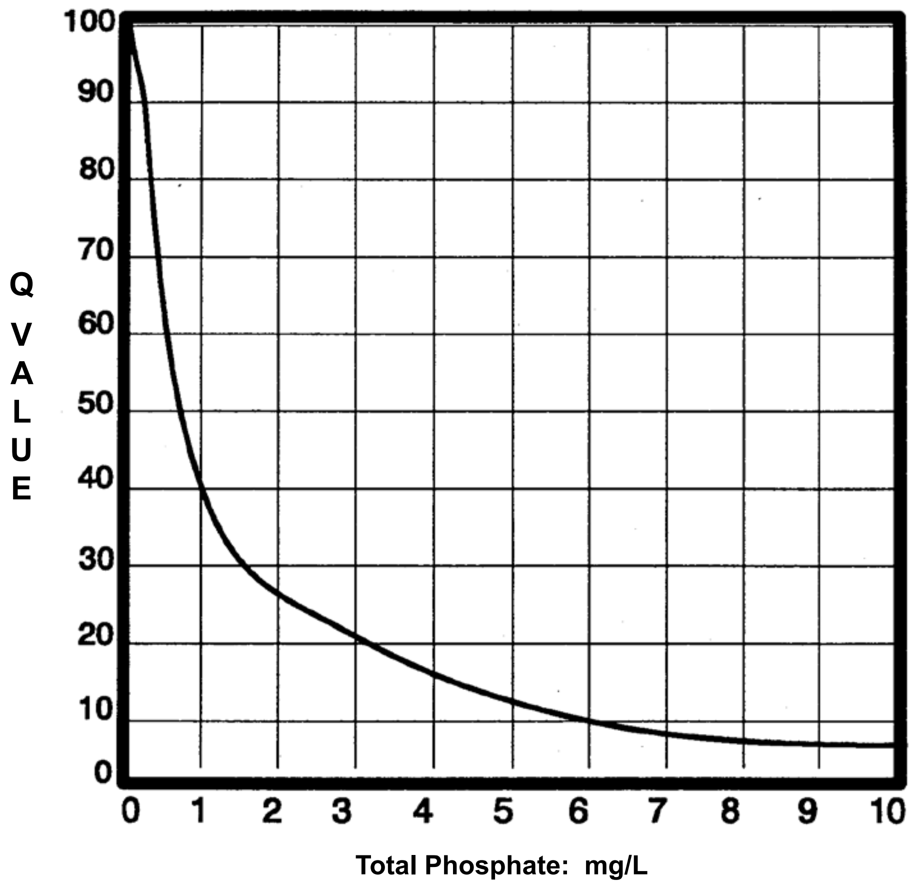
Turbidity Q-values



Transparency (cm) Reading from Tube	Turbidity (NTU) *(Approximate)*	Q Value
150	0	97
120	5	85
90	10	76
67.5	13	70
60	15	68
30	20	62
27.5	25	57
25	30	53
22.5	35	48
20	40	45
15	50	39
12.5	60	34
10	70	28
7.5	80	25
5	90	22
2.5	100	17
<2.5	>100	5

Total Phosphate (PO_4) Q-Values

The Total Phosphate Q-value graph and table are provided for your general information. A Total Phosphate result cannot be obtained using the methods provided in this manual.



Total Phosphate (mg/L P)	Q-Value
0	99
0.05	98
0.1	97
0.2	95
0.3	90
0.4	78
0.5	60
0.75	50
1	39
1.5	30
2	26
3	21
4	16
5	12
6	10
7	8
8	7
9	6
10	5
>10	2

REMEMBER:

There are no Q-value charts or tables for Orthophosphate or Nitrite (NO_2).

Appendix E - Glossary

A

acid mine drainage: waters of low pH (less than 6) from mining areas.
algae: small plants which lack roots, stems, flowers, and leaves; living mainly in water and using the sun as an energy source.
alkalinity: a measurement of water's ability to neutralize acid.
aquatic habitat: all of the areas in a stream, lake or wetland that are occupied by an organism, population or community.
aquifer: any geological formation containing water, especially one that supplies water for wells, springs, etc.

B

banks: the portion of the stream channel which restricts the movement of the water out of the channel during times of normal water depth. This area of the stream is characterized as being the exposed terrestrial areas on either side of the stream.
benthic: an adjective which describes all things associated with the bottom, or sediments of a stream.
bedrock: unbroken solid rock, overlain in most places by soil or rock fragments.
biochemical oxygen demand (BOD): an empirical test in which standardized laboratory procedures measure the oxygen required for the biochemical degradation of organic material, and the oxygen used to oxidize inorganic materials, such as sulfides and ferrous iron. Can be done over various lengths of time.

C

channelization: the straightening of a stream or the dredging of a new stream channel to which the stream is diverted. A channelized stream is straight with little or no meanders.
class: a taxonomic rank which falls under the taxonomic rank of Order.
cobble streambed: a watercourse predominately lined with naturally rounded stones, rounded by the water's action. Size varies from a hen's egg to that used as paving stones.
complete metamorphosis: the type of insect development that includes four stages; egg, larva, pupa, adult.
conservation practice: an engineered structure or management activity that eliminates or reduces an adverse environmental effect of a pollutant and conserves soil, water, plant, or animal resources.

D

Dissolved Oxygen (DO): the amount of oxygen dissolved in water. Generally, proportionately higher amounts of oxygen can be dissolved in colder waters that in warmer waters.
drainage basin: the total land area draining to any point in a stream. A drainage basin is composed of many smaller watersheds.

E

ecology: the relationship between living things and their environments or the study of such relationships.
effluent: a discharge of partially or completely treated pollutants into the environment; generally used to describe discharge into the water.
emergent plants: plants rooted in the bottom of the watercourse, that rise above the water surface.
erosion: the wearing away of the land surface by wind or water.
***Escherichia coli* (*E. coli*):** a bacterium of the intestines of warm-blooded organisms, including humans, that is used as an indicator of water pollution for disease producing organisms.
eutrophic: a waterbody enriched with nutrients (nitrates and phosphates) and consequently overgrown with plants or algae.

eutrophication: natural eutrophication is the process of lake aging. Cultural eutrophication occurs when nutrients are added from agricultural runoff, sewage, or other sources until a lake is filled in with sediment and plants to become swamp, marsh, and eventually dry land.

F

fecal coliform bacteria: the portion of the coliform group which is present in the gut or feces of warm-blooded animals. The presence of fecal coliform bacteria in water is an indication of pollution and potential human health problems.
floodplain: an area on both sides of a stream where flood waters spread out during high rains. The surface may appear dry for most of the year, but it is generally occupied by plants that are adapted to wet soils.
food chain: a transfer of energy in a sequence of organisms (algae, fish, etc.) in a community in which each member of the chain feeds on the member below it.

H

habitat: the area in which an organism lives.
herbaceous vegetation: plants having a stem that remains soft and succulent during the growing, not woody.

I

incomplete metamorphosis: the type of insect development that consists of three stages; egg stage, a nymph stage and an adult stage.
indicator organism: organisms which respond predictably to various environmental changes, and whose presence or absence, and abundance, are used as indicators of environmental conditions.
inorganic: any compound not containing carbon.
intermittent stream: A watercourse that flows only at certain times of the year, receiving water from springs or surface sources; also, a watercourse that does not flow continuously, when water losses from evaporation or seepage exceed available stream flow.
invertebrate: an organism without a backbone.

J

JTUs - Jackson Turbidity Units: a unit of measurement commonly used in electronic turbidity meters that indicate how far light can penetrate into a water sample before the cloudiness of the sample cuts the light. Similar to NTUs or Nephelometric Turbidity Unit.

L

lake: a body of fresh or salt water of considerable size, whose open-water and deep-bottom zones (no light penetration to the bottom) are large compared to the shallow-water (shoreline zone, which has light penetration to its bottom zones).

M

macroinvertebrates: animals lacking backbones that are large enough to be visible without the aid of a microscope.
meanders: curves. Streams with meanders display sinuosity, or snake-like curving of a natural stream channel.
metamorphose: to change into a different form, such as from an insect pupa to an adult.
methemoglobinemia: the presence of methemoglobin in the blood, making the blood useless as a carrier of oxygen. Methemoglobin, a compound closely related to oxyhemoglobin, is found in the blood following poisoning by certain substances, such as nitrate. Young babies, both human and animal, are particularly susceptible to methemoglobinemia, leading to a condition known as “blue baby” which if untreated can cause death.
mollusk: soft-bodied (usually hard-shelled) animals such as clams or mussels.

N

nitrogen: a limiting nutrient for the aquatic environment. Nitrogen is considered to be limiting because it is needed by the plants and animals in the stream in moderate amounts. When present in higher amounts, such as large amounts of fertilizer runoff from local farm fields, large algal blooms occur which cause a depletion of dissolved oxygen.

nonpoint source pollution: a type of pollution whose source is not readily identifiable as any one particular point, such as pollution caused by runoff from streets and agricultural land.

NTU - Nephelometric Turbidity Units: a unit of measurement commonly used in electronic turbidity meters that indicates how far light can penetrate into a water sample before the cloudiness of the sample cuts into the light. Similar to Jackson Turbidity Units.

nutrient: any substance which is necessary for growth of living things.

nymph: a juvenile, wingless stage of an insect.

O

order: axonomic grouping of related families of organisms.

organic material: any compound containing carbon.

P

pathogenic: capable of causing disease.

pH: the measurement of acidity or alkalinity on a scale of 0 - 14. A pH of 7 is neutral, less than 7 is acidic, and more than 7 is alkaline (basic).

phosphorus: an essential plant nutrient that, in excessive quantities, can contribute to the eutrophication of water bodies.

photosynthesis: process by which green plants use sunlight to produce food.

perennial stream: a watercourse that flows continuously throughout the year and whose upper surface generally stands lower than the water table in the area adjacent to the watercourse.

point source pollution: pollutants originating from a “point” source, such as a pipe, vent, or culvert.

pollution sensitive organisms: those organisms which cannot withstand the stresses applied on the aquatic environment by pollution.

pollution tolerant organisms: those organisms which can withstand many of the stresses applied to an aquatic environment by pollution.

pond: a body of fresh or salt water, smaller than a lake, and where the shallow-water zone (light penetration to its bottom) is relatively large compared to the open water and deep bottom (no light penetration to the bottom).

pools: in a watercourse, an area often following a rapids (riffle), which is relatively deep with slowly moving water compared to the rapids.

pupa: the stage of an insect in which it is enclosed in a protective case while changing from larva to an adult.

R

riffle: in a watercourse, an area often upstream of a pool, which is relatively shallow with swiftly moving water compared to the pool.

riparian zone: an area, adjacent to and along a watercourse, which is often vegetated and constitutes a buffer zone between the nearby lands and the watercourse.

riprap: any hard material (such as concrete blocks, rocks, car tires or log pilings) which are used to protect a stream bank from erosion.

runoff: water from rain, snowmelt, or irrigation that flows over the ground surface and runs into a water body.

S

sediment: soil, sand, and minerals washed from land into waterways.

sedimentation: the process by which soil particles (sediment) enter, accumulate and settle to the bottom of a waterbody.

septic odor: the sulfur (rotten egg) smell produced by the decomposition of organic matter in the absence ofoxygen.
sewage: the organic waste and wastewater produced by residential and commercial establishments.
sewage treatment plant: a facility designed to remove organic pollutants from wastewater.
silt: fine particles of soil or rock that can be picked up by air or water and deposited as sediment.
siltation: the process of silt settling out of the water and being deposited as sediment.
species: a unit of classification for a group of closely related individuals. The lowest common taxonomic unit.
stream bed: the bottom of a stream where the substrate and sediments lay.
stream depth: a measurement of the depth of a stream from the water's surface to the stream bed.
stream flow: the amount of water moving in a stream in a given amount of time.
submergent rooted plant: an aquatic plant whose roots are in the watercourse's bottom with the upper part of the plant submerged below the surface of the water.
substrate: the surface upon which an organism lives or is attached.

T

tolerant species: an organism that can exist in the presence of a certain degree of pollution.
topographic map: a map representing the surface features of a particular area.
total coliform bacteria: a group of bacteria that are used as an indicator of drinking water quality. The presence of total coliform bacteria indicates the possible presence of disease-causing bacteria.
total dissolved solids: substances that are dissolved in the water which can color the water brown or yellow. Tannic acids that leach from tree roots or from decomposing leaves can color the water brown to black due to dissolved chemicals. This color does not disappear by filtering the water.
total suspended solids: whole particles carried or suspended in the water, such as silt, sand or small algae or animals, that cause a green or brown color in the water. These substances can be filtered out of the water and weighed.
toxicity: a measurement of how poisonous or harmful a substance is to plants and animals.
trend data: data or measurements of a stream system which will show how particular characteristics changed over time.
turbidity: the presence of sediment in water, making it unclear, murky or opaque.

U

urban runoff: water which has drained from the surface of land which is used for urban uses, such as paved roads, subdivisions and parking lots.

W

wastewater: water carrying unwanted material from homes, farms, businesses and industries.
water quality: the condition of the water with regard to the presence or absence of pollution.
watershed: the entire surface drainage area that contributes water to a stream or river. Many watersheds which drain into a common river make a drainage basin.
woody vegetation: plants having a stem or trunk that is fibrous and rigid.

Appendix F -
Other Resources

Water Quality Targets

www.IN.gov/idem/nps/watershed-assessment/water-monitoring-and-you/interpreting-data/water-quality-targets

The IDEM Watershed Management Plan (WMP) Checklist (2009) requires groups to identify targets for water quality parameters of concern. A target is defined as the desired measured level of a water quality or habitat/biological parameter that a group has decided streams in the watershed should meet.

Where an Indiana Water Quality Standard or TMDL exists for a parameter of concern, the watershed group must, at a minimum, set the target to meet the respective standard or the loading limit set in the TMDL. Groups are welcome to set more stringent targets if they wish. Table 1 below shows water quality parameters watershed groups are often concerned with and which have an Indiana Water Quality Standard.

A complete list of Indiana's Water Quality Standards can be found in the Indiana Administrative Code (www.IN.gov/legislative/iac/T03270/A00020.PDF).

Table 1

Parameter	Target	Reference/Other Information
Total Ammonia (NH3)	Range between 0.0 and 0.21 mg/L depending upon temperature and pH	Indiana Administrative Code (IAC)
Atrazine	Max: 3.0 ppb	U.S. EPA Drinking Water Standard
Dissolved Oxygen (DO)	Min: 4.0 mg/L Max: 12.0 mg/L	Indiana Administrative Code (IAC)
	Min: 6.0 mg/L in coldwater fishery streams	Indiana Administrative Code (IAC)
	Min: 7.0 mg/L in spawning areas of coldwater fishery streams	Indiana Administrative Code (IAC)
E. coli	Max: 235 CFU/ 100mL in a single sample	Indiana Administrative Code (IAC)
	Max: Geometric Mean of 125 CFU/ 100mL from 5 equally spaced samples over a 30-day period	Indiana Administrative Code (IAC)
Nitrate	Max: 10 mg/L in waters designated as a drinking water source	Indiana Administrative Code (IAC)
Nitrite	Max: 1 mg/L in waters designated as a drinking water source	Indiana Administrative Code (IAC)
Nitrate-N + Nitrate-N	Max: 10 mg/L in waters designated as a drinking water source	Indiana Administrative Code (IAC)
Temperature	Dependant on time of year and whether stream is designated as a cold water fisheries	Indiana Administrative Code (IAC)

Many of the water quality parameters watershed groups are concerned with do not have a standard. In these instances groups are free to set whatever target they deem appropriate. But that freedom can be overwhelming given the myriad of targets being used across the county. This guidance does not attempt to tell watershed groups what targets to choose, but rather lists (Table 2, following page) several targets used by other watershed groups in Indiana and the source of those targets. IDEM hopes this information helps watershed groups wisely choose water quality targets for their specific watershed.

Table 2		
Parameter	**Target**	**Reference/Other Information**
Nitrate-nitrogen (NO3)	Max: 0.633 mg/L	U.S EPA recommendation *
	Max: 1.0 mg/L	Ohio EPA recommended criteria for Warm Water Habitat (WWH) headwater streams and Modified Warm Water Habitat (MWWH) headwater streams
	1.5 mg/L	Dividing line between mesotrophic and eutrophic streams (Dodd et al. 1998)
	10.0 mg/L	IDEM draft TMDL target
Ortho-phosphate also known as soluble reactive phosphorus (SRP)	Max: 0.005 mg/L	Wawasee Area Conservancy Foundation recommendation for lake systems
Suspended Sediment Concentration (SSC)	Max: 25.0 mg/L	U.S. EPA recommendation for excellent fisheries
	Range: 25.0-80.0 mg/L	U.S. EPA recommendation for good to moderate fisheries
Total Kjeldahl Nitrogen (TKN)	Max: 0.591 mg/L	U.S. EPA recommendation *
Total Phosphorus	Max: 0.076 mg/L	U.S. EPA recommendation
	Max: 0.07 mg/L	Dividing line between mesotrophic and eutrophic streams (Dodd et al. 1998)
	Max: 0.08 mg/L	Ohio EPA recommendation to protect aquatic biotic integrity in WWH
	Max: 0.3 mg/L	IDEM draft TMDL target
Total Suspended Solids (TSS)	Max: 80.0 mg/L	Wawasee Area Conservancy Foundation recommendation to protect aquatic life in lake systems
	Max: 30.0 mg/L	IDEM draft TMDL target
	Range: 25.0-80.0 mg/L	Concentrations within this range reduce fish concentrations (Waters, 1995)
	Max: 40.0 mg/L	New Jersey criteria for protection of fish/macroinvertebrate health
	Max: 46.0 mg/L	Minnesota TMDL criteria for protection of fish/macroinverte-brate health
Turbidity	Max: 25.0 NTU	Minnesota TMDL criteria for protection of fish/macroinverte-brate health
	Max: 10.4 NTU	U.S. EPA recommendation

** U.S. EPA recommended criteria are different for parts of southwest Indiana within Ecoregion IX. See Ecoregional Nutrient Criteria Documents for Rivers & Streams for more information.*

Geometric Mean: In mathematics, a type of mean or average, which indicates the central tendency or typical value of a set of numbers. It is similar to the arithmetic mean, which is what most people think of with the word "average," except that instead of adding the set of numbers and then dividing the sum by the count of numbers in the set, n, the numbers are multiplied and then the nth root of the resulting product is taken. A geometric mean, unlike an arithmetic mean, tends to dampen the effect of very high or low values, which might bias the mean if a straight average (arithmetic mean) were calculated. This is helpful when analyzing bacteria concentrations, because levels may vary anywhere from 10 to 10,000 fold over a given period.

Geometric Mean Formula:
Geometric Mean = ((X1)*(X2)*(X3)*.......(XN))1/N
where
X = Individual score
N = Sample size (Number of scores)

Geometric Mean Example:
Use the following set of values - 1, 2, 3, 4, and 5 to find the Geometric Mean.

Step 1: Find 1/N
a. N = 5, the total number of values
b. Using the above value, 1/5 = 0.2

Step 2: Calculate the Geometric Mean
a. ((1)*(2)*(3)*(4)*(5)) 0.2 = (120)0.2
b. Geometric Mean = 2.60517

The Indiana Administrative Code uses the Geometric Mean as a calculation for five evenly spaced samples of *E. coli* over 30-days in order to determine compliance with the water quality standard.

In Microsoft Excel, the equation for geomean is =Geomean(Xx:Yy)

Notes:

Useful Contacts

Regardless of which watershed you are working in, there are likely others in your area with similar interests and goals. Finding such persons and organizations can seem daunting at times. There are five regional Watershed Specialists at IDEM who can assist you in locating others with whom you may want to communicate and/or collaborate. A link to the Specialists is referenced here as primary contacts for you, in addition to a list of their respective watersheds that they support. Following that is a brief overview of other agencies who may be working in your area of interest. They may be monitoring streams. They may have funding for grants. And don't forget to look across state lines for others working in your watershed!

IDEM Watershed Specialists www.idem.IN.gov/nps/contact		
Northwest Region:	Chicago Iroquois Kankakee Little Calumet-Galien Middle Wabash-Deer	Middle Wabash-Little Vermillion Sugar Tippecanoe Vermillion Wildcat
Northeast Region:	Auglaize Eel (Wabash R.) Maumee Mississinewa Salamonie	St. Marys St. Joseph (OH) St. Joseph (MI) Upper Wabash Upper White
Southwest Region:	Eel (WFWR) Highland-Pigeon Lower Ohio-Little Pigeon Lower Wabash	Lower White Middle Wabash-Busseron Patoka
Southeast Region:	Blue-Sinking Driftwood Flatrock-Haw Lower East Fork White Lower Great Miami Middle Ohio-Laughery	Muscatatuck Silver-Little Kentucky Upper East Fork White Upper Great Miami Whitewater

Clean Water Indiana Program www.in.gov/isda/divisions/soil-conservation/ clean-water-indiana	Indiana Clean Lakes Program https://clp.indiana.edu
DNR Healthy Rivers Initiative www.in.gov/dnr/healthy-rivers	Indiana Conservancy Districts https://www.in.gov/dnr/water/publications/indiana- conservancy-district-directory
Indiana Conservation Partnership http://icp.iaswcd.org	Indiana Environmental Organizations https://ecoindiana.net/people
Indiana Association of Soil and Water Conservation Districts http://wordpress.iaswcd.org	Indiana Regional Water and Sewer Districts www.in.gov/idem/cleanwater/information-about/ regional-water-sewer-and-solid-waste-districts/region- al-district-users-guide-for-citizens-and-governments
Indiana River Basin Commissions www.in.gov/dnr/water/publications/indiana- conservancy-district-directory	Indiana State Department of Health Laboratories www.in.gov/health/laboratories
Indiana State Department of Agriculture www.in.gov/isda	Local Health Departments https://in.gov/health/health-and-human-services/ local-health-department-outreach-division/ local-health-department-information
Indiana Watershed Leadership Academy https://engineering.purdue.edu/watersheds/ academy.html	Natural Resources Conservation Service www.nrcs.usda.gov/wps/portal/nrcs/in/home
Indiana Water Quality Atlas www.in.gov/idem/nps/eservices/indiana- water-quality-atlas	Navigable Waterways of Indiana www.in.gov/nrc/nonrule-policy-documents-npd/ navigable-waterways-roster
River Organizations in Indiana www.in.gov/dnr/state-parks/recreation/wa- ter-trails/paddling-and-river-organizations	River Rights & Usage in Indiana www.in.gov/dnr/state-parks/recreation/water-trails/ river-rights-and-usage

Notes:

Appendix G -
Additional Reading Material

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Appendix H -
Extra Data Sheets

- **Citizens Qualitative Habitat Evaluation Index**
- **Stream Flow (Discharge) Data Sheet**
- **Stream Site Map**
- **Chemical Monitoring Data Sheet**
- **Biological Monitoring Data Sheet**

Citizens Qualitative Habitat Evaluation Index (CQHEI)

Date: __/__/__ Volunteer ID: ____________ Site ID: ____________

Stream Name: ____ CQHEI Total

I. SUBSTRATE (bottom type) Score:

a) Size

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

b) "Smothering"

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

- ☐ 5 pt No
- ☐ 0 pt Yes

Symptoms: Hard to move pieces, often black on bottom.

c) "Silting"

Are Silts and Clays Distributed Throughout Stream?

- ☐ 5 pt No
- ☐ 0 pt Yes

Symptoms: Light kicking results in substantial clouding for more than a minute.

II. FISH COVER (hiding places) - Add 2 Points For Each One Present Score:

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

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
- ☐ 9 pt Few Minor Man-Made Changes (e.g., a bridge)
- ☐ 6 pt Many Man-Made Changes, but Some Natural Conditions left (e.g., trees, meanders)
- ☐ 0 pt Heavy, Man-made Changes (e.g., leveed or channelized)

IV. STREAM FORESTS & WETLANDS (riparian area) & EROSION Score:

a) Riparian Width Mostly:

- ☐ 8 pt Wide (Can't throw a rock through it)
- ☐ 5 pt Narrow (can throw a rock through it)
- ☐ 0 pt None

b) Land Use - Mostly:

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

c) Bank Erosion

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

d) Stream Shading

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

V. DEPTH & VELOCITY Score:

a) Deepest Pool is At Least:

- ☐ 8 pt Chest Deep
- ☐ 6 pt Waist Deep
- ☐ 4 pt Knee Deep
- ☐ 0 pt Do Not Exist

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

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

VI. RIFFLES/RUNS (areas where current is fast/turbulent, surface may be broken) Score:

a) Riffles/Runs Are:

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

b) Riffle/Run Substrates Are:

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

Hoosier Riverwatch

Stream Flow (Discharge) Data Sheet

Date ____/____/____ Volunteer ID________________ Site ID ________________________________

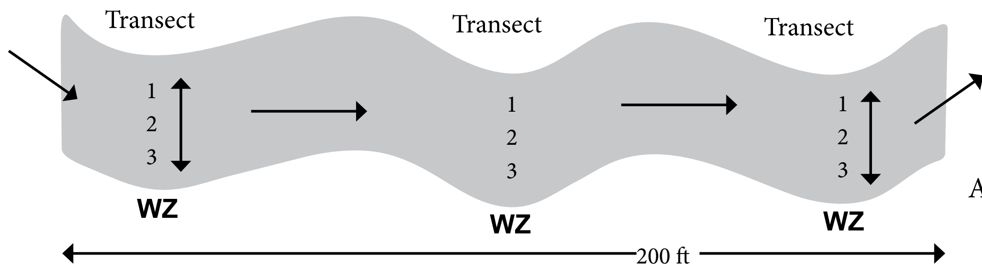
Stream Name____

Solving the equation:	*Where:*
FLOW (D) = W x Z x V x n	**W** = Average Width **Z** = Average Depth **V** = Average Velocity **n** = Coefficient - 0.8 for gravel/rocky bottom streams 0.9 for muddy or bedrock bottom streams **D** = Flow/Discharge

Convert measurements of feet + inches to 10ths of feet. **1 inch = 0.0833 feet**

W
River Width

(one measurement at each transect)



Transect	Width (ft)
1	
2	
3	
Average	

Z
River Depth

(three measurement along each transect)

Transect	Transect 1 (ft)	Transect 2 (ft)	Transect 3 (ft)
1			
2			
3			
Average of Transects			

Average of Averages

V
Surface Velocity = Length/Time

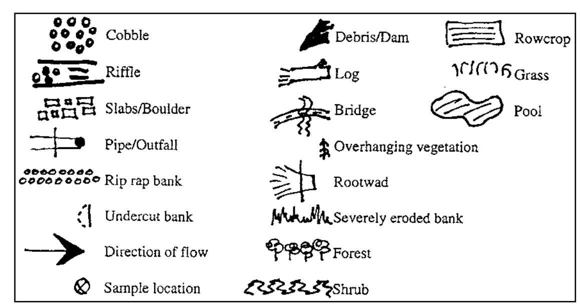
(allow the object to attain velocity before timing)

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

D
Stream Flow or Discharge

				=	
W x	**Z** x	**V** x	**n***		**D (cfs)**

**Coeffecient (0.8 for gravel/rocky bottom streams, 0.9 for muddy or bedrock bottom streams*


Cobble
Riffle
Slabs/Boulder
Pipe/Outfall
Rip rap bank
Undercut bank
Direction of flow
Sample location
Debris/Dam
Log
Bridge
Overhanging vegetation
Rootwad
Severely eroded bank
Forest
Shrub
Rowcrop
Grass
Pool

Hoosier Riverwatch
Chemical Monitoring Data Sheet

Date _____ / _____ / ______ Volunteer ID _______________ Site ID ___________________

Stream Name ____ Latitude ____________ Longitude ____________

Time _____ : _____ AM / PM Time Sampling ___________ hrs Air Temp.: _____________ °C

Current Weather: ☐ Clear/Sunny ☐ Overcast ☐ Showers ☐ Rain (steady) ☐ Storm (heavy)

Worst Weather (past 48 hours): ☐ Clear/Sunny ☐ Overcast ☐ Showers ☐ Rain (steady) ☐ Storm (heavy)

	Units	Sample # 1	Sample # 2	Sample # 3	Avg.	**Q-Value**	x Weighting Factor	= **Calculation** *(Q-value x Wt. Factor)*
Temperature								
Water Temp at Site	°C							
Water Temp 1 Mile Upstream	°C							
Water Temp Change: *Site Temp - Upstream Temp*	°C						0.11	
Dissolved Oxygen								
Dissolved Oxygen	mg/L							
DO% Saturation: *Determine from chart or table/equation*	%						0.18	
BOD								
Avg. Dissolved Oxygen: *(Calculated Above)*	mg/L							
Dissolved Oxygen after 5 days	mg/L							
BOD *Avg DO (original)-DO after 5 days*	mg/L						0.12	
pH								
pH							0.12	
Nutrients								
Orthophosphate	mg/L							
Total Phosphate *(boil in acid)*	mg/L						0.11	
Nitrate (NO3) *multiply by 4.4*	mg/L						0.10	
Nitrite (NO2) *multiply by 3.3*	mg/L							
Turbidity								
Transparency *(from tube)*	cm							
Turbidity *(convert from chart/table)*	NTU						0.09	
Bacteria								
E.Coli Bacteria	cfu/100 mL						0.17	
Fecal Coliforms	cfu/100 mL							

Use Average DO value for BOD calculation.

Remember to convert your reading from the tube to NTUs.

Add Weighting Factors for test completed.

Add the calculation column.

TOTALS

Divide Total of Calculation Column by Total Weighting Factor Column

WQI

WQI Ratings	
Excellent	90 - 100%
Good	70 - 87%
Medium	50 - 69%
Bad	25-49%
Very Bad	0-24%

H o o s i e r   R i v e r w a t c h

Biological Monitoring Data Sheet

Date: ____ / ____ / ____   **Volunteer ID:** __________   **Site ID:** __________

Stream Name: ______________________________   **Latitude:** ________   **Longitude:** _______

Time _____:____ AM / PM   **Time Sampling:** ______ hrs   **Air Temp.:** ___________ °C

Current Weather: ☐ Clear/Sunny ☐ Overcast ☐ Showers ☐ Rain (steady) ☐Storm (Heavy)

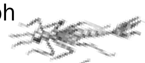
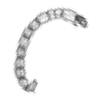
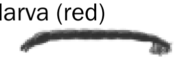
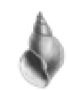
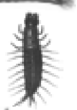
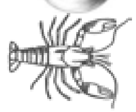
Worst Weather (past 48 hours): ☐ Clear/Sunny ☐ Overcast ☐ Showers ☐ Rain (steady) ☐Storm (Heavy)

Check Methods Used: ☐ Kick Seine Net (3 times) ☐ Dip Net (20 jabs or scoops)

Check Habitats Sampled: ☐ Undercut Banks ☐ Riffles ☐ Leaf Packs ☐ Snags/Vegetation ☐Sediment

Pollution Tolerance Index (PTI)

Record the taxa (group) represented in your sampling by either entering the number of organisms you counted or a ✓

Group 1 - Intolerant	Group 2 - Moderately Intolerant	Group 3 - Fairly Tolerant	Groups 4 - Very Tolerant
☐ Stonefly nymph 	☐ Damselfly nymph 	☐ Leech 	☐ Aquatic worm 
☐ Mayfly nymph 	☐ Dragonfly nymph 	☐ Midge larva 	☐ Blood midge larva (red) 
☐ Caddisfly larva 	☐ Scud 	☐ Planaria/ Flatworm 	☐ Rat-tailed Maggot 
☐ Riffle Beetle 	☐ Sowbug 	☐ Black fly larva 	☐ Left-Handed or Pouch snail 
☐ Dobsonfly Larva 	☐ Cranefly larva 		
☐ Right-Handed or Gilled snail 	☐ Clam/Mussel 		
☐ Water Penny 	☐ Crayfish 		
☐ **# of TAXA represented**	☐ **# of TAXA represented**	☐ **# of TAXA represented**	☐ **# of TAXA represented**
☐ Weighting Factor (x4)	☐ Weighting Factor (x3)	☐ Weighting Factor (x2)	☐ Weighting Factor (x1)

Pollution Tolerance Index Rating

(Add the final index values for each group)

PTI Ratings	
Excellent	23 or More
Good	17 - 22
Fair	11 - 16
Poor	10 or Less

Please check other Biological Indicators you observed:

☐ Native Mussels ☐ Zebra Mussels ☐ Rusty Crayfish ☐ Aquatic Plants _____ % Algae Cover _____ Diversity Index

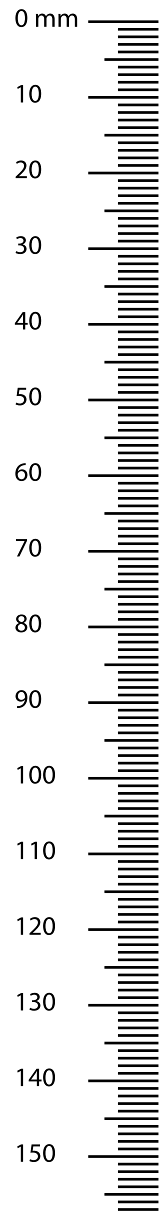
WEIGHTS AND MEASUREMENTS

Metric System

LINEAR MEASURE		
1000 millimeters (mm)	=	1 meter
100 centimeters (cm)	=	1 meter
1000 meters (m)	=	1 kilometer (km)
AREA MEASURE		
100 sq. millimeters (mm^2)	=	1 sq. centimeter
10, 000 sq. centimeters (cm^2)	=	1 sq. meter
1,000,000 sq. millimeters (mm^2)	=	1 sq. meter
100 sq. meters (m^2)	=	1 are(a)
100 ares (a)	=	1 hectare (ha)
100 hectares (ha)	=	1 sq. kilometer (km^2)
1,000,000 sq. meters (m^2)	=	1 km^2
VOLUME MEASURE		
1 liter	=	0.001 cubic meter (m^3)
1000 milliliters	=	1 liter
100 centiliters	=	1 liter
1000 liters	=	1 kiloliter
WEIGHT		
1000 milligrams	=	1 gram
100 centigrams	=	1 gram
1000 grams	=	1 kilogram
1,000 kilograms	=	1 metric ton

U.S. Customary System

LINEAR MEASURE		
12 inches	=	1 foot
3 feet	=	1 yard
AREA MEASURE		
144 sq. inches	=	1 sq. foot
9 sq. feet	=	1 sq. yard
30 1/4 sq. yards	=	1 sq. rod
150 sq. rods	=	1 acre
640 acres	=	1 sq. mile
1 sq. mile	=	1 section
36 sections	=	1 township
LIQUID MEASURE		
3 teaspoons (tsp)	=	1 Tablespoon Tbsp)
4 Tbsp	=	1/4 cup
5 1/3 Tbsp	=	1 pint
16 Tbsp	=	1 cup
2 cups	=	1 pint
4 cups	=	1 quart
2 pints	=	1 quart
4 quarts	=	1 gallon
WEIGHT		
16 ounces	=	1 pound
2000 pounds	=	1 ton



Conversion Table

LINEAR MEASURE

To convert	into	Multiply by
Centimeters	Inches	0.394
	Feet	0.0328
	Meters	0.01
	Millimeters	10
Inches	Centimeters	2.54
	Feet	0.0833
	Meters	0.0254
	Yards	0.0278
Meters	Centimeters	100
	Feet	3.281
	Inches	39.37
	Kilometer	0.001
	Miles	0.0005214
	Millimeters	1000
	Yards	1.093
Kilometers	Feet	3281
	Meters	1000
	Miles	0.621
	Yards	1093
Miles	Feet	5,280
	Yards	1,760
	Kilometers	1,609
Yards	Inches	36
	Feet	3
	Meters	1
	Miles	0.0005682

DRY AND LIQUID MEASURE

To convert	into	Multiply by
Pounds	Grams	435.59
	Ounces	16
	Kilograms	0.02
Grams	Ounces	0.035
	Pounds	0.002
	Kilograms	0.001
Kilograms	Grams	1000
	Ounces	35274
	Pounds	2205
Liters	Cups	4.225
	Pints	2.113
	Gallons	0.264
	Milliliters	1000
	Quarts	1.057
Pints	Liters	0.473
	Quarts	0.5
	Gallons	0.125
Quarts	Pints	2
	Liters	0.946
	Gallons	25
Gallons	Pints	8
	Liters	3.785
	Quarts	4
Ounces	Grams	28.35
	Pounds	0.0625
	Kilograms	0.028

www.idem.IN.gov/riverwatch

IDEM

Indiana Department of Environmental Management

Office of Water Quality

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"Never doubt that a small group of thoughtful, committed citizens can change the world. Indeed, it's the only thing that ever has."

Margaret Meade

A State that Works

06/2022