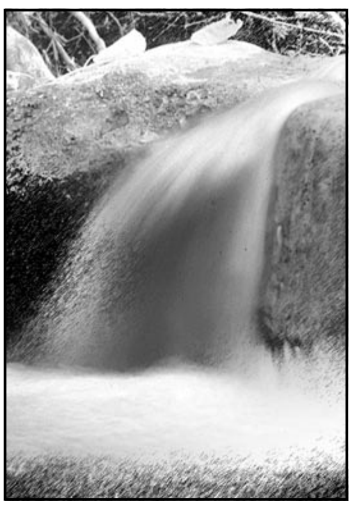
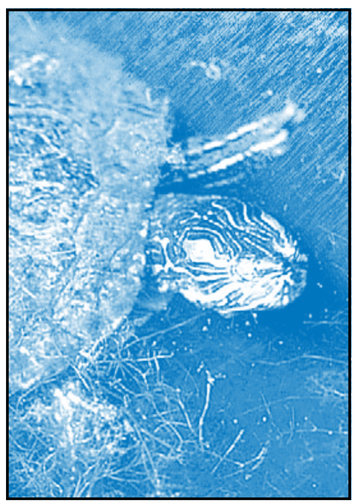
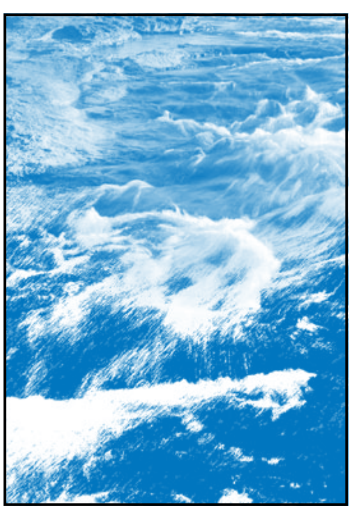
TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

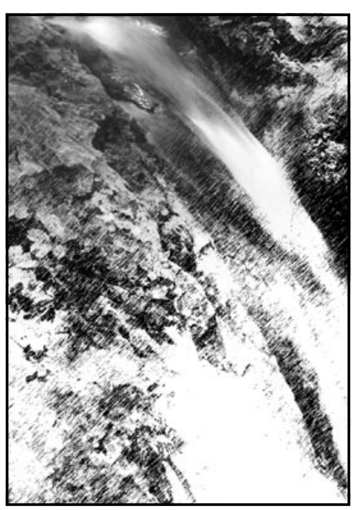
Water Education Field Guide

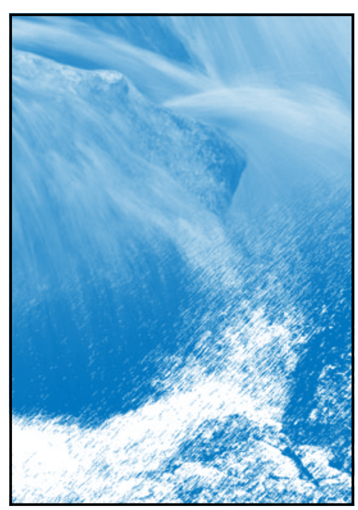




TCEQ guide for engaging 4th-8th grade students in hands-on field study of Texas waters







Water Education Field Guide

TCEQ guide for engaging 4th-8th grade students in hands-on field study of Texas waters

TCEQ

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Introduction

Texas is the second largest state in the country, in both area and population. The state supports approximately 20 million people along with a variety of businesses, industries and diversified agriculture. Without a doubt, supporting the needs of its citizens puts great demands on the state's natural resources.

The resource that most affects growth is water. Growth and development in Texas have created the challenge of preserving the quality and quantity of the state's water supplies. In recent years, extended drought conditions in the state have elevated concern over the ability to maintain the quality and quantity of water to support not only economic growth but also the natural environment.

Environmental education is essential to the future of Texas. Developing an appreciation for water and understanding how human activities affect its quantity and quality is the first step in the protection and conservation of the state's water resources for a healthy, viable future.

Since the future of Texas depends on the wise management of water, the state's crucial supply of water must be protected. Through water education we can work together to understand and help conserve and protect water resources in our local environment. Although water quantity and quality issues are of equal importance, the activities in this book focus on water quality.

What This Course Covers

Keep in mind that this book and the activities in it are geared toward streams and rivers and not lakes or reservoirs.

Lessons in this handbook guide participants as they select and survey a local body of surface water, which may be a creek, stream, or river. Although ponds and lakes should not be overlooked, creeks and streams are more suitable for study and access by students doing the activities in this handbook. Through water testing, field observations, and problem solving, student teams work to recognize possible pollution sources. At the conclusion of the water quality activities, students can prepare community awareness projects to share what they have learned.

Also contained in this handbook are indoor/outdoor water quality activities that provide hands-on experiments for students in areas where surface water is not readily available. These experiments may also be used to supplement the "Water Quality Activities" section.

It is vitally important that students study pollution problems, understand the value of water, and realize the need to conserve and protect water supplies. It is the goal of the Texas Commission on Environmental Quality (TCEQ), through this guide, to encourage young people to become environmentally conscious decision makers.

Objectives

At the completion of these activities, students will have gained experience in doing the following:

- completing laboratory experiments
- collecting information from the field using senses like sight and smell
- ordering and sequencing data
- drawing logical conclusions
- forming generalized statements
- communicating data orally and in writing
- understanding concepts and skills of measurement
- applying defined terms based on observations

Participation

These motivating activities are appropriate in the regular classroom, as an extension, or an extracurricular activity. These activities have been the basis of Science Fair projects. The suggested grade levels for most of the activities are 4th-6th grade, but with some modifications, they can be appropriately offered from Kindergarten through 12th grade.

Youth groups, such as the following, also have used these activities in planning individual and group projects.

- Scouts and other youth organization members
- Science club members
- 4-H club members
- Youth (summer) campers
- Volunteer students

Suggested Group Organization

Example #1: A teacher from any grade or specialty with a group of students may wish to organize a once-a-week project that would last six to eight weeks.

Example #2: A teacher may wish to involve an entire class in the project during the school day.

Example #3: A youth leader may wish to organize water education outings and complete several of the water quality activities at each gathering.

Note: Guest speakers are a real asset to the program. Examples include wastewater treatment plant operators (you may wish to set up a tour of the plant); local science professionals at universities, government agencies such as TCEQ, Texas Parks and Wildlife Department (TPWD), or the U.S. Geological Survey; river authorities; cities; local volunteer monitoring programs; or teachers active in water quality projects.

Resources Needed

The following materials are required to do the suggested activities:

- *Water Education Field Guide*
- copies of Field Data Sheets as needed for student use (at the back of this handbook)
- street map of the area
- topographic map of the watershed where water education activities take place
- scientific data collection materials; each activity has a list of required supplies specific to the task. The following are examples of the type of equipment necessary:
  - dissolved oxygen test kit*
  - coliform test kit*
  - pH test kit*
  - phosphate test kit*
  - containers for water quality tests (collection and measurement)
  - thermometers
- goggles for students doing dissolved oxygen tests
- wooden stakes or other markers
- measuring tape or meter sticks
- trash bags
- rubber gloves
- work gloves or garden gloves for picking up trash
- pencils
- paper
- optional: magnetic compasses, aerial photos*, hand lenses or microscopes, and blank slides

Community Sponsorship

Many businesses, public agencies and civic organizations are looking for ways to become involved in community projects. Some that may wish to participate are:

- city health departments
- college or high school biology/hydrology departments
- state environmental agencies (for example, TCEQ, TPWD)
- local river authorities
- private environmental engineering firms
- water recreation groups
- soil conservation organizations
- garden clubs
- environmental groups
- the Agriculture Extension Service

Potential sponsors should be approached with specific proposals about the costs, resources, time, and personnel needed. They should be allowed to become involved as little or as much as they like. They may be able to provide assistance with speakers, field trips, participation certificates, a place to display student products, or financial support.

**available from science education suppliers such as Wards (www.wardsci.com), Frey (www.Freybg.com), La Motte (www.lamotte.com) or Hach (www.hach.com). Check in a school library or the Internet for a catalog.*

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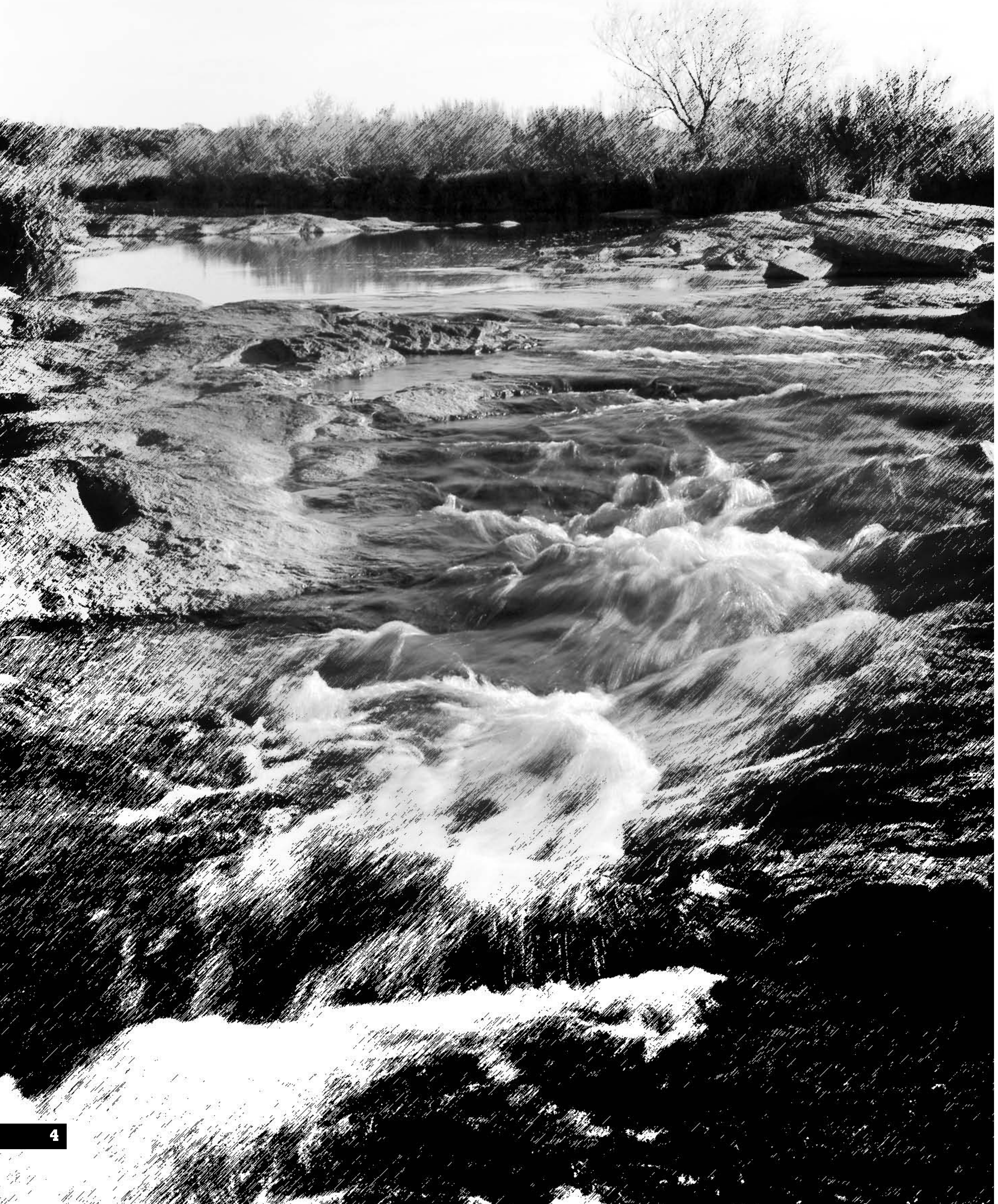
Once a relationship with a sponsor has been formed, the sponsor should be consulted on how they would like to be acknowledged.

- Participants working with chemical tests should always wear goggles and latex type rubber gloves.
- All participants should wash their hands with soap and water after contact with a natural water source (creek, river, pond, lake, and so on).
- Teachers/group leaders should select safe routes to the adopted area.
- Teachers/group leaders should not allow participants to get in water above their ankles without a life jacket.
- Participants should not carry glass containers during outdoor activities.
- Teachers/group leaders should take along a simple first aid kit to handle minor injuries.
- Participants should work in teams of at least two.
- Teachers/group leaders should always let someone know exactly where the group is working each day.
- Teachers/group leaders should position themselves so that they can see each participant during outdoor activities.
- Teachers/group leaders should cancel on-site visits during periods of heavy rain when flash flooding is possible.
- Participants should wear work or garden gloves when picking up trash.
- Poison ivy is common along streams; available poison ivy washes and preventive lotions may be used.
- Sunscreen should be available.
- Teachers/group leaders should ensure accessibility to chosen site(s). For example, permission should be obtained in advance to go onto private property.

For complete instructions on Texas safety standards in the classroom, laboratory and field investigations, visit the Charles A. Dana Center's web site: www.utdanacenter.org/sciencetoolkit/safety/texas_safety.php



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Basics of Water Quality

Water Facts

What is water?

Water is...

- the most abundant, unique, and important substance on earth
- essential to life
- an essential part of all living things
- a universal solvent that makes all biological functions possible
- the only substance that occurs naturally in all three physical states (solid, liquid, and gas)
- odorless, tasteless, colorless, and transparent in its pure liquid state
- two atoms of hydrogen and one atom of oxygen (H_2O)

Basics of Life in the Water

- Photosynthesis occurs in aquatic environments (rivers, streams, lakes, ponds, and other bodies of water) as well as on land.
- In the aquatic environment, aquatic plants (for example, cattails, water lilies, hydrilla), phytoplankton (microscopic free-swimming algae), and filamentous algae (thread-like strands) absorb sunlight and convert it to sugar through the process known as photosynthesis.
- During the day, photosynthesis allows aquatic plants and algae to produce oxygen and then use this oxygen at night when there is no light to continue photosynthesis. Other aquatic organisms (invertebrates, fish) rely on the oxygen produced by the plants and algae. Oxygen is usually lowest in a water body in the early morning hours slightly after dawn before photosynthesis begins.
- Zooplankton (microscopic aquatic animals) eat phytoplankton and are in turn eaten by small fish or invertebrates, who are eaten by larger fish, birds and invertebrates; this process is commonly referred to as a food chain.

Basics of Water Study

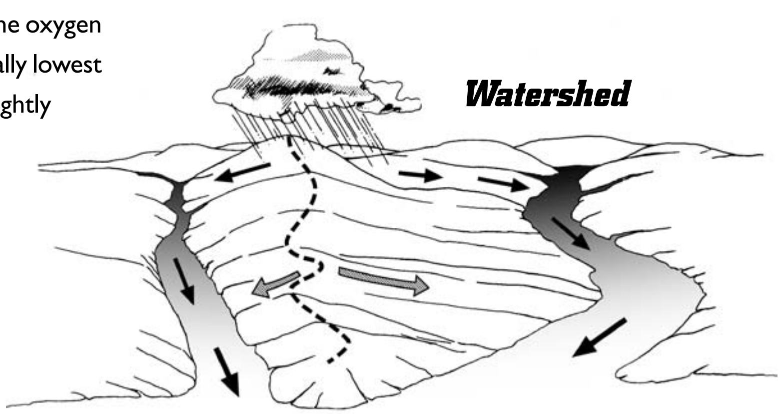
- The study of water involves physical, chemical, and biological conditions.
- Physical parameters refer to conditions such as water temperature, stream flow, pH, dissolved oxygen, and turbidity (water clarity).
- Chemical parameters refer to the chemical makeup of water such as the amount of nutrients (phosphorus and nitrogen compounds) or heavy metals (arsenic, copper, lead, and others).
- Biological parameters refer to organisms supported in the water such as bacteria, plankton, benthic macroinvertebrates, and fish.

Stream Systems and Watersheds

Stream systems are a dynamic part of the environment. They include surrounding watersheds; stream channels; in-stream habitats; stream banks; and ponds, lakes and rivers. All of the components in the stream system influence living things within the water, so it is important to consider every element in the study of stream systems.

Watersheds

A watershed is a geographic area in which water, sediments, and dissolved materials drain into a common outlet. This outlet could be a stream, lake, playa, estuary, aquifer,



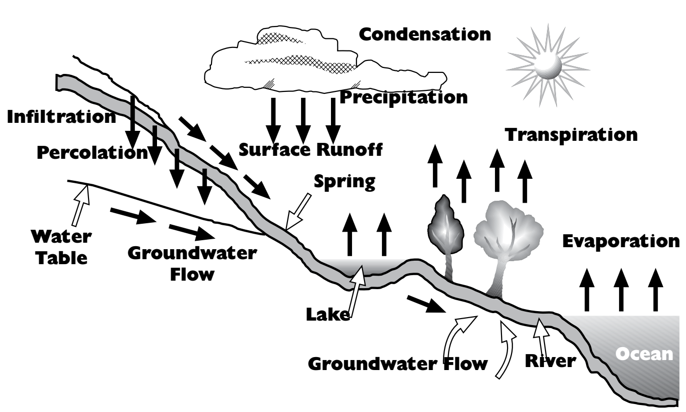
or ocean. Watersheds are also commonly called drainage basins or drainage areas. The total area of land that contributes runoff to the stream is determined by topographic boundaries. A ridge or other area of elevated land, called a divide, separates one watershed from another. Streams on one side flow a different direction than streams on the other side of the topographic boundary.

Watersheds are complex systems. Each watershed differs depending on things like climate; amount of rainfall; geology and geography of an area (rocks, soil, hills, lowlands, forests, urban areas); and human activities — all interacting within the system.

When it rains, water flows overland and through soils, recharging underground water supplies and draining into nearby streams. Everything that happens in the watershed can contribute to what ends up in a stream. Impurities such as oil and grease or bacteria (from untreated wastewater, septic tanks, and other sources) are picked up in the water flow and deposited in a nearby stream. The concentration of these impurities, and the speed and the amount of water flowing to a stream, can affect the stream's water quality.

In natural areas, such as forests, vegetation slows the flow of water over the land, filtering some impurities and decreasing erosion. In these areas as much as half of all rainfall is absorbed into the ground, becoming ground water. In urban areas, many vegetated surfaces are replaced with impervious cover, like parking lots, which does not allow water to soak into the ground; instead the water flows more swiftly downhill. This increased flow can lead to flooding and erosion, and allows more pollutants to reach surface waters. In many urban areas, less than one-third of all rainfall is absorbed into the ground.

The Hydrologic Cycle

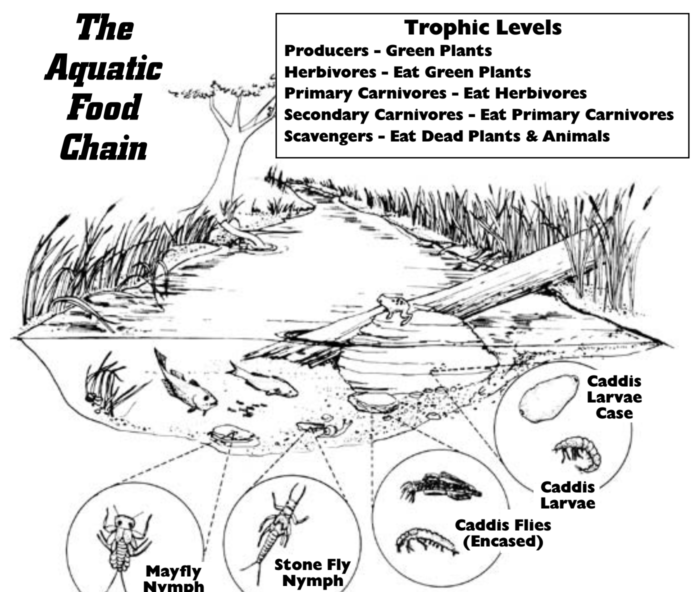


The concentration of impurities, the speed and amount of water, the materials the water flows over or through, and the steepness of the land all play a part in water quality.

Stream Channels

Stream channels are created as runoff from the watershed seeks a path of least resistance. If the watershed has very steep terrain, the resulting swift-moving water may cut a deep stream channel and keep the stream bed flushed of sediments. If the topography is flat, the stream may be shallow and meandering, with sediments suspended in the water column.

In its natural condition, a stream channel provides a variety of habitats for many species of aquatic plants and animals. These in-stream habitats provide areas for feeding, resting, and reproduction and generally support a great diversity of organisms.



Source: Kentucky Division of Water

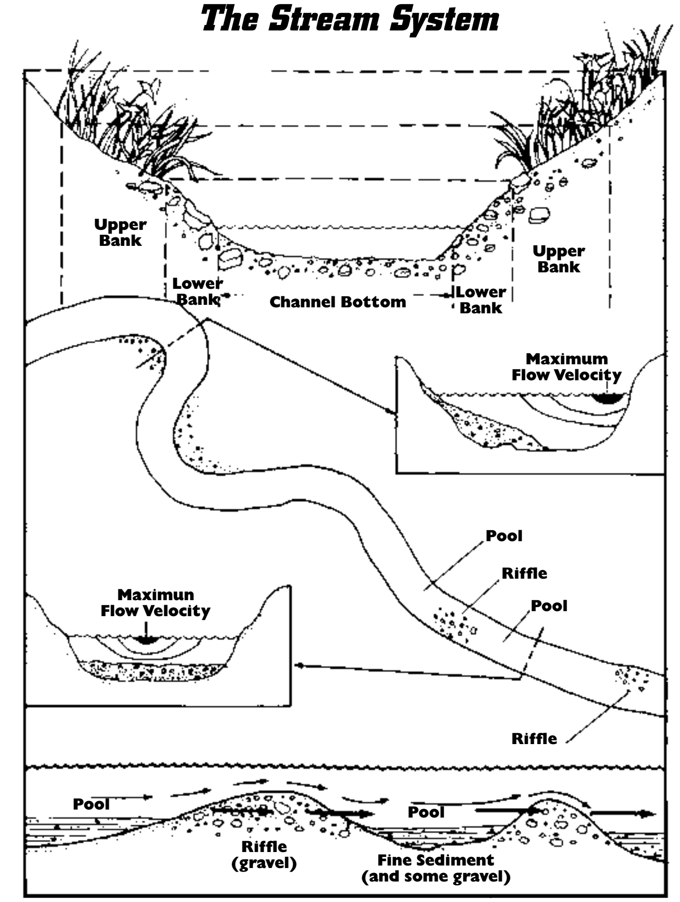
In-Stream Habitats

In-stream habitats include pools, riffles, root mats, aquatic plants, undercut banks, overhanging vegetation, leaf litter, and submerged rocks and logs. These, along with the depth and flow of the water, are key factors in determining the type of aquatic organisms found in a stream. Again, under natural conditions, a greater variety of combined habitats means a greater diversity of aquatic life. Poor quality in-stream habitats can often be the cause of low diversity of aquatic life in streams with no water quality problems.

Stream Banks

Stream banks and the associated riparian zones (which generally includes the vegetated area of a stream bank and out onto the flood plain) serve many functions other than keeping the water in the channel. They are home to many plants and animals and, under natural conditions, help protect the stream from outside influences. When these areas are covered with trees, shrubs, and herbaceous (non-woody) plants, they provide erosion control, sediment collection, and nutrient absorption, all of which contribute to maintaining water quality.

The Stream System



The above diagram shows the water flow and major structures of a stream. Notice how the pools and riffles alternate. A major feature of the riffle is that water flows through the gravel as well as over it. This enables small fish and small benthic invertebrates to obtain the oxygen they need while being protected from predation by larger organisms such as fish. (Source: Kentucky Division of Water).

Rivers

Rivers are large natural streams that carry a considerable volume of water. Rivers serve as a collection point for all the smaller creeks and streams in a watershed and ultimately carry water to coastal areas.

They are extremely important water supply sources for domestic, agricultural, and industrial uses and for hydroelectric power.

The amount of water a river transports is the result of many factors. The size of the drainage basin; the climate; geography; geology; size of the stream channel; stream alterations (channelization, dredging, reservoir construction); and the water table (level of ground water) are the main factors that influence stream flow. When it is not raining, a river can receive water from groundwater subsurface flow; thus the water-storing capacity of rocks and soil surrounding a river can strongly influence flow.

All natural stream systems, whether in mountains or flatlands, possess a great diversity of plants and animals. A decline in the number of different organisms (diversity) or the total number of organisms (density) occurs when the system is in some way altered. Although there are some natural conditions that can create problems for streams, ponds, lakes, and rivers, most problems result from human activities.

Reservoirs

Reservoirs are created when people erect structures to dam surface water. Most reservoirs consist of a retaining structure or dam, and a spillway that limits the maximum water level. Many reservoirs also have outlet structures that allow the controlled release of water. Whatever the size, the main function of a reservoir is to stabilize the flow of water from a watershed or to satisfy the varying demands of water consumers.

The construction of reservoirs causes significant changes to rivers and streams. In addition to the control of flow in streams and rivers, reservoirs can alter the quality of water and in-stream habitat.

Sources of Pollution

There are several main groups of pollutants that can affect water quality: sediment, nutrients, toxic substances, and organic wastes. Observable signs of water pollution can include discoloration, unpleasant odors, excess algae growth, cloudy or silty water, and in extreme cases, dead fish, plants or animals. Water pollution originates from two categories related to human activities: point source and nonpoint source. "Pollution" can also be the result of natural conditions. For example, in arid climates the salt content of the soil can be high causing increased salinity in area surface and ground waters.

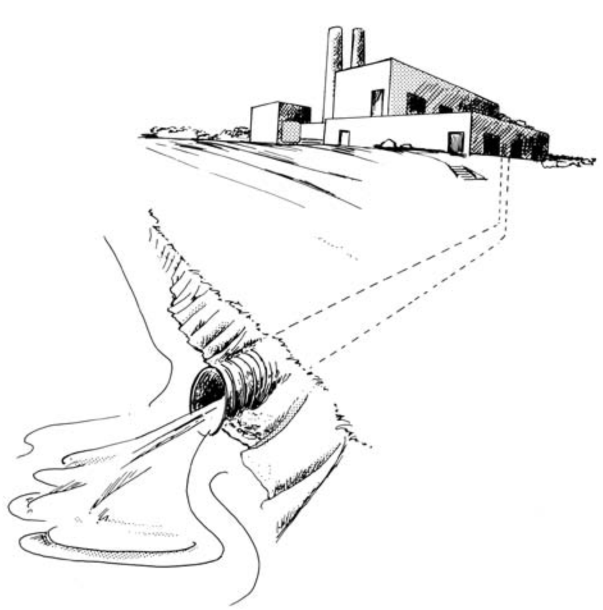
Point Source Pollution

Pollution that comes in ***large*** amounts from a ***single*** source (pipe or ditch), called "**point source pollution**," has been extensively addressed over the past three decades, largely through the process of issuing permits to sources such as industrial and municipal wastewater treatment facilities.

Examples of point sources of pollution are industrial and domestic wastewater treatment plant discharges. Generally, pollution from point sources is controlled by treatment technology, either chemical or biological, at or before the point of discharge.

Point sources must obtain a permit for their discharge. Permit holders must monitor and document chemical parameters of the effluent (wastewater discharged into the environment) to ensure that the water quality meets permit requirements.

Point Source



Nonpoint Source Pollution

One of the major environmental issues that remains to be fully addressed is the problem of water pollution coming in **small amounts** from a **large number** of sources carried by rainfall runoff into streams, lakes, or bays. This is called **"nonpoint source (NPS) pollution**."

A nonpoint source means that pollutants come from a broader area so that their origins are not easily identified or controlled. Nonpoint source water pollution originates in water that runs in a thin layer or "sheet" over the land; in other words, it does not come from a stream, ditch, or pipe. This type of pollution occurs as rainfall runoff carries pollutants from the land, through the watershed, and into a stream. As the runoff flows over the land, it picks up sediments, organic wastes, nutrients, toxic substances, bacteria and other pollutants from industrial, agricultural and urban sources. Lawns, pastures, streets, and parking lots are examples of sources of pollutants that ultimately find their way through the watershed to a stream in this manner.

As watershed areas become more populated, natural surfaces become covered over with hard solid surfaces like streets, sidewalks, and rooftops. As a result, water that previously soaked into the ground, to replenish underground and surface water supplies, flows instead over land in the watershed and enters a stream more rapidly. Some of the common pollutants that enter streams with this runoff are sediment, pesticides and fertilizers from yards, oils from roadways and parking lots, and improperly disposed of wastes including hazardous materials from dumping grounds and storage areas. Also, the increased stream flow may cause flooding and erosion of stream banks, which can tear out vegetation, increase sedimentation, and reduce the quantity and quality of aquatic habitats.

Just as many problems with point sources are being solved through permitting, programs addressing nonpoint source pollution are becoming increasingly important in water quality management. The U. S. Environmental Protection Agency (USEPA) estimates that over one-half of all water pollution originates from nonpoint sources. Identifying all of the small yet significant sources of nonpoint source pollution is a difficult task, since these activities are widespread across the land. Therefore, public education and involvement is crucial to making people aware of

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the impact their activities can have on surface water.

As a result of the Clean Water Act, cities are now making plans to capture their urban runoff in order to treat the contaminated water in a wastewater treatment plant before releasing it into a stream. Other management practices being promoted include modification of home and business activities, proper drainage practices, and stream maintenance.

Types of nonpoint source pollution include:

- excess fertilizers (nutrients), herbicides, and insecticides from residential areas and agricultural land;
- oil, grease, and toxic chemicals from roadways, parking lots, spills, and energy production;
- sediment from poorly managed construction sites, crop and forest lands (logging), and eroding stream banks;
- motor oil, car batteries, and home chemical containers that have been improperly disposed of; and;
- bacteria from faulty septic systems, livestock, and pet wastes.

Types of Pollution

For the purposes of this manual we will focus on the three most common categories of pollutants; nutrients, organic wastes, and sedimentation. The effects of these pollutants are either easily observed or measured with simple test kits. A fourth pollutant category, toxic substances, although also important, requires advanced methods to determine its presence. Simple observational information will be discussed for chlorine, one of the most common toxic substances in surface water due to wastewater treatment.

Nutrients

Nutrients, primarily nitrogen and phosphorus, are essential for plant growth. The rate of plant growth is controlled by a *limiting nutrient*, typically nitrogen or phosphorus, although it can be any of the essential minerals needed for growth. A limiting nutrient is available in quantities smaller than necessary for aquatic plants to reach maximum abundance.

When the limiting nutrient is used up, algae will stop growing. However, the addition of excessive nutrients into surface waters from human activities, or *cultural eutrophication*, can cause phytoplankton to multiply at an accelerated rate. Algae will continue to grow until the limiting nutrient is exhausted. Excess nutrients can cause phytoplankton blooms, which are often associated with and followed by a zooplankton bloom.

A bloom creates a situation in which the population numbers of plankton exceed the capacity of the system. These excessive numbers can cause problems for fish populations (stress and/or death) since respiration (consumption) from large plankton populations can bring about low dissolved oxygen (DO) levels. Major sources of nutrients are urban runoff (fertilizers from lawns and golf courses), domestic wastewater effluent, and agricultural activities (fertilizer, manures).

Organic Wastes

Oxygen is as essential to aquatic life as it is to life on land. The amount of oxygen in water depends on the water temperature (the colder the water the more oxygen it can hold). Oxygen is added to water in two ways: it is taken directly from the air, a process enhanced by areas of turbulent water (for example, waterfalls and wave action), and it is produced as the result of photosynthesis by aquatic plants and algae. Oxygen is removed from water by the respiration of aquatic organisms and the decomposition of wastes and dead plants and animals. The addition and removal of oxygen are generally balanced in normal, healthy streams, and the dissolved oxygen (DO) in the water maintains a diverse population of aquatic organisms. Sluggish streams can be naturally low in DO, since DO levels tend to be lower in slower, less turbulent streams. In streams with extremely low DO, organisms such as "bloodworms" (midge larvae), worms, and air-breathing snails may be the only aquatic organisms present.

Organic material, such as that found in raw wastewater, uses oxygen for decomposition. The amount of oxygen required to decompose waste is called biochemical oxygen demand (BOD). When the BOD of the waste exceeds the available oxygen, the DO in the stream is reduced or depleted and is unavailable for aquatic life. Very low DO can cause fish kills.

Sedimentation

A common cause of water quality degradation is sedimentation. Sediment is defined as small particles of "dirt" that are carried along by water as it runs off the land.

The most common sources of sediment are construction activities (buildings, roads, bridges); the erosion of agricultural lands; and the erosion of surface-mined land (for example sand and gravel operations). Waters with heavy sediment loads are very obvious because of their muddy appearance. This is especially evident in rivers during high flows, where the force of the water keeps the sediment suspended rather than allowing it to settle on the bottom.

However, when the river reaches a lake or reservoir, the water loses speed and the sediment drops to the bottom, a process called sedimentation. The sedimentation process is pronounced during periods of high flow. Increased sedimentation is one major effect of reservoir construction. In a natural river system, high flows scour the bottom, carrying sediments downstream. During periods of flooding water leaves the river channel and flows out over the flood plain. Sediment is deposited out on the flood plain.

Reservoirs serve as flood control structures and in most situations (with the exception of major flood events) severely limit the ability of a stream to remove sediment. This limiting effect can cause larger rivers to become clogged with sediment (for example, in Texas, the Pecos River, the Rio Grande) and in some cases sediment accumulates in reservoirs, causing them to prematurely age (for example, in Texas, Lake Houston, Falcon Reservoir).

Lakes and reservoirs, over a period of years, undergo a natural process of aging. They begin to fill and eventually go from lake to wetland, and then forest or some other terrestrial habitat. Human activities speed up sedimentation and the aging process.

Increased sediment also reduces aquatic habitat and changes the types of aquatic plants and animals living in a stream or river. As sediment settles out, it covers the bottom, thus changing the bottom of a reservoir or stream.. What was once a sandy or clay bottom becomes a "muck" bottom, where different and possibly fewer organisms can live .An abundance of sediment in flowing water can affect fish by clogging their gills, covering their breeding areas, and smothering their eggs.

Toxic Substances

Substances that are considered toxic are separate from the others because of the acute effect they can have on aquatic ecosystems. These are substances that can kill organisms directly and in a relatively short period of time (acute toxicity). **Acute toxicity** results when high concentrations of a substance cause immediate danger or death. These toxicity levels generally disrupt an entire ecosystem, severely reducing the stream's natural ability to recover. The volume of a toxic substance that can cause acute toxicity is generally associated with spills or releases , whether accidental or intentional.

The two most common substances acutely toxic to aquatic life are ammonia and chlorine. Both substances are associated with wastewater treatment; ammonia with raw sewage and chlorine with the final treated wastewater. Most large wastewater treatment plants remove chlorine before treated wastewater (effluent) is discharged to a stream. Smaller treatment plants, at times, discharge effluent containing excess chlorine. Chlorine can be measured with a simple test, but the effects over time can be easily detected by the presence of "bleached" plants at an outfall.

Toxic substances, in sublethal concentrations can produce chronic effects. **Chronic toxicity** is the long-term effect of sublethal levels of a substance, which can alter growth, reproduction, or development. Chronic concentrations can reach water from urban runoff (roads, parking lots), leaking storage tanks, agricultural runoff, mining runoff, oil and gas production, and other sources.

Toxic substances can also enter bodies of water in very low concentrations that pose no apparent risk at that level. However, certain toxins can bioaccumulate and biomagnify. Bioaccumulation is a process in which a substance accumulates in an organism's body. Biomagnification is a process in which a substance moves through the biological food chain by being passed from one organism to another as the contaminated organism is preyed upon by another organism. The substance becomes more concentrated as it travels to the top of the food chain. The two substances best-known to bioaccumulate in animal tissue are mercury and DDT.

Indicators of Stream Health

Bacteria

Bacteria have long been an indicator of drinking water and recreational water quality. Their presence is extremely significant.

Historically, total bacteria and fecal coliform bacteria have been the most widely used "indicator bacteria." Fecal coliform bacteria are commonly found in the small intestine of humans and other warm-blooded animals. They are not necessarily harmful, but are often associated with harmful bacteria found in various water sources. Total bacteria refers to the total amount of bacteria found in a body of water. High levels of bacteria in surface water are not desirable for recreational use (swimming, water sports, and other water recreation). E. *coli*, more commonly associated with human waste, will eventually replace fecal coliform as the indicator bacteria in Texas.

Fungus

Sewage fungus is an indicator of organic pollution in flowing waters. Any growth of slimy, cottony, wood-like plumes (usually white, grey, or brown), generally in massive amounts of long streamers clinging to twigs, leaves, or even the sides and bed of the stream, indicates sewage fungus. Sewage fungus often appears in streams receiving waste from paper mills, sugar refineries, canneries, breweries, alcohol refineries, and other sources of organic pollution.

Benthic Macroinvertebrates

Freshwater macroinvertebrates (for example, mayflies, dragonflies, stone flies, crayfish, blood worms) are used more than any other group of animals or plants as indicators of water pollution. Water chemistry only tells what the water quality is at a particular point in time, or a "snap shot."

Why Are Freshwater Benthic Macroinvertebrates Used As Indicators of Water Pollution?

- Important component of virtually all aquatic ecosystems
- Found in all types of aquatic habitats
- Relatively easy to collect
- Have different levels of tolerance to environmental disturbance
- Most are sedentary or move over a small area
- The kind of organisms and number present in a stream reflect recent past and present conditions
- Life cycles and taxonomy of most groups are well documented

What Can Freshwater Benthic Macroinvertebrates Indicate?

- Long-term water quality trends
- Impacts of various pollutants
- Impact of changes to the physical habitat
- Improvements or declines in water quality

Algae

Algae are divided into three general groups: (1) free-floating (planktonic); (2) filamentous algae, attached to the rocks, submerged logs, vegetation (periphyton) or floating mats; and (3) plant-like algae (shallow roots). Filamentous algae and plant-like algae are dominant in streams and make up the base of the food chain (primary producers). Planktonic algae are dominant in lakes, ponds and slow-moving rivers.

Algae attract attention because of their bright colors and overabundance in nutrient-enriched streams, ponds, and lakes. While the majority of freshwater algae are microscopic, the more obvious forms are often referred to as "pond moss" or "scum." Slick rocks in streams are often due to algal growths. Although most nonplanktonic algae are visible to the naked eye, a microscope must be used in their identification.

The presence of little or no algae in a water body indicates a low nutrient content. Water bodies with low nutrient concentrations are known as oligotrophic. In addition to low nutrient concentrations, oligotrophic water bodies are characterized by clear water capable of only supporting small populations or plants, invertebrates, fish, and wildlife. In contrast, water bodies with high nutrient levels capable of supporting an abundance of living organisms are called eutrophic. Eutrophic water bodies are also susceptible to algal blooms and resulting fish kills.

Water Clarity

Material that becomes mixed and suspended in the water column reduces water clarity and increases water turbidity. Factors contributing to this turbidity are varied. In the summer, an important contributor is plankton. Planktonic organisms grow and multiply very rapidly in warm, sunlit, nutrient-rich water. During periods of heavy runoff, silt is also a factor.

Turbidity affects fish and aquatic life in the following ways:

- Cloudy waters interfere with the penetration of sunlight. Submerged aquatic vegetation needs light for photosynthesis. If suspended particles block out light, photosynthesis and the production of oxygen for fish and aquatic life are reduced. If light levels get too low, photosynthesis may stop altogether and plant life will die. Conditions that reduce photosynthesis in plants also increase oxygen use and the amount of carbon dioxide produced.
- Large amounts of suspended matter clog the gills of fish and shellfish, and kill them directly.
- Suspended particles may provide a place for harmful microorganisms to attach.
- Turbid water reduces the visibility for fish and increases their difficulty in finding food. High turbidity also makes it easier for small fish to hide from larger predators.
- Turbidity increases the temperature of the water when suspended particles absorb heat from the sun.

Water Temperature

High water temperatures increase metabolism, respiration, and oxygen demand of fish and other aquatic organisms. In general, metabolism rates in aquatic organisms double with every 10°C rise in temperature. Increased temperatures also enhance the effect of nutrients on plankton blooms. The effects of oxygen-demanding wastes (sewage, food process waste, feedlot waste) are intensified by temperature increases. The main sources of heated water are power plants and industry discharging heated effluents.

Temperature characteristics of an aquatic environment determine the composition of the existing biological community (see Table 1). In general, aquatic organisms have body temperatures that fluctuate with the water temperature. Lower oxygen levels and warmer temperatures create environments dominated by tolerant organisms. The effects of temperature on a stream are normally chronic, with gradual changes in the aquatic community. However, extreme weather conditions can cause die-offs due to drastic temperature changes. Artificially heated water bodies (for example, water bodies receiving discharges of warm water) can create a dependence on warm water. Fish kills can occur if for some reason the warm water discharges stop during cold weather.

Table 1.
Temperature Ranges Required for Growth of Certain Organisms

Temperature	Examples of Life
Over 68° F (warm water)	Most plant life; most bass, crappie, bluegill, carp, catfish, caddisfly
Less than 68°F (cold water)	
• Upper Range (55-68°F)	Some plant life; stone fly; mayfly, caddisfly, water beetle
• Lower Range (less than 55°F)	Trout, caddisfly, stone fly, mayfly

Dissolved Oxygen

Dissolved oxygen (DO) is one of the most important indicators of water quality for aquatic life because it is essential for all plants and animals. When oxygen levels in the water fall below 2 to 3 parts per million (ppm), fish and many other aquatic organisms may become stressed and some may not survive. Oxygen is a particularly sensitive factor because chemicals, biological processes, and temperatures often determine its availability at different times during the year.

A DO test (using a kit or meter) tells how much oxygen is dissolved in the water. By using the DO value and the water temperature measurement, you can tell how much dissolved oxygen the water is capable of holding at the time the measurements were taken. When water holds all the DO it can hold at a given temperature, it is said to be 100 percent saturated with oxygen. Elevated temperatures reduce the amount of oxygen water can hold. For example; at 0°C water can hold approximately 14.6 ppm of oxygen at the saturation point; at 30°C the amount decreases to 7.7 ppm. Table 2 shows this relationship at various temperatures.

Oxygen is transferred from the atmosphere into surface waters by the aerating action of the wind. It is also added at or near the surface as a by-product of plant photosynthesis.

Since the existence of plants also depends on the availability of light, the oxygen-producing processes occur only near the surface or in shallow waters where sunlight can penetrate. Oxygen levels may be reduced because the water is too warm (such as near a power plant or due to seasonal variations in flow and temperature) or because there are too many bacteria or aquatic organisms using the oxygen in a given area.

During plankton/algae blooms, dissolved oxygen levels in the daylight hours can be extremely high, often greater than 10 mg/L. However, during the night when oxygen production (photosynthesis) ceases and respiration begins, dissolved oxygen can drop to lethal levels. Lethal levels depend on the water body and the type of fish present. The effect of a plankton bloom can be compounded on overcast days. Decreased sunlight causes a reduction in oxygen production (photosynthesis), which results in a net loss of dissolved oxygen. Water bodies with fluctuating oxygen levels support tolerant fish species that can acclimate to conditions that would otherwise be deadly to more sensitive fish species.

When filamentous algae growth is excessive, as in a "bloom," the algae floating on the surface can decrease light penetration to the algae underneath and cause the algae to die off. Decay of the dead algae uses up oxygen leading to very low DO levels, potential fish kills and strong odors. The effect is intensified at night when photosynthesis stops and oxygen consumption continues.

As shown in Table 2, amounts of dissolved oxygen in the water can vary greatly, depending upon temperature. Under ideal conditions water should hold a certain amount of DO at a given temperature. In addition to temperature, there are other things that influence the amount of DO water can hold. Some examples of these influences include photosynthesis, wind, light, and algae blooms. Super-saturated levels above the maximums listed in Table 2 for a given temperature can occur. Highly productive water bodies (eutrophic), those with elevated nutrient concentrations, high water temperature and large amounts of filamentous and planktonic algae can create super-saturated conditions during daylight hours.

Most aquatic macroinvertebrates (mayfly, caddisfly, stone fly, black fly, dragonfly) and fish (bass, sunfish, crappie, gar, carp, catfish) commonly found in Texas are considered warm-water species. Texas is large and changes greatly in climate, geology, and topography when moving from east to west. For example, streams in the Hill Country of central Texas are higher in gradient (slope), generally clear, swift-moving streams with rocky bottoms. Aquatic organisms living in these streams are generally adapted for cooler water temperatures and high oxygen levels. In contrast, streams in east Texas are lower gradient, warmer, slower moving with muddier bottoms. Aquatic organisms inhabiting these streams are generally more tolerant of warmer temperatures and lower DO levels. A DO level of 5.0 ppm or greater is generally considered the optimum to sustain the growth and health of aquatic organisms.

Table 2.
Solubility of Dissolved Oxygen in Water

Temp. (°F)	Temp. (°C)	Saturation mg/L (ppm)*
32	0	14.6
33.8	1	14.2
35.6	2	13.8
37.4	3	13.5
39.2	4	13.1
41	5	12.8
42.8	6	12.5
44.6	7	12.2
48.2	9	11.6
50	10	11.3
51.8	11	11.1
53.6	12	10.9
55.4	13	10.6
57.2	14	10.4
59	15	10.2
60.8	16	10.0
62.6	17	9.8
64.4	18	9.6
66.2	19	9.4
68	20	9.2
69.8	21	9.0
71.6	22	8.9
73.4	23	8.7
75.2	24	8.7
77	25	8.6
78.8	26	8.2
80.6	27	8.1
82.4	28	7.9
84.2	29	7.8
86	30	7.7

** Maximum amount of oxygen water will hold at a given temperature*

The pH Scale

The pH scale, numbered from 0 to 14, is used to measure the acidity of a water body. Pure water has a pH value of 7.0, which is considered neutral, which means neither acidic or basic. When the pH is less than 7.0, the water is considered acidic and a pH greater than 7.0, basic or alkaline.

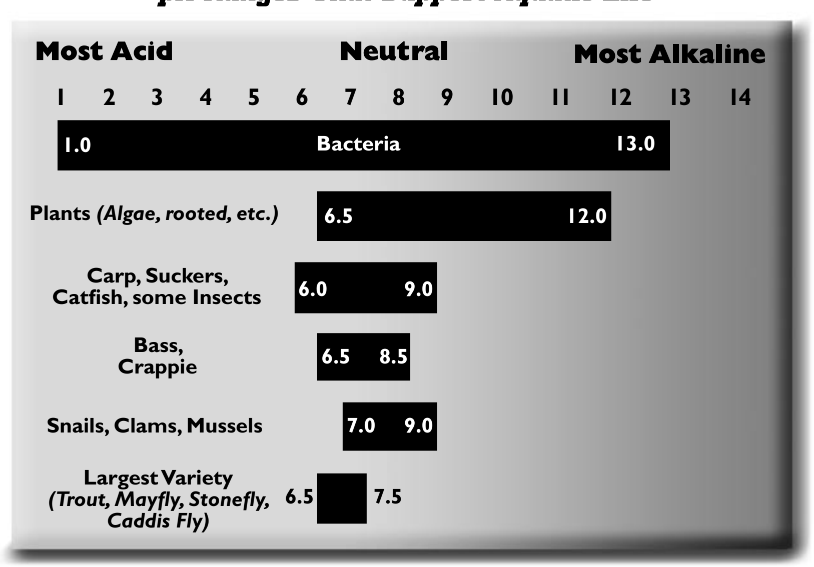
The pH scale represents units of 10. This means each number on the pH scale is ten times the number that precedes it. For example, a pH of 4 is 10 times more acidic than a pH of 5, and 100 times more acidic than a pH of 6. A pH change of one whole number is therefore quite a large change.

Water dissolves mineral substances it comes in contact with, picks up aerosols (fine solid or liquid suspended in air) and dust from the air, receives man-made wastes, and supports photosynthetic organisms, all of which affect pH. The buffering capacity of water, or its ability to resist pH change, is critical to aquatic life. Generally, the ability of aquatic organisms to complete a life cycle greatly diminishes as pH becomes greater than 9.0 or less than 5.0.

Photosynthesis by aquatic plants removes carbon dioxide (CO_2) from the water, which can significantly increase pH. Therefore, in waters with abundant plant life (including planktonic algae), an increase in pH can be expected during a sunny afternoon, especially in low-velocity or still waters.

Other events in the watershed that may also affect pH include increased leaching of soils or minerals during heavy rainfall runoff, accidental spills, agricultural runoff (pesticides, fertilizers, soil leachates), and sewage overflows.

pH Ranges That Support Aquatic Life



Nutrients

Nutrients, primarily **nitrogen** and **phosphorus**, are essential for plant growth. The rate of plant growth is controlled by a ***limiting nutrient***, typically nitrogen or phosphorus, although it can be any of the essential minerals (copper, selenium, zinc, and so on) needed for growth. A limiting nutrient is available in quantities smaller than necessary for aquatic plants to reach maximum abundance. When the limiting nutrient is used up, algae will stop growing.

The addition of excessive nutrients into surface waters from human activities, or **cultural eutrophication**, can cause phytoplankton to multiply at an accelerated rate. Algae will continue to grow until the limiting nutrient is exhausted. Excess nutrients can cause phytoplankton blooms which are often associated with and followed by a zooplankton bloom. The effects of excess nutrients are discussed in the section on dissolved oxygen.

Phosphates, chemical compounds that are made from the element phosphorus, are used in detergents and fertilizers. Urban activities such as washing cars and applying fertilizers can greatly increase phosphate levels through nonpoint source runoff.

Phosphates in wastewater are not generally removed by conventional wastewater treatment processes. The type of advanced wastewater treatment that removes phosphates is becoming more common, but is not universal. It is common for streams to have higher phosphate levels downstream of many wastewater treatment plants.

Nitrate, also a plant nutrient, is found in fertilizers and in discharges from wastewater treatment facilities. During the wastewater treatment process, ammonia is converted to nitrate. Depending on the amount of ammonia in wastewater, this conversion can result in the discharge of elevated nitrate concentrations to streams.

Physical Habitat Alteration

Channelization

Channelization is the straightening of a natural stream channel to control flood water. Channelization typically removes large trees and natural bank vegetation that provide shading and stream cover, and results in high, steep, exposed banks. While most channelized streams have grass-covered banks, some in urban areas are lined with concrete. Bottom substrates are disturbed and important biological habitats are removed (for example, logs, rock, tree stumps, root masses). Channelization represents one of the major causes of decreasing biological community health. Normal, healthy streams can maintain a rich diversity of aquatic organisms. Channelization of streams for flood control can cause a stream to become nearly lifeless.

Effects of Channelization

Water Temperature

The removal of stream bank vegetation reduces shading (to almost zero) and increases exposure to sunlight, causing increases in water temperature.

Increased Turbidity

Erosion of exposed banks during storms and high flows increases turbidity. Turbidity can also increase the water temperature by absorbing the suns' rays.

Changes in Flow

The removal of natural stream channel characteristics, and straightening the channels to accommodate flood waters, increase the velocity of the water and the potential for downstream flooding. Channelization creates high, steep banks that remove the stream's natural ability to decrease the velocity of flood waters. Under normal conditions the flow in a stream will leave the stream channel and move out and over the flood plain. A flood plain is the area adjacent to the channel which is occasionally submerged under water. The flood plain is usually a low-gradient area well covered by various types of vegetation. The flood plain allows the force of the water to be displaced over a larger area. With flows confined to a straight and narrow channel, the stream loses the ability to reduce the force of the water.

Bottom Substrate

Channelized stream bottoms tend to be unstable, muddy, and unsuitable for many benthic organisms. Channelization can also result in increased sediment buildup in streams.

Water Education Field Guide

Management of Pollution

The quality of life-sustaining water affects us both physically and aesthetically. We depend on surface waters for drinking water as well as for food, recreation, transportation and agriculture. In addition to our own needs, it is important to protect surface waters for aquatic and terrestrial wildlife. Our water resources cannot continue to support these activities unless water quality is a top priority for everyone in the state.

Because of the deterioration of our national water systems, Congress passed the Clean Water Act in 1972 to "restore and maintain the chemical, physical, and biological integrity of the nation's waters." Through the Act, the USEPA has legal authority and funding provisions to control water pollution at the national level. TCEQ is the agency responsible for regulation of water quality at the state level in Texas.

As a result of the Clean Water Act, and the actions of concerned citizens, state and federal agencies, and regulated businesses and organizations, significant progress has been made in the cleanup of the nation's waters. Many of the most severe pollution problems that plagued our waterways in the 1960s and 1970s have been ended. However, many problems remain, including the cleanup of toxic substances in sediments and water, the protection of ground water, and the management of nonpoint sources of pollution.

Pollution Check List

- Is the stream receiving runoff from lawns, fields, highways, or parking lots?
- Are the banks of the stream unstable?
- Has the stream been altered from its natural condition?
- Is there a buildup of silt in the stream?
- What is the color of the water?
- How much algae and plant growth is present?
- Are there any unusual odors (sewage, chlorine, rotten eggs)?
- What kind of aquatic habitat is available (for example, gravel, logs, aquatic plants, root masses, undercut banks)?
- Is there an oily film on the water surface?

A Summary of Stream Health Indicators

Dissolved Oxygen

Oxygen in water is essential for fish and other aquatic life. Low oxygen levels can cause fish to literally suffocate and die. Many fish kills in ponds and streams during the summer months are usually caused by depletion of the oxygen supply from a combination of elevated nutrients and warm water temperatures. Excessive plant growth, the decay of organic material, and high water temperatures can all reduce oxygen supply.

The pH Scale

The pH scale of numbers from 0 to 14 is used to measure the acidity of a water body. At a pH value of 7.0, water is considered neutral, which means neither acidic nor basic. Pure water has a pH of 7.0. When the pH is less than 7.0, the water is considered acidic, and a pH greater than 7.0 is basic or alkaline. Rain, geology, and human disturbances can affect the pH of surface and ground water.

Water Temperature

High water temperatures increase metabolism, respiration, and oxygen demand of fish and other aquatic organisms. Increased temperatures also enhance the effect of nutrients on plankton blooms. The effects of oxygen-demanding wastes (sewage, food process waste, feedlot waste) are intensified by temperature increases. The main sources of heated water are power plants and industry discharging heated effluents. Water temperatures in excess of 89 degrees Fahrenheit are considered poor for all but the most tolerant aquatic organisms (for example, gar, carp).

Nutrients

The nutrients phosphorus and nitrate are essential for plant growth. Elevated nutrient levels can stimulate excessive plant growth, which can rob a stream of oxygen when the plant matter dies and decays. Nutrient sources include fertilizers from urban and agricultural runoff, domestic wastewater.

Coliform Bacteria

Coliform bacteria are found in the intestines of animals to assist in the digestion of food. Bacteria of the species *E. coli* is found in human intestines. Though these bacteria are not harmful to humans, their presence in creek water is an important indicator of the health of the creek. When *E. coli* counts are high, sewage leaks are usually indicated.

Water Quality Activities

ACTIVITY ONE: Learning About the Study Site and Water Pollution

Texas Essential Knowledge and Skills — (TEKS)

The Texas Essential Knowledge and Skills (TEKS) "identify what Texas students should know and be able to do at every grade" (Texas Education Agency, 1998). For example, TEKS 4.1 states "The student listens actively and purposefully in a variety of settings."

The TEKS are included here for the benefit of teachers who use the Water Education Field Guide in their school classes. For full information about these important standards, visit the TEA's Web site (www.tea.state.tx.us/teks/).

The following are TEKS that apply to this activity:

4.1A	5.1 A	6.1 A
4.2 A, B	5.2 A, B	6.2 A, B
4.3 D	5.3 D	6.3 D
4.5 A	5.5 A, B	
4.10 A	5.6 A	
	5.11 A	

Objective

Students identify a creek for water quality study. Using a county map, they locate its source and mouth. After identifying the creek, students outline the watershed of the creek by using a county or topographic map. Once this is done, students can then identify a section of the creek for water quality study. Before the water quality study begins, the instructor introduces the students to information on water quality. Instructors may want to review the introductory materials in the chapter "Basics of Water Education" and "Basics of Water Quality" when preparing the students for their water quality study.

Materials

- apple and knife
- copies of Field Data Sheets to be used (see an example of a "Field Data Sheet" later in this handbook. This form is used to record field notes on various aspects of the water quality study)
- stapler
- county and topographic maps
- overhead transparency pens in at least two colors
- clear overhead transparency sheets
- scotch tape
- rulers
- aerial photos (optional)
- copies or overheads of background information

Instructor Preparation

This would be a good time to have a guest speaker introduce concepts of water pollution to your students.

Tape together several clear overhead transparency sheets or other clear plastic sheets so that a protective cover can be placed over a topographic or county map. This allows students to trace the watershed or waterway without defacing the map. Tracings can be wiped off as needed to correct mistakes, and ongoing comments can be recorded as data is collected at the site.

Background information on designing and conducting a field survey begins with the section "Survey Design." Instructors may want to duplicate some of that information to share with students.

Procedure

A. Starter Activity "Adam's Apple"

Objective— To emphasize the relatively small amount of water that is available for human consumption.

1. Using an apple to represent the earth, ask the following questions and carve out the specified amount:
   a. What percentage of the earth is water? 75%
   b. What percentage of the earth's water is ocean salt water? 97%
   c. What percentage of the earth's water is tied up in glaciers and polar ice caps? 2%

d. What percentage of the earth's water is held in lakes, rivers, and groundwater aquifers? 0.62%

2. The last small slice (0.62%) is all that remains to represent possible human water sources: 0.6% represents groundwater and 0.02% represents surface water (roughly the peel on the slice).

3. Ask the question: What happens if we don't protect this resource? Then, eat the last apple slice.

B. Orientation to the Water Education Field Guide Project Activities

1. Outline for the students the specific Water Education Field Guide activity and its purpose (discussed in the section "Basics of Water Education").
2. Share with them the safety measures and behavioral guidelines.
3. Set up a schedule of meetings and a rain plan.
4. Have them list the equipment they need to bring from home.

C. Map Activities

1. Show students the county map. If a creek site has already been identified for study, show the students where it is on the map. Then let the students use their fingers to trace the creek's course from its source to its mouth. The creek's mouth may be a river, or the creek may flow into another creek that has its mouth in a river. This is important because whatever affects your creek may actually be coming from another creek. This is one example of the complexity of tracking down the sources of water pollution.
2. Using a wipe-off pen on the clear plastic overlay, have the students outline the course of the creek in one color, then estimate the boundaries of the creek's watershed. The watershed can be estimated by drawing a line between the selected creek and other creeks and allowing an area around the source of your creek. A topographic map is best for this activity.

How to draw a watershed boundary:

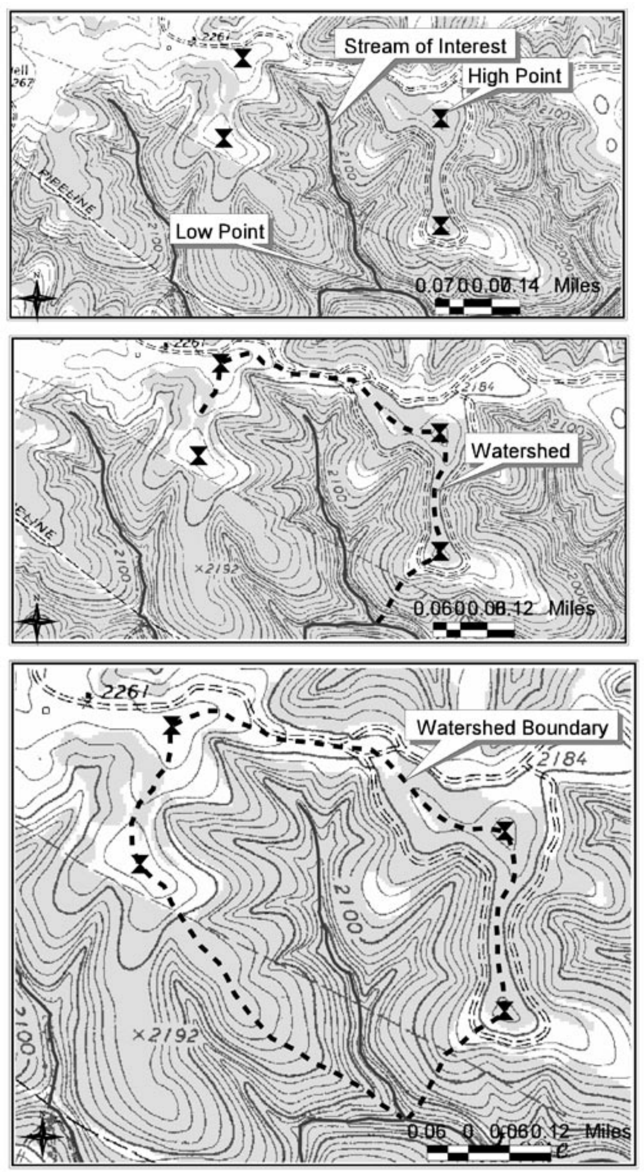
a. Find the low point of the stream of interest.

b. Mark the high points—usually a small enclosed topographic line—along the ridge of the stream.

c. Try to visualize the topography of the streambed and the watershed; always ask yourself which way the water would flow.

d. Start connecting the high points, following ridges, and crossing slopes at right angles to contour lines. A good reference for this exercise is the TCEQ publication, "Conducting a Watershed Survey" (GI-232).

e. Shade in or draw dots to fill in the estimated watershed area.



3. Locate the scale on the map and, using rulers, estimate the dimensions of the watershed. Students may draw a grid of square-mile units on another transparency and lay it over the watershed area in order to arrive at an estimate. Write on the map an estimated square-mile area for the watershed of the creek you have selected.
4. Ask students to name all of the possible human and natural activities that may be taking place within the watershed of the creek. Point out to the students that water pollution is difficult to control and sources are difficult to identify because of the extensive nature of the watershed and the variety of activities that can affect it.

D. Discussion of Water Quality

1. Before discussing sources of water pollution, the instructor should go over basic concepts related to water quality (using information provided in the section "Basics of Water Quality"). The instructor can then introduce the following information on water pollution.

■ Classification of Pollution

a. Point source pollution (from discrete sources, such as discharge pipes)

b. Nonpoint source pollution (from many sources, such as urban runoff from parking lots).

■ Types of pollution

a. Sedimentation

b. Organic waste

c. Nutrients

d. Toxic substances

e. Thermal

2. Ask students to name possible examples of each type of pollution that might be found in the selected creek, using the map for ideas.

E. Discussion of Stream Health Indicators

1. Introduce some of the indicators of the health of a creek (for details, refer back to "Indicators of Stream Health"):

a. The presence or absence of aquatic life

b. The amount of sediment on the stream bottom

c. The amount of oxygen dissolved in the water

d. The acidity/alkalinity as determined by pH

e. The presence or absence of nutrients such as phosphates and nitrates

f. The presence or absence of coliform bacteria

2. Tell the students that another sign of a creek's health is how much the creek has been altered (for example, channelization, dredging).

Table 3.
Pollution Tolerance of Selected Freshwater Benthic Macroinvertebrates

Sensitive	Moderately Tolerant	Tolerant
Mayflies*	Damselfly*	Cranefly
Stone flies*	Dragonflies*	Snails
Caddisflies*	Aquatic Sow Bug	Flatworm
Freshwater clams	Amphipod/Scud	Aquatic Earth Worms
Dobsonfly/ Hellgrammite	Fingernail Clam	Leeches
Riffle Beetle	Blackfly Larvae	Midges

** A few families fall in categories of tolerance*

It is important to note that pollution-tolerant organisms may be found in clean water, too, but sensitive organisms will not be found in polluted water.

Survey Design

Before beginning, the group should first determine their long- and short-term goals (see "Objectives" below) and become familiar with the stream. At this point, a driving tour of the watershed may be useful. Get acquainted with the lay of the land and the various land use activities occurring in the drainage basin. In conjunction with the driving tour, walk as much of the stream channel as possible. These activities will provide information on stream size, habitat types, stream bottom material, stream slope (gradient), and riparian (streamside) vegetation development, as well as scenic qualities of the stream.

Objectives

The objectives of stream studies are quite varied. However, these should be considered:

1. Determining present-day conditions of the stream (biological, physical and/or chemical)
2. Watching the stream for a period of time to determine whether it is improving, remaining the same, or getting

worse. Something to keep in mind: will this be a long-term project where each year a class/group collects information on a stream, or will this be a short-term project where the class/group learns how a stream changes with the seasons? A long-term project is better suited for documenting water quality changes in a creek.

Study Area Selection

In choosing study areas, getting to the stream is of primary concern. Consider the "lay of the land"— distance to be traveled, steepness of the stream banks, water depth, and water speed. If private land must be crossed, seek permission from the owner. Deep or fast-flowing waters are difficult and possibly dangerous to sample, require special equipment and techniques not covered in this project guide, and therefore should be avoided.

When selecting a specific stream section to study, try to find one that has the major stream habitat types, that is pools and riffles (shallow places). Finding all stream habitat types (see "Instream Habitats") is not always possible , especially in many urban streams. But that is ok because it will give students a chance to see the effects of urbanization (stream alterations, streams dominated by wastewater discharges, and other changes). Note and record the presence of undercut banks, weed beds, rock ledges, and backwater areas on the Field Data Sheet. The best access points are generally bridge crossings. If a bridge crossing is selected, observations should be made in an area not affected by the bridge. This generally means walking upstream or downstream of the bridge.

The greater the variety and stability of stream habitats, the greater the diversity of aquatic organisms. Slow-moving streams occurring in areas of well-developed flood plains may lack some of the habitat types mentioned above.

Survey Types

Three types of surveys are used when studying a stream:

1. the visual survey,
2. the biological survey, and
3. the water quality survey.

All three types can and should be conducted at the same time.

ACTIVITY TWO: Using the Data Sheets and Planning the Creek Study Outing

Texas Essential Knowledge and Skills (TEKS)

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The TEKS are included here for the benefit of teachers who use the Water Education Field Guide in their school classes. For full information about these important standards, visit the TEA's Web site (www.tea.state.tx.us/teks/).

The following are TEKS that apply to this activity:

4.1A	5.1 A	6.1 A
4.2 A	5.2 A	6.2 A
4.3 B, D	5.3 B, D	6.3 B, D
	5.6 A, B	

Objective

Surveying teams are formed and data collection booklets are assembled and read in preparation for the on-site visit in the next activity.

Materials (for Each Team)

- Field Data Sheets
- "Diagnosis" and "Physical Indicators of Water Pollution" (Both materials are located in "Instructor Resources and Reference" section)

Procedure

1. Review with the students the creek health indicators and the specific creek information they uncovered during the previous lesson (under "Discussion of Stream Health Indicators"). Tell the students they will visit the selected site and use data sheets to collect information about their creek during the next activity.
2. Hand out copies or put on the overhead projector the pages called "Diagnosis" and "Physical Indicators of Water Pollution" from Instructor Resources and Reference section of this book. Read the information with the students in order to get an idea of what they will be looking for on-site next time. Some of the diagnosis information can be derived from the map, such as land use (see "Characteristics of the Surrounding Area Draining into Stream" in the Instructor Resources and References section).
3. Hand out copies of the following sheets and read them over with the students:
   - Field Data Sheets
   - Characteristics of the Surrounding Area
   - Physical Indicators of Water Pollution
4. Have the students discuss their roles within their research teams. Each team will build a field notebook or folder that will contain Field Data Sheets, the "Characteristics of the Surrounding Area" and "Physical Indicators of Water Pollution." They will see that the Field Data Sheets require a lot of work to get all the information needed. The work will include:
   a. noting the appearance of the water
   b. mapping and describing the site
   c. taking the temperature of the water and the air
   d. measuring dissolved oxygen is in the water
   e. collecting water samples to observe and test later
   f. measuring the pH of the water
   g. classifying the trash
   h. noting pipes, bridges, and other structures in the area
   i. finding out how fast the water flows
5. The students may have some suggestions about dividing up the work over the next two visits to the site. Every student should play a part in the collection of data.
6. After the students have reviewed the meaning of each item on the data sheets, make plans for the creek outing that will be the next activity.

ACTIVITY THREE: On-Site Surveying and Data Collection

Texas Essential Knowledge and Skills (TEKS)

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The following are TEKS that apply to this activity:

4.1A	5.1 A	6.1 A
4.2 A, B	5.2 A, B, C	6.2 A, B, C
4.4 A, B	5.4 A, B	6.4 A, B
4.10 A	5.6 A, B	6.6 A, B, C
		6.14 B

Objective

Students visit the creek site and collect information by drawing, describing, surveying, and making physical measurements of the temperature and flow rate.

Materials for Each Team

- Field Data Sheets
- pencils
- thermometers
- cork or an orange (to estimate stream flow)
- watch or stopwatch
- meter sticks

Materials for the Whole Group

- soap and water
- paper towels
- camera and film (optional)

Procedure

1. Review with the students the safety rules, and take along soap, water, and some paper towels for wiping hands after contact with water.
2. Review with the students some of the "Diagnosis" information concerning the color of the creek and signs of life (see Instructor Resources and References section). Tell the students that today they will conduct a "visual survey" to collect some information for their Field Data

Sheets that can be used to tell others about the general characteristics of the study site.

3. Conduct the visual survey. Though he visual survey is the simplest of the survey types, it can provide a great deal of information about the stream while requiring little equipment. Basically, you'll need a clip board, pencils, data sheets, maps, and if possible, high boots, poison ivy wash, and a camera. You may also want to take a walking stick of known length for balance, probing, and measurements of depth and width.

   During the visual survey, the participants should map the stream or stream section. The map does not have to be a perfect likeness of the stream, but it should include the major habitat types, dams, bridges, location of discharge pipes, and dumps. Make notes on a field data sheet about stream depth and width, bottom (substrate) materials (for example, rocks, clay, sand, and mud), types of riparian vegetation (grasses, shrubs, and/or trees), adjacent land use, and unusual stream odors or colors.

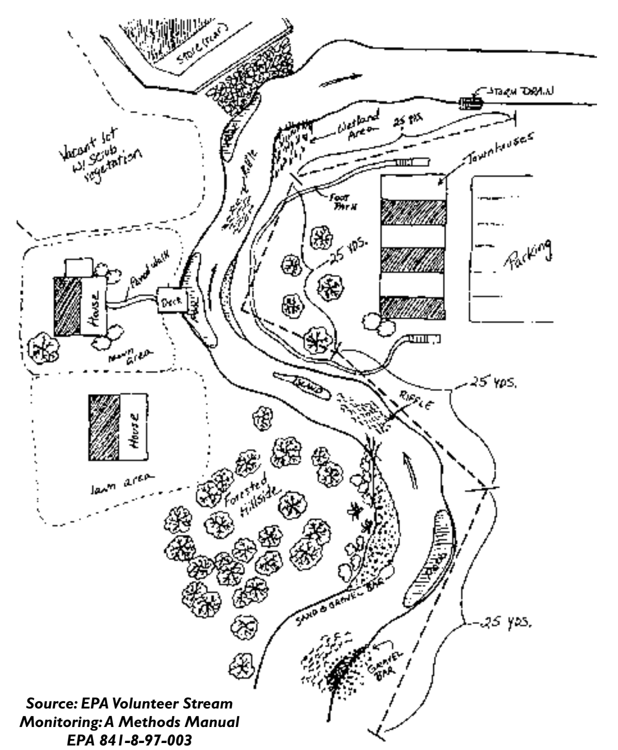
   A camera is useful in recording the various natural or unnatural stream characteristics mentioned above. Record information associated with each picture: for example, location, date, time, and names of photographer and other study participants.

4. Help the students form study teams. Each team should take one section of the study area and complete the following work:
   a. measurement of the air and water temperature
   b. measurement of the rate of water flow
   c. identification of plants and animals
   d. mapping of the team's section of the creek
   e. written description of the team's section of the creek

5. Give the students the following directions for finding the rate of flow of the creek in their section:
   a. Mark off a 2-meter length (200 cm) along the creek.
   b. Place the cork slice at the upstream end of the measured section.
   c. Time 10 seconds as the cork or orange is released into the stream.
   d. Measure how many centimeters the cork or orange traveled in 10 seconds. Divide by 10.
   e. Express the flow rate as "centimeters per second."
   Example: If the cork traveled 25 centimeters in 10 seconds, then the rate of flow in that place is 2.5 centimeters per second.

6. Take photos of the teams doing their work (optional).

Stream Sketch



Source: EPA Volunteer Stream Monitoring: A Methods Manual EPA 841-8-97-003

ACTIVITY FOUR:
Water Quality Testing

Texas Essential Knowledge and Skills (TEKS)

The Texas Essential Knowledge and Skills (TEKS) "identify what Texas students should know and be able to do at every grade" (Texas Education Agency, 1998). For example, TEKS 4.1 states "The student listens actively and purposefully in a variety of settings."

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The following are TEKS that apply to this activity:

Water Education Field Guide

4.1A	5.1 A	6.1 A
4.2 A, B, C	5.2 A, B, C	6.2 A, B, C
4.3 A	5.3 A	6.3 A
4.4 A	5.4 A	6.4 A
	5.6 B	6.7 B
	5.7 B, C	

Objective

Students visit the creek site to test for dissolved oxygen, pH, coliform bacteria and phosphates.

Materials

- phosphate test kit and directions
- dissolved oxygen test kit and directions (You may want to laminate the directions for outdoor work.)
- coliform bacteria test kit and directions
- scissors
- pill bottles
- pH paper
- goggles
- rubber gloves
- Field Data Sheets
- pencils
- soap, water, and paper towels
- camera and film (optional)

Procedure

1. Go over the directions supplied with each kit for the tests measuring dissolved oxygen and phosphate. Remind the students to wear goggles and rubber gloves as they use the chemicals.
2. Likewise review the pH test, and remind the students of what a low and high pH means in terms of water quality and organisms in the creek environment (Use the background information on the pH scale in the section "Indicators of Stream Health.")
3. The teams should decide where to do the dissolved oxygen and phosphate tests. Depending on the number of tests your group is to do, have the tasks divided up like this:
   a. One team does the dissolved oxygen test(s).
   b. One team does the phosphate test(s).
   c. One team does the pH testing at several different locations and begins the coliform test.
   d. One team shares the camera to record the groups doing the testing (optional).
4. While they are on-site, have the teams complete the Field Data Sheets they started during the last activity.
5. Be sure the students wash their hands with soap and water after water contact.
6. Tell the students that the next time they meet with you, they will identify any problems associated with their creek based on the evidence in their Field Data Sheets.

ACTIVITY FIVE:
Biological Survey

Texas Essential Knowledge and Skills (TEKS)

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The following are TEKS that apply to this activity:

4.1A	5.1 A	6.1 A
4.2 A, B	5.2 A, B	6.2 A, B
4.3 D	5.3 D	6.3 D
4.5 A	5.5 A, B	
4.10 A	5.6 A	
	5.11 A	

Introduction to a Biological Survey

Biological surveys of streams usually involve collecting aquatic macroinvertebrates (small animals without backbones) and fish. Data from these collections can be used to determine the past and present water quality of the stream, as well whether the stream is improving, degrading, or remaining the same over a period of time. For the purposes of this project, only benthic (organisms living on the bottom of a water body) macroinvertebrates will be discussed. While fish are commonly used as indicators of stream quality, a scientific collection permit is required to legally collect fish in Texas. The Texas Parks and Wildlife Department (TPWD) generally issues permits to universities, government agencies, and other organizations involved in the study of aquatic ecosystems. If information on fish is needed, try contacting a local office of the TPWD and/or TCEQ to see if they have collected any fish from your stream. Collection permits are also required to collect invertebrates in state and federal parks.

Objective

Students learn what lives in a stream and how these organisms act as indicators of pollution. Rather than an accurate count, it is more important to see how many different kinds of freshwater benthic macroinvertebrates are present in a stream.

Collection Equipment

Most freshwater organisms can be collected with simple homemade equipment. A little ingenuity is all that is required. A few pieces of equipment that have proven useful over the years are described in the following subheadings on personal and sampling equipment. While all of them can be purchased at a biological supply house, most can be made at home.

Personal Equipment

a. Clothing suitable for fieldwork including rubber boots or tennis shoes, waders, and other waterproof gear.

b. A small case, such as a discarded pocketbook or tobacco pouch, outfitted with a pocket lens, pencils, notebook, and forceps.

c. Containers suitable for bringing back collected materials. These containers should include small unbreakable jars of assorted sizes with tight-fitting lids, and one or two large jars in which to bring home unsorted material. Also needed are a few vials of 70 percent alcohol and some heavy duty plastic bags.

d. Poison ivy wash or preventive lotion, sunscreen, camera, and film.

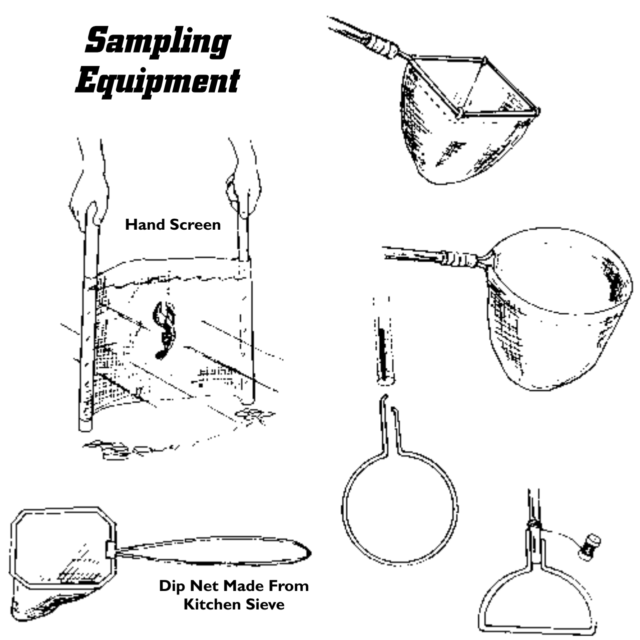
Sampling Equipment

a. Hand screen

Materials:

- nylon or wire door screen (1' x 2')
- 2 wooden poles (5 to 6 feet long)
- small nails or staples
- tin shears or tin snips

The piece of nylon or wire door screen will be attached between the two wooden poles. If wire screen is used, the woven (finished) edge is put on the end that will be in contact with the stream bottom. The opposite edge should be folded, leaving no projecting wire ends. The folded ends of the screen are wrapped around the poles and either nailed or stapled.



b. Observation pan

An ordinary white enamel or plastic pan can be used for examining a catch.

c. Dip nets

Aquarium dip nets, sold by most pet stores, are useful for light work around weed beds and along the banks of streams or ponds. An ordinary kitchen sieve tied to a long handle will serve well as a dip for light work along stream or pond banks.

Water Education Field Guide

Materials to make a dip net:

- heavy gauge steel wire
- wood pole (5 to 6 feet)
- thin wire
- any meshed fabric (curtains, mosquito netting)
- heavy twine
- heavy fabric strip (4 inches wide) or duct tape

The frame, made of heavy gauge steel wire, may be circular, semi-circular, triangular, or diamond-shaped, about eight inches in diameter. The handle has two grooves at one end, one on each side. Each groove is a different length and each ends in an inch-deep hole. The two loose ends of the wire frame also differ in length to match the grooves in the handle. The tip of each wire is bent at a right angle. The end of the frame can then be fitted into the grooves in the handle and bound in place by wire.

The net bag is made of coarse-meshed material and bound with a heavy fabric around the frame. Before cutting out the two pieces of netting from which the bag will be made, be sure to measure the frame and estimate the width of the cloth needed. The two pieces should be stitched together. The strip of four-inch, heavy fabric should be folded lengthwise, the edges turned in and bound to the net bag, with the two open ends coming together above one of the seams. These ends are left open for the insertion of the wire frame.

Procedure

Fine mesh nets (kicknets) or screens are used to collect benthic macroinvertebrates from streams. Benthic macroinvertebrates can be identified in the field or laboratory, although field identifications are preferred. There are many simple identification keys available. Keys use the physical characteristics of organisms to place them in the appropriate group. The following are examples of available benthic references:

- McCafferty, W.P. 1983. *Aquatic Entomology*. Jones and Bartlett Publishers, Inc., Boston.
- Merrit, R.W. and K.W. Cummins, Editors. 1995. *An Introduction to the Aquatic Insects of North- 3rd Special Edition.* America. Kendall Hunt Publishing Co., Dubuque, Iowa. 722 pp.
- Pennak, R.W. 1989. *Fresh-water Invertebrates of the United States-Protozoa to Mollusca, 3rd Edition.* John Wiley and Sons, New York. 628 pp.
- Thorp, J.H. and A.P. Covich, eds. 1991. *Ecology and Classification of North American Freshwater Invertebrates.* Academic Press, Inc. New York, 911 pp.

When collecting invertebrates from riffles, place the collecting net or screen firmly on the stream bottom approximately two feet downstream of where you are standing. Disturb the substrate with your feet and/or hands for a minimum of five minutes until the area in front of the net has been thoroughly disturbed.

Nets can also be used to sample margins of weed beds and undercut banks, and other habitats. Place the net in roots, stick piles, or in aquatic vegetation and vigorously move it back and forth for several seconds. Organisms are placed in a pan and identified in the field. Take care not to overlook any of them. Other collection methods include lifting rocks and logs from the stream and carefully looking for invertebrates. Remove the organisms carefully with forceps and place them in a pan. In this type of collecting, the movement of the invertebrates will often help you locate them.

If a field identification cannot be made, select several representative specimens and preserve in a 70 percent alcohol solution. For example, students have counted 50 of the same mayfly. In the field notes this can be described as species "A". Several representatives of species "A" are put in a container, labeled species "A", preserved, and taken back to the class/lab for identification. There is no need to take them all. Isopropyl (rubbing) alcohol is a suitable preservative and can be purchased from any drugstore.

Once benthic macroinvertebrates have been identified, they can be placed in categories of tolerant, moderately tolerant, and sensitive to pollution. This information, along with the information gathered during the water and visual surveys, will give the students a general idea of stream quality.

If time is limited, much information can be obtained about the condition of the invertebrate community and the water quality of a stream without identifying the organisms. By carefully sorting the collection and grouping organisms that look alike, the number of types present can be determined. To sort, use primarily body shape and the number of legs and tails; secondary characteristics such as size and color patterns may also be used. In general, the more variety of types present, with small numbers of each type observed or collected, the better a stream's quality. A stream of poor quality will generally have only a few types, with large numbers of each.

Again, for this level of study, students should complete work in the field. Although sorting and identifying aquatic organism can be done on preserved samples, it is much easier to work with live specimens that can be returned to the stream. There are many manuals available for advanced benthic macroinvertebrate collection. The following is a selected reference for Texas:

- Texas Commission On Environmental Quality. 1999. *Receiving Water Assessment Procedures Manual.* Publication No. GI-253. TCEQ, Austin, TX.

Benthic Macroinvertebrate Count and Water Quality

a. a great variety of insects, with few of each kind—great water quality.

b. less variety of benthic macroinvertebrates, with great abundance of each kind and a with a mixture of pollution tolerant types—good water quality.

c. only one or two kinds of tolerant benthic macroinvertebrates, with great abundance—poor water quality

d. no insects, but the stream appears clean (is there habitat available for benthics? Check the water quality data)—unknown water quality

Stream Problems and Their Impact on Aquatic Life

After a survey of aquatic macroinvertebrates is complete, try to determine why you found what you did. What did you note during the visual and water quality surveys? The following are summaries of topics presented earlier in the manual. Refer back to these sections for additional information.

Physical Problems— may include excessive sedimentation from erosion; the sediment may create poor riffle characteristics, contribute to excessive flooding, reduce water in stream flow, cause increases in water temperatures, and reduce habitat for aquatic macroinvertebrates. The result will usually be a reduction in the number of all animals in the study area.

Organic Pollution—from excessive human or livestock wastes. The result is usually a reduction in the number of different insects types. Many different aquatic organisms are replaced by large numbers of a few species that can tolerate low dissolved oxygen.

ACTIVITY SIX: Data Analysis

Texas Essential Knowledge and Skills (TEKS)

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The following are TEKS that apply to this activity:

4.2 A, C, D	5.2 A, C, D	6.2 A, C, D
4.3 A, B, D	5.3 A, B, D	6.3 A, B, D
	5.6 B	

Objective

Students look over the Field Data Sheets to give themselves a rough idea of the health of their selected creek. Teams report on the dissolved oxygen, phosphates, pH, and aquatic life. Any obvious problems with the creek are identified.

Materials

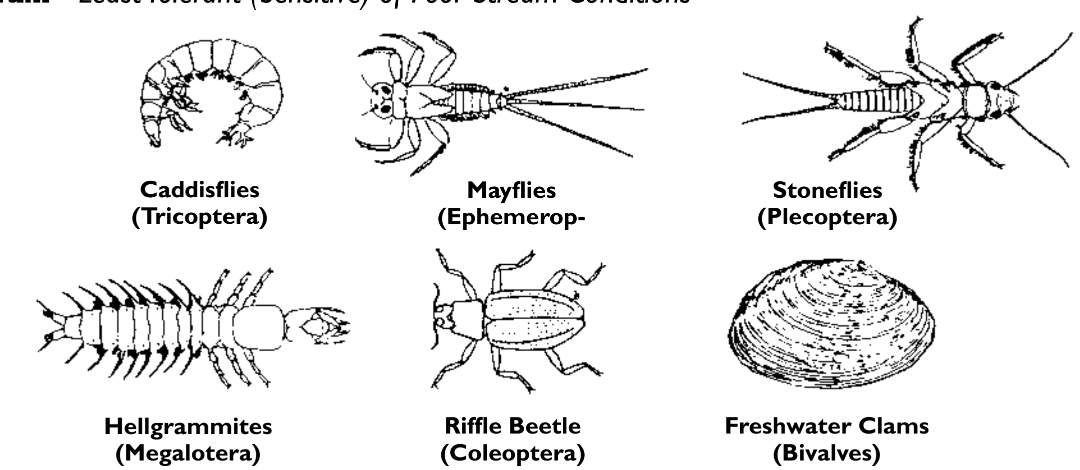
- Field Data Sheets
- pencils

Procedure

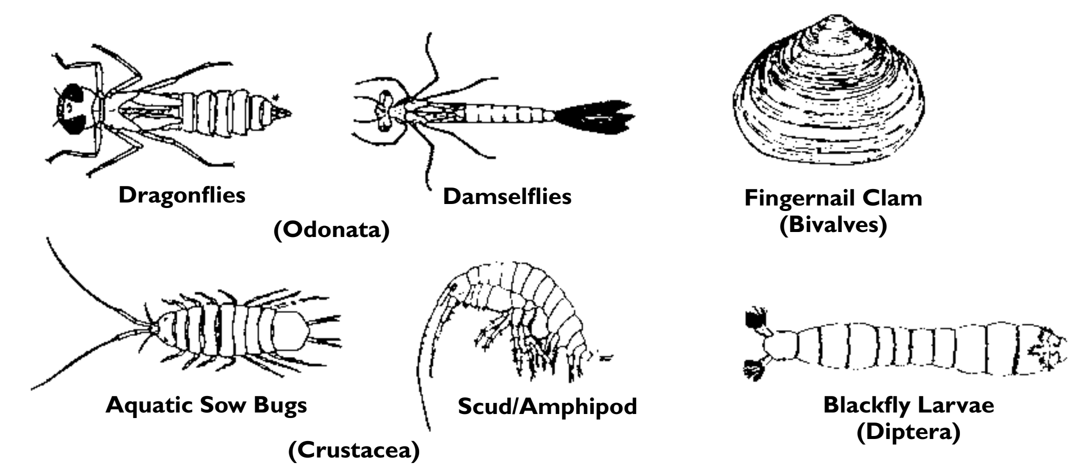
1. Have the teams share their field data notebooks and discuss the differences and similarities between their data. Point out that the creek appearance and water quality may change along its length.

Representative Stream Invertebrates Associated With Different Degrees of Habitat and Water Quality Degradation

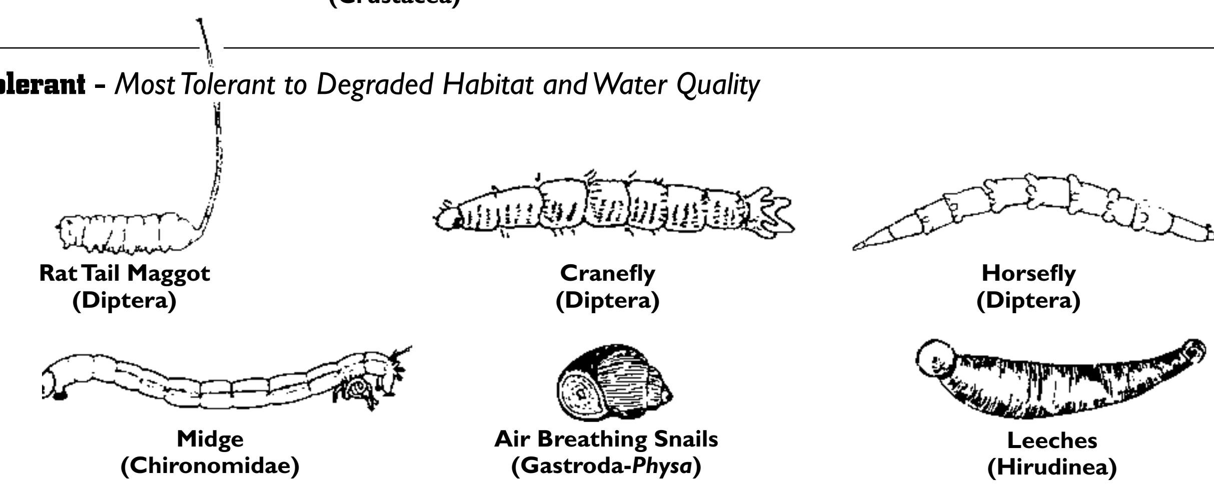
Intolerant - *Least Tolerant (Sensitive) of Poor Stream Conditions*



Intermediate - *Moderately Tolerant to Degraded Habitat and Water Quality*



Tolerant - *Most Tolerant to Degraded Habitat and Water Quality*



2. The teams that performed the dissolved oxygen, phosphate, and pH tests should report to the group so that they can add the data into their field notebooks.
3. Review with the students what the data may mean for each test (dissolved oxygen, pH, water temperature, and phosphate.) For example, when the results of the dissolved oxygen test are low, it may mean that the decay of organic wastes is using oxygen, or that the water temperature is warm, or that there are too few plants such as algae in the water, or simply that the water doesn't move much. Have students discuss how the components are related to each other.

   It is important for the students to understand that determining the most important underlying causes may not be easy in diagnosing water quality problems with the few tests they have performed. They may only be able to speculate on the underlying causes, especially if they have not seen direct evidence of point source pollution (a discharge pipe, for example).
4. If benthic macroinvertebrate samples were collected have the students report what was found. The entire group can work on determining the tolerance of each collected organism (sensitive, moderately tolerant, tolerant).
5. Ask the students if they can think of any immediate solutions to the problems in their creek. Is there something they can do to improve the creek directly?

   If the creek has trash in it, for example, they may want to spend a day cleaning it up. For that activity they will need trash bags and gloves to protect their hands. In some urban streams, trash may include car parts, shopping carts, and other large objects.

   Any other problems may be too complex to solve without professional information, so the problem-solving students will do beyond picking up trash will target community awareness. How and what can they tell others that may make a difference in the water quality in their creek?
6. Tell the students that during the next session they will use problem-solving strategies that will address that question.

ACTIVITY SEVEN: Problem-Solving and Goal-Setting

Texas Essential Knowledge and Skills (TEKS)

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The following are TEKS that apply to this activity:

4.2 A, C, D, E	5.2 A, C, D, E	6.2 A, B, C, D, E
4.3 A, B, D	5.3 A, B, D	6.3 A, B, D

Objective

Using the data collected during the on-site visits, students brainstorm to identify existing or potential problems associated with their creek. They select a problem and a way to raise community awareness about the problem, then identify the target group they will approach.

Materials

- Field Data Sheets
- background information
- county maps
- pencils

Procedure

1. Remind the students that even though they may not be able to solve the water quality problems associated with their creek, they can do something very important: they can make other people aware of water quality issues. As they know, nonpoint source pollution can originate from a variety of sources, and some of those sources may be individuals who can learn to take better care of their waterways. If they can influence those individuals, the students are contributing to the solution of a problem!

Bug Picking – Is Your Creek Polluted?

Have you ever noticed the many small animals such as insects, snails, and worms that live on the rocks and roots at the bottom of creeks, rivers, ponds, and lakes? Some of these small aquatic animals are very sensitive to changes in the water and will die if the water becomes polluted. By looking for and recognizing the different types of aquatic animals in aquatic environments, you can begin investigating the water quality of those environments.

Equipment:

Safe footwear for wading, forceps, magnifiers, small aquatic nets, pipettes, Bug Picking Data Sheet, pencils and shallow pans for holding specimens

Directions:

1. Wade into shallow water, turning over rocks, looking for aquatic animals ("bugs"). Replace rocks where you found them after you inspect them.
2. Place each "bug" you find in a specimen pan and begin to divide them into different types and groups according to the Bug Picking Data Sheet. (Water in the pans will keep them alive while you take data.)
3. On the Bug Picking Data Sheet, put a tally mark next to the picture that matches each aquatic animal you find. Gently return the animals to the water.
4. Look at the 3 different groups of aquatic animals you found in the water. To determine if your water **might** be polluted, answer these questions or circle the correct response.

■ Did you find animals that are pollution sensitive?	None	1-3 species	More than 3 species
■ Did you find animals that are somewhat sensitive?	None	1-3 species	More than 3 species
■ Did you find animals that are tolerant of pollution?	None	1-3 species	More than 3 species

■ What could be happening upstream or on land around the water to affect the water quality where you are sampling?

This water appears to be *(circle one)*: Not Polluted OK Polluted

I am basing this hypothesis (guess) on:

____

____

____

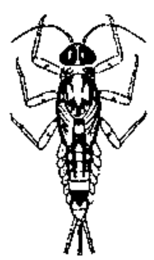
Provided courtesy of Texas Parks & Wildlife Department

Bug Picking Data Sheet

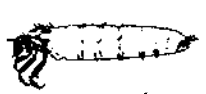
Group 1
Pollution Sensitive

Stonefly Larva (1/2 to 1 1/2")

Whirligig Beetle (1/2")



Mayfly Nymph (1/4 to 1")



Caddisfly Larva (*up* to 1")

Grass Shrimp (*1* to 2")

Dobsonfly Larva (3/4 to 4")

Number of Species Found:

_____ 3 or more species
_____ 1-3 species
_____ no species found

Group 2
Somewhat Sensitive

Diving Beetle (*1* to 1 1/2")

Dragonfly Larva (1/2 to 2")

Damselfly Nymph (1/2 to 1")

Scud (1/4")

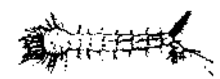
Water Boatman (1")

Coiled Snail (7/16")

Number of Species Found:

_____ 3 or more species
_____ 1-3 species
_____ no species found

Group 3
Pollution Tolerant



Mosquito Larva (5/16")

Grilled Snail (1/2")

Freshwater Clam (1/2 to 1")

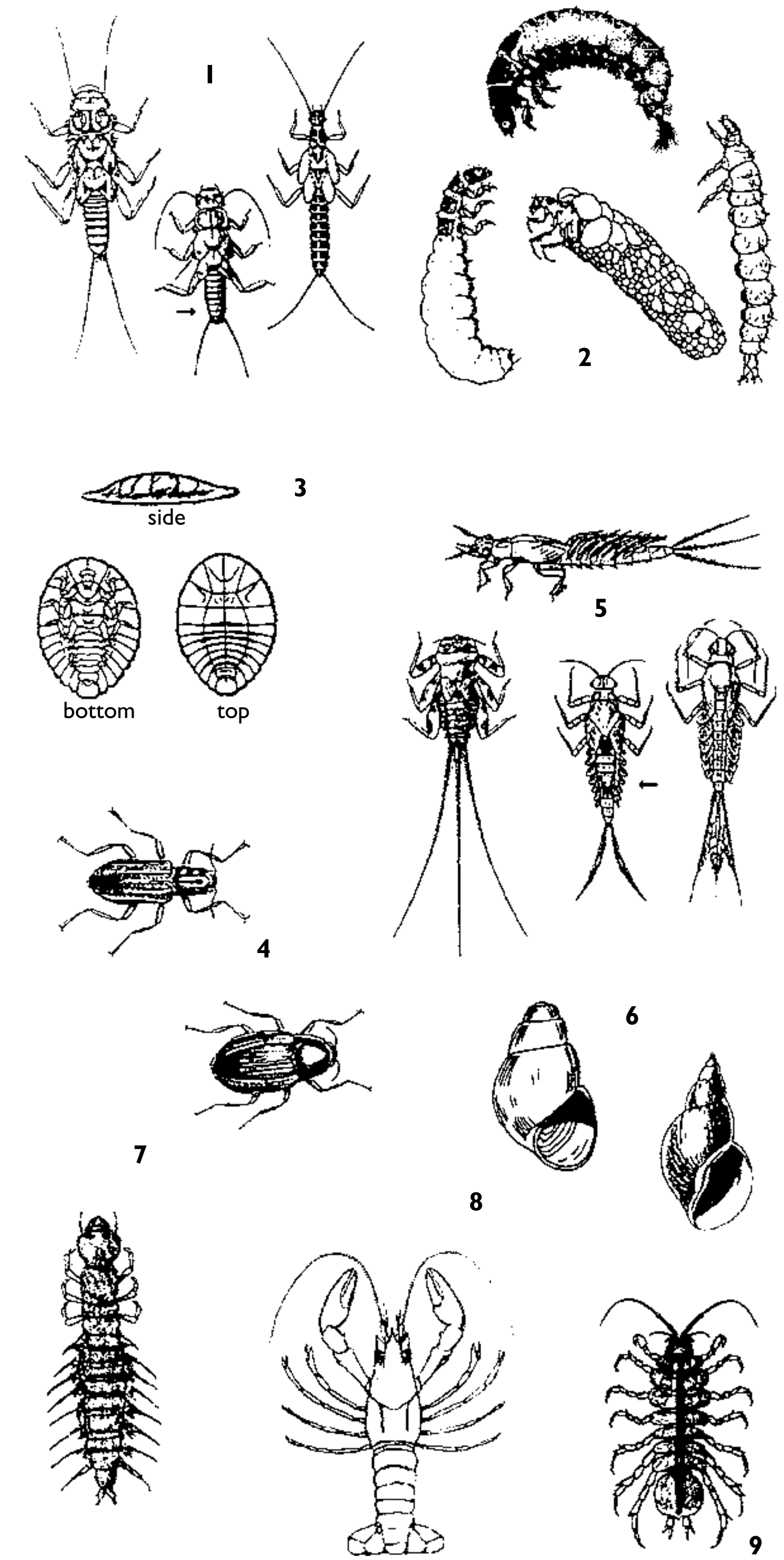
Leech (1/4 to 2")

Aquatic Worm (1/4 to 2")

Midge Larva (*up* to 1/4")

Number of Species Found:

_____ 3 or more species
_____ 1-3 species
_____ no species found



Provided courtesy of Save Our Streams

Stream Insects & Crustaceans

GROUP ONE TAXA

*Pollution **sensitive** organisms found in good quality water.*

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

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

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

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

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

6 ***Gilled Snail: Class Gastropoda.*** Shell opening covered by thin plate called operculum. When opening is facing you, shell usually opens on right.

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

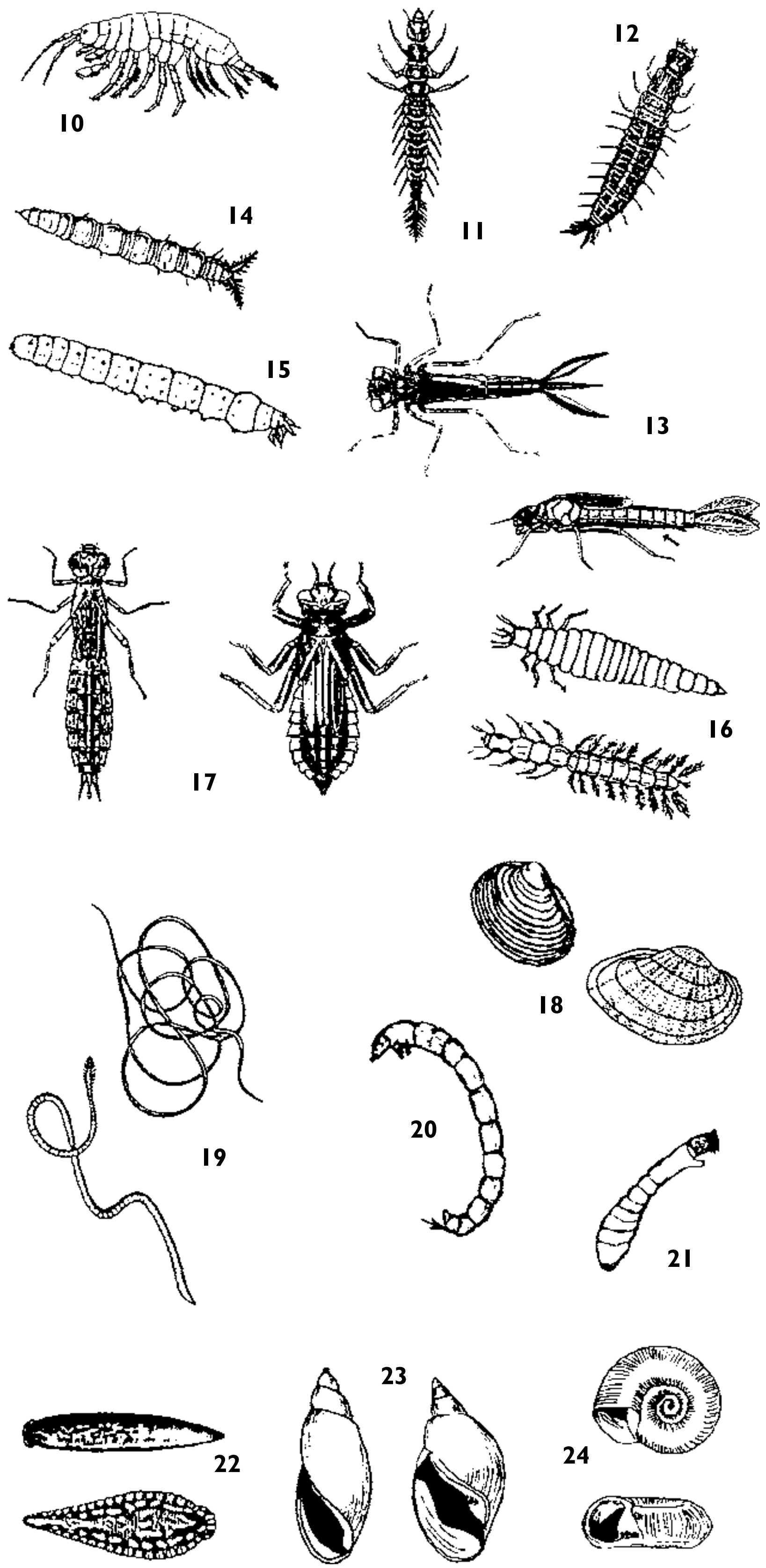
GROUP TWO TAXA

Somewhat pollution tolerant organisms can be in good or fair quality water.

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

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

Save Our Streams
Izaak Walton League of America
707 Conservation Lane
Gaithersburg, MD 20878-2983
1(800)BUG-IWLA



GROUP TWO TAXA *continued*

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

11 ***Alderfly Larva: Family Sialidae.*** 1" long, looks like small hellgammite but has 1 long, thin, branched tail at back end (no hooks). No gill tufts underneath.

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

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

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

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

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

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

18 ***Clam: Class Bivalvia.***

GROUP THREE TAXA

Pollution tolerant organisms can be in any quality of water.

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

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

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

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

23 ***Pouch Snail and Pond Snail: Class Gastropoda.*** No operculum. Breathe air. When opening is facing you, shell usually opens on left.

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

2. If the group hasn't had much experience in problem-solving, tell the students that they will be using a creative problem-solving process that is used in schools around the world as well as in business and industry. It involves opening up their minds to all of the possible ideas they may have, then choosing the best ones.
3. In order to get ideas for the brainstorming process, have the students look again at the highway map and the course of the creek they have been studying. Have them look all through the watershed and try to find some specific answers to their creek's problems. Also, have them look through their field data notebooks.
4. Problem Solving Steps:
   a. ***Brainstorm***: Identify any of the problems that you have noticed with your creek. (Write all of their ideas on the board. Tell them that there are no bad ideas when brainstorming.)
   b. ***Select***: Select one (or more) of the problems identified. Select a problem because you can explain it, you understand it, it is manageable, interesting, or important to the students or community.
   c. ***Brainstorm***: How can you raise community awareness about the problem(s) you have selected? (Write all of their ideas on the board. In order to help the students get more specific in their solutions, use the following steps to identify the specific activity they might do.)
      i. ***Who should be the target group?***
      Examples: Possible Target Groups for the Community Awareness Activity
      Nongovernmental groups:
      - students and teachers at school
      - parents of students at school (or PTA) family
      - neighborhood
      - people in the creek's watershed
      - people who shop at local grocery stores
      - neighborhood associations
      - environmental organizations like the Audubon Society

      Governmental groups:
      - federal legislator(s)
      - state legislator(s)
      - TCEQ regional offices
      - TPWD (Resource Protection Division)
      - county health departments
      - city councils
      - city environmental protection departments
      - local municipal utility districts
      - local river authorities

      ii. ***What should be the message?***
      Example: Big Creek has oil in it: be sure your car doesn't drip oil.
      iii. ***What form should the message take?***
      Example: A note will be clipped onto grocery bags.
   d. ***State Objective***: (An objective includes a statement telling who will do what)
   Example: We will make notes to staple onto grocery bags that tell people who shop at local grocery stores to make sure their cars don't drip oil.
5. When the students have agreed upon an objective for their goal of raising community awareness, discuss with them the ***Implementation Phase*** of the problem-solving process:
   a. In order to accomplish the goal, ***What Needs to Be Done***? (List the steps on the board.)
   b. ***How Should We Do It?***
   c. ***Who Should Do What?*** (Divide up the tasks.)
6. As the tasks are assigned, you may want to include the creation of a product that could be displayed at your school or by your sponsoring organization to show the results of your students' work.
7. Tell the students that in the next activity or activities they will be working on their community awareness product, so they should bring any special supplies needed for that activity.
8. Notify the regional office of the TCEQ about your groups' findings and plans. (See the list of TCEQ Regional offices in the reference section of this handbook.)

ACTIVITY EIGHT: Implementing the Community Awareness Solution

Texas Essential Knowledge and Skills (TEKS)

The Texas Essential Knowledge and Skills (TEKS) "identify w hat Texas students should know and be able to do at every grade" (Texas Education Agency, 1998). For example, TEKS 4.1 states "The student listens actively and purposefully in a variety of settings."

The TEKS are included here for the benefit of teachers who use the Water Education Field Guide in their school classes. For full information about these important standards, visit the TEA's Web site (www.tea.state.tx.us/teks/).

The following are TEKS that apply to this activity:

4.2 C, D, E	5.2 C, D, E	6.2 C, D, E

Objective

Student teams work to complete and disseminate the actual product to raise community awareness of the problems in their selected creek.

Materials

- paper
- pencils
- crayons, paints, markers
- scissors
- glue
- other supplies as needed for the community awareness product(s)
- Field Data Notebook
- photos taken of the group (optional)
- posterboard (optional)

Procedure

1. During the last Water Education Field Guide activity or activities, the students complete a community-awareness product (for example, a set of fliers or posters), which they disseminate to the target group they have selected. You may also wish to have them make a documentation product, which could be displayed at the school or local city or county government office in recognition of their participation in Water Education Field Guide activities.
2. The documentation could include one or more of the following elements.
   a. ***Information***
   - name of creek studied
   - school name
   - instructor name
   - first and last names of students
   - grade level(s) of students
   - dates of involvement
   - objective
   - brief description of the plan and implementation
   - feedback received from the focus group or follow-up plans made by the group

   b. ***Samples***
   - One completed field data notebook
   - One sample of the community-awareness product

   c. ***Photographs***
   - Several photos of the students at work in the creek area
3. Arrange to have the product displayed where people can see the students' involvement in water quality issues.

Indoor/Outdoor Water Quality Activities

Indoor/Outdoor Water Quality Activities

The following list of activities can be completed in an area of the state where no surface water is available for testing; these experiments can also be used to supplement the field study portion of the Water Education Field Guide.

1. Create a watershed

Use a large tub, deep wagon, or wading pool to create a model watershed by placing two large mounds (hills) of dirt on either side of a gully (potential stream). The first three activities listed below will all be conducted in this model.

a. Create a stream system: Pour water down one of the hills to show how a stream system is formed. Discuss where the water comes from and where it goes—some into the ground, some to the stream, some into the air.

b. Illustrate how sediment can be a nonpoint source pollutant.

Place a sheet of white paper in the bottom of the gully. Pour water down one of the hills and observe the run-off of topsoil that makes its way to the stream (easily seen on the white paper). Discuss how the sediment (soil) can become a pollutant, harming stream life and eventually filling up the stream with soil. This happens naturally, over a long period of time, but how do human activities speed up the process?

c. Illustrate how nonpoint source activities on the land affect the stream.

Dig a small hole in one of the hills and pour in 1/2 cup motor oil. Cover the hole. This simulates a leaking underground storage tank or sewer system. With a watering can, "rain" on the contaminated area and observe the oil that makes its way to the stream system traveling underground. Discuss how nonpoint source pollution occurs as the ground and surface water is polluted from human activities on the land.

2. Illustrate how difficult it is to clean up pollution

Put a drop of oil into a bowl of water and observe. Try to remove it with various tools such as a spoon, pencil, leaf, paper, or eyedropper. Discuss how difficult it is to clean up pollution once it occurs.

3. Illustrate how water plants produce oxygen

Place a test tube over a water plant. Observe oxygen bubbles being produced when the tube is in strong light. Discuss the importance of water plants in the stream system.

4. Illustrate the importance of sunlight for life in streams

Collect some creek water in two airtight bags or jars. Hang or place one in a window and the other in a dark closet or box where no light can reach the water. Discuss the changes in the water over time and the importance of sunlight for life in the water.

5. Illustrate how phosphates affect surface water

Collect 5 gallon-size bags or jars of creek water. Leave bag #1 as it is. In bag #2, place 1/8 teaspoon powdered detergent (check the label to be sure it contains phosphates). In bag #3, place 1/4 teaspoon detergent. Put 3/8 teaspoon detergent in bag #4 and teaspoon detergent in bag #5. Discuss phosphates' effect on the water and the danger of too much plant growth in a stream. Remember that plants use carbon dioxide in the day and oxygen at night, so they would be competing with other living things for oxygen. (If nothing happens when the detergent is added, the creek where you got the water may have a low nutrient concentration or the detergent may have been too strong.)

6. Illustrate the succession of life

Set up a mini pond with a dish pan, wading pool, or large tub by filling the container partially with water, digging a hold in the ground, and placing the container in the hole. In several weeks, a "real" living pond will have formed.

7. Illustrate how important water is in natural recycling

Place some dead vegetation (grass, vegetable peelings, leaves) in a nylon stocking. Next, place some dead vegetation in a mesh bag. Finally, place some dead vegetation in a plastic bag. Weigh the three bags. Place the bags in water for a period of about two weeks. After removing the bags and allowing them to dry, weigh the bags once more and observe their appearance. Discuss the role water plays in natural recycling. The end result, in addition to a weight change, would be the rate at which the vegetation breaks down or decomposes.

8. Illustrate how oxygen in water is used in decaying processes

Obtain two small glass jars with screw-cap tops. Clean the jars thoroughly, and in one jar place a clean pad of steel wool. Fill both jars with tap water, adding two drops of methylene blue solution to each. Fasten the caps securely and allow the jars to remain undisturbed in an area where they can be observed periodically. Note the fading of the blue color and the rusting of the steel wool pad in one jar, while the blue color persists in the other jar in the absence of steel wool. Relate the blue color of the dye to the presence of dissolved oxygen, which, if removed to take part in the formation of rust, causes the color of the methylene blue solution to fade.

9. Illustrate how temperature affects life in water

Place a goldfish in warm water (about 30 degrees Centigrade) in a glass beaker. Count the number of times the gill on the fish moves in one minute. Drop the temperature to 5 degrees Centigrade by placing the beaker in a larger beaker full of ice/water mixture. Count the number of times the gill cover on the fish moves in one minute. Discuss the effect the temperature change had on the fish.

10. Illustrate how plants affect water quality

Pour tap water into a jar with leaves, plants, and grass. Seal the jar. Observe the contents of the jar over time. Discuss the decay of the vegetation. Mention that the decay process uses oxygen from the water. How would this affect living things?

11. Illustrate how water moves through the watershed

Observe water traveling over a variety of surfaces such as wood, sod, and linoleum. Measure the amount of water poured compared to the amount collected after runoff. Time how long it takes water to run over one substance compared to another. Discuss how urbanization, agriculture, and many human activities affect the water that travels through the watershed.

12. Check for erosion and nonpoint source pollution

Tour the playground or some other outdoor area and see if there is evidence of runoff occurring there. Discuss why it has or has not occurred. This activity will be especially meaningful after a heavy rain.

13. Observe living things in water

Using a microscope, observe the life that is supported in pond water.

14. Test the acidity of various substances in water

With litmus paper, test the acidity of various substances in water such as bleach, egg whites, egg yolks, orange juice, lemon juice, and vinegar. Now test water from various sources of water such as well water, sink water, fountain water, toilet water, or pond water. Discuss what can be learned about a water supply by testing its pH.

15. Create a natural system of filtration

With a hot nail, punch a hole in the bottom of a clear plastic cup. Create a natural filter by filling the bottom of the cup with small rocks, pebbles, gravel, and sand. Pour dirty water into the cup and observe the difference in the water that comes out through the hole. Discuss how the land naturally filters the water as it makes its way to streams, aquifers, and other water supplies.

Water Education Field Guide

Instructor Resources & References

Diagnosis

"How can I tell what is wrong with my creek?" Just like diagnosing a person or a pet who is sick, you take all the symptoms and signs together and try to decide what has happened and what is happening in the creek.

The following tables show what kinds of problems you might have in your area and the obvious signs of those problems. Read each table several times to allow yourself to get a feel for threats to streams.

Table 4.
General Land Uses That Might Affect Water Quality

Land Use Type	Potential Effects
Woodland	Erosion from logging, road construction, or clear cutting may cause muddy water
Agricultural Land (for example, crops, pasture, feedlots)	Fertilizers or manure draining into a stream may cause excessive algal growth; sedimentation from soil erosion; streams can be clogged with aquatic plants (macrophytes); pesticides, herbicides in stormwater runoff
Cities and Towns	Urban runoff carries with it a variety of contaminants such as oil, pesticides, metals, or chemicals. Note dominant area activities
Industry	Numerous types of chemicals and products produced. Identify specific industry types; color changes, excessive algae, odors, absence of aquatic life and fish kills; elevated BOD; sewage fungus
Wastewater Treatment Plants	Organic pollution; excessive algal growth, white foam, sludge deposits (fluffy dark brown/gray solids), absence of fish and insects or the abundance of tolerant forms (mosquitofish); variable DO levels; chlorine odor; sewage fungus (slimy growth, white, gray brown); elevated levels of bacterial indicators (fecal coliform bacteria, *E. coli*); bleached vegetation (chlorine) near the outfall
Construction	Muddy turbid water
Residential	Lawn fertilizers, oil drained from cars, septic tank overflows, detergents used to wash cars, trash (cans/bottles, paper)

Table 5.
Physical Indicators of Water Pollution

If you see. . .	The general causes could include. . .
Color	
Muddy tan to light brown	Suspended sediments common after rainfall; runoff from construction, roads, agricultural/range land; soil erosion (for example, vegetation removal from riparian zone, rangeland, agriculture, logging)
Pea green, bright green, yellow, brown, brown-green, brown-yellow, blue-green	Water with these colors generally indicate a plankton bloom if DO is high (especially during the day), pH is usually elevated; water color dependent on dominant plankton type present
Tea/coffee	Dissolved humic matter (organic portion of soil); usually from woodlands or swampy areas
Milky white	Paint, milk, lime
Dark red, purple, blue or black	Industrial sources-fabric dye, inks from paper and cardboard manufacturers
Milky gray/black	Oxygen depletion from raw sewage discharge or other oxygen- demanding waste; rotten egg or hydrogen sulfide odor present
Clear black	Turnover of oxygen-depleted bottom waters or sulfuric acid spill
Orange-red	Deposits on stream beds often associated with oil wells and production areas, but not always; color due to iron; oily sheen or residue may be present, which can occur naturally (not oil or petroleum)
White crusty deposits	Common in dry/arid areas where the evaporation of water leaves behind salt deposits (for example, chloride, sulfate); also found in association with brine water discharge (from oil production areas); petroleum odor, along banks oily sheen may be present
If you smell...	***Odor***
Rotten eggs/hydrogen sulfide (septic)	Raw sewage
Chlorine	Wastewater treatment plant discharges; swimming pool overflow; industrial discharges
Sharp, pungent odor	Chemicals or pesticides
Musty odor	Presence of raw or partially treated sewage, livestock waste, or algae
Surface Scum	
Tan foam	Usually associated with high flow or wave action; wind action plus flow churns water containing organic materials (increased with rainfall runoff) creating harmless foam; produces small patches to very large clumps
White foam	Sometimes patchy or covering wide area around wastewater outfall; thin or billowy; mostly due to soaps
Yellow, brown, black film	Pine, cedar, and oak pollens form film on surface; pollen seeds and other natural debris may collect behind logs and at shorelines
Rainbow film	Oil or other fuel type; ***Note***: sheens are common especially after rains; oil/ gas wash off streets after rain; other sources include spills, pipelines, oil/gas production areas; petroleum odor may be present if there is a large sheen; some organisms cause a sheen

Field Data Sheets

Date: ____________________

River Basin: ____________________ Stream Name: ____________________

Stream Location: ____________________ County: ____________________

Collectors: ____________________

Weather Conditions: ❑ Clear ❑ Cloudy ❑ Rain ❑ Other: ____________________

Field Tests

Coliform Bacteria: ____________________

Temperature (air): __________ Phosphate: ____________________

Temperature (water): __________ pH: ____________________

Dissolved Oxygen (ppm): __________ Other: ____________________

Water Appearance	Stream Bed Coating	Odor
❑ Scum	❑ Orange to red	❑ Rotten
❑ Foam	❑ Yellowish	❑ Musky
❑ Muddy	❑ Black	❑ Acrid
❑ Milky	❑ Dark Brown	❑ Chlorine
❑ Clear	❑ Brownish Tan	❑ Other
❑ Oily sheen	❑ None	❑ None
❑ Other		

Habitat

❑ Pool	❑ Undercut Banks	❑ Log Piles
❑ Riffle	❑ Rock Ledges	❑ Weed Beds
❑ Wetlands	❑ Tree Roots	❑ Large Boulders
❑ Backwaters	❑ Logs or Stumps	❑ Made Objects

❑ Other (explain)____________________

Field Data Sheets *(page 2)*

Depth

Pool ____________________ Riffle _________________

Width

Pool ____________________ Riffle _________________

Stream Cover

❑ Fully exposed (0-25% of stream is shaded from the sun)

❑ Partially exposed (25-50%)

❑ Partially shaded (50-75%)

❑ Fully Shaded (75-100%)

Vegetation

Trees (%) ___________ Plants (%) ___________ Exposed (%) ___________

Shrubs (%) ___________ Root Mats (%) ___________

Biological Samples

1. ***Algae:***

Is the algae located: ❑ Everywhere ❑ In spots

Is the algae: ❑ Attached ❑ Floating ❑ Other (explain)

2. ***Benthic Macroinvertebrates*** (Insects, crayfish):

Number: Number of different types: ____________________

Kinds (list):____

3. ***Fish***: Types of fish observed (for example, bass or sunfish):______________________________

____

4. Other aquatic and semi-aquatic organisms (list):

Amphibians:____

Reptiles:____

Shore birds:____

Waterfowl:____

Mammals:____

Field Data Sheets *(page 3)*

Visual Survey Checklist

Land Uses in the Watershed

1. Farming: ❑ Pasture/Grazing Land ❑ Crops ❑ Woods ❑ Other (explain) ________________

2. Urban areas: ❑ Homes ❑ Factories ❑ Stores

3. Mining: ❑ Surface ❑ Deep

4. Logging

5. Other (explain)____

Water Uses

1. Drinking Water Supply: ❑ Yes ❑ No

2. Industrial Water Supply: ❑ Yes ❑ No

3. Agricultural Water Supply: ❑ Irrigation ❑ Livestock

4. Recreation: ❑ Swimming ❑ Fishing ❑ Other (explain) ______________________________

5. Waste Disposal:

Are there any discharge pipes: ❑ Yes ❑ No

If so, from where: ❑ Wastewater Treatment Plant ❑ Industry (factory) ❑ Farm Lots ❑ Unknown ❑ Other (explain)_________________________

Stream Channel Alternations

❑ Dredging ❑ Channelization ❑ Other (explain) ______________________________

Structures or Barriers in the Stream

❑ Dams ❑ Bridges ❑ Islands ❑ Waterfalls ❑ Other (explain) ____________________

Trash

Average number of small and large items

Paper, Small Trash	❑ 0-5	❑ 5-10	❑ 10-50	❑ over 50
Cans and Bottles	❑ 0-5	❑ 5-10	❑ 10-50	❑ over 50
Tires, Carts, etc.	❑ 0-5	❑ 5-10	❑ 10-50	❑ over 50

Field Data Sheets *(page 4)*

Map of Sampling Location

List pool-riffle areas, hydraulic structures (for example, bridges or dams), areas of physical impact, point sources, gravel bars, islands, and other points. Describe banks, width of riparian zone and adjacent land uses. Show dwellings, businesses, roadways and tributaries, direction of stream flow and a north arrow (N).

Water Education Field Guide

Field Data Sheets *(page 5)*

Visual Site Description

Give visual description of stream, substrate, banks, riparian zone, and adjacent land areas.

Water Education Field Guide

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Web Sites to Get Started

US Environmental Protection Agency—www.epa.gov/bioindicators/

US Geological Survey— http://ask.usgs.gov/

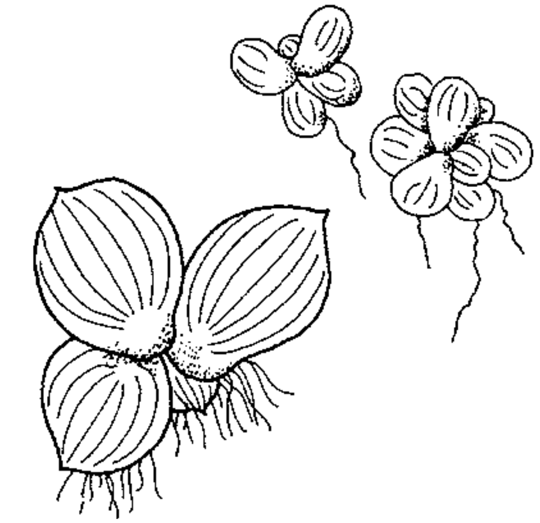
Rapid Bioassessment in Wadeable Streams and Rivers by Volunteer Monitors
www.dep.state.ct.us/wtr/volunmon/rbv.htm

Macroinvertebrate Field Identification Cards
www.dep.state.ct.us/wtr/volunmon/rbvcards.pdf

Aquatic Plants

Source: Aquatic Plant Control, Texas Department of Parks & Wildlife

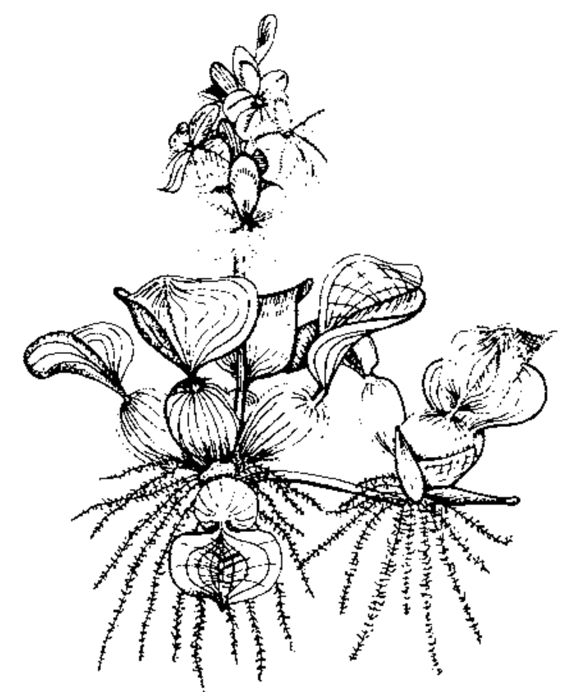
Floating Plants



Duckweed

Description: The leaves of these plants actually are fronds which occur singly or in groups up to 16 or 18. Each frond has one or more roots; giant duckweed has many. The fronds usually are ridged and range from two to four mm in diameter for the common duckweed and from five to eight mm in length for the giant duckweed. Both species usually disappear with the first cold spell, but return from spores the following spring.

Habitat: Duckweeds are found in fertile water with little current.



Water Hyacinth

Description: This aquatic plant, one of the oldest and most troublesome, was introduced into the United States in 1894. Left untreated, it can take over any body of water. It reproduces by fragmentation, seeds and production of daughter plants. The beautiful violet-blue and pink flowers resemble orchids, which is the probable cause of the species' wide distribution by well-meaning admirers. This plant usually is found floating on the water surface, although in shallow areas it can be rooted to the mud. The plant is dark green and ranges from seed plants, four to six inches across and four inches high to large plants measuring 24 inches across and up to three feet high. The elliptical leaves are leathery in appearance and are attached to petioles (leaf-stalks) that are slender under crowded conditions, but bulblike in free-floating stages. An individual flower has a yellow marking on the upper portion of the topmost petal. The many hair-like roots obtain nutrition from the water. Short roots often indicate water high in nutrients and long roots with excessive branches indicate water of low fertility.

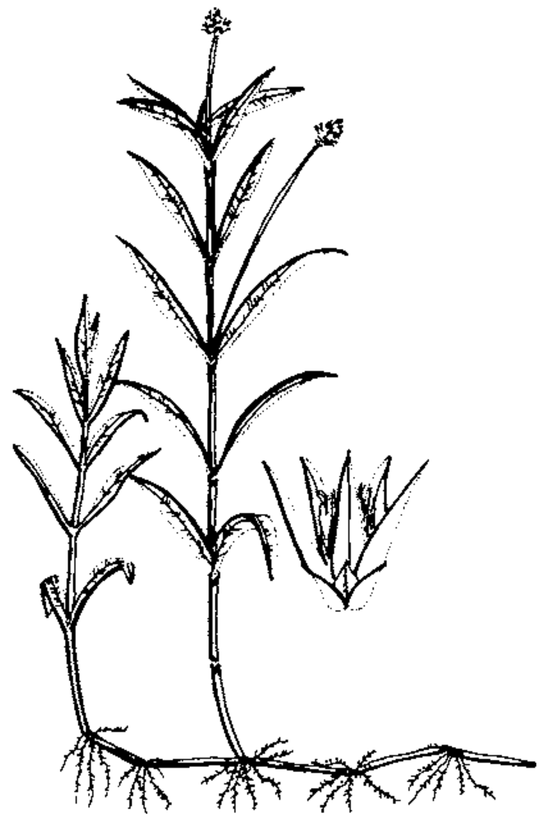
Habitat: Water hyacinths will grow in almost any moist environment, but often are found rooted to damp sand. The plants grow rapidly except in cold weather. Plant masses often result from young plants being washed or flooded into new areas. Seeds can lie dormant as long as 17 years in a dry habitat and then germinate when flooded.

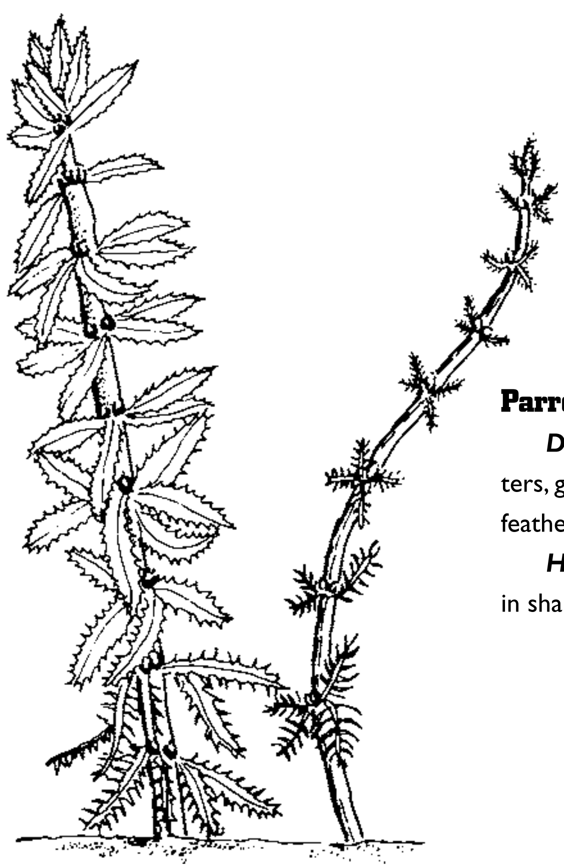
Floating Plants *continued*

Alligator Weed

Description: This perennial plant has roots at every node and grows luxuriantly, often forming thick mats on the surface of the water. The leaves are long, narrow and elliptical. White, cloverlike flowers appear near the tip of individual plants. Reproduction can be by seeds, but mostly it results from broken fragments of plants that take root in the hydrosoil.

Habitat: Alligator weed will grow in any freshwater habitat and has become established in low saline areas. When roots are in fertile soil and water is high in nutrients, the free-floating branches grow profusely.





Parrotfeather

Description: Parrotfeather, found in neutral or slightly alkaline waters, grows rooted to the hydrosoil and has firm blue-green stems with featherlike leaves extending to the surface.

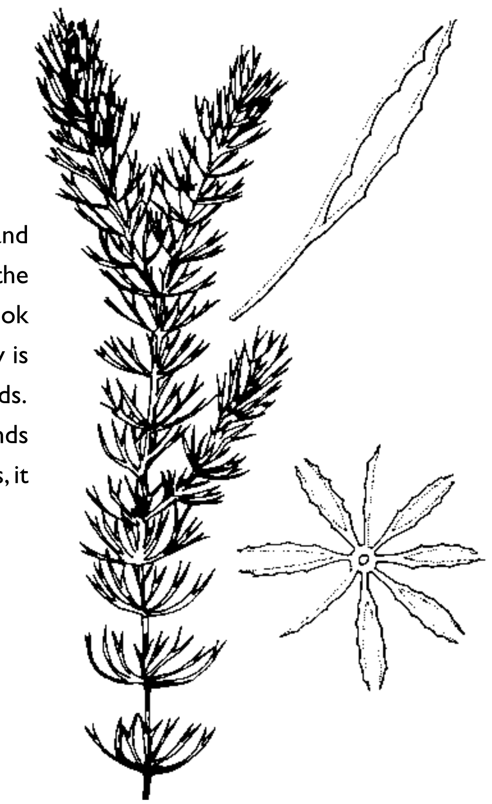
Habitat: This plant was introduced into the U.S. It is most common in shallow, still waters and reproduces by fragmentation.

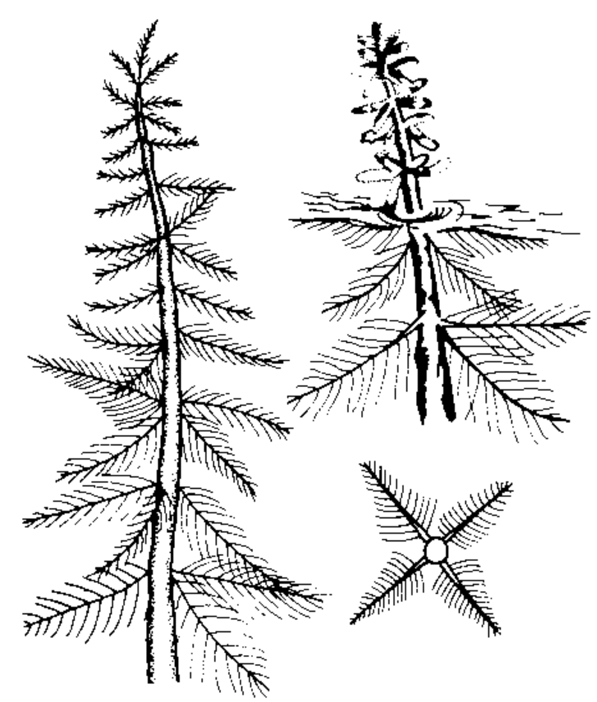
Submerged Plants

Coontail

Description: Coontail's slender leaves are olive to drak green and are rather elongated and whorled about the stem. The leaves, for the most part, are found toward the tip. When submerged, the leaves look much like the tail of a raccoon. This plant is unique in that it usually is rootless. Reproduction of the coontail is by fragmentation and seeds.

Habitat: This plant lives in a variety of habitats, from quiet ponds to slow-moving streams. Because of its structure and long branches, it can survive fluctuating water levels and some turbidity.



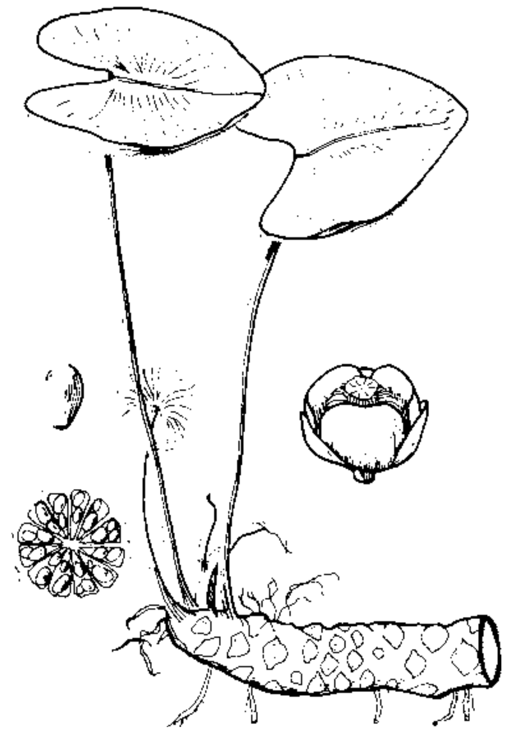


Water Milfoil

Description: This is a submerged aquatic plant capable of rapid reproduction by seeds, vegetative reproduction and fragmentation. Several species are pesent in Texas. All have stringy, branched stems with many whorled, threadlike leaflets. Roots hold the plant in shallow hydrosoil. In some species, the leaves above water are different in structure and composition from those below water.

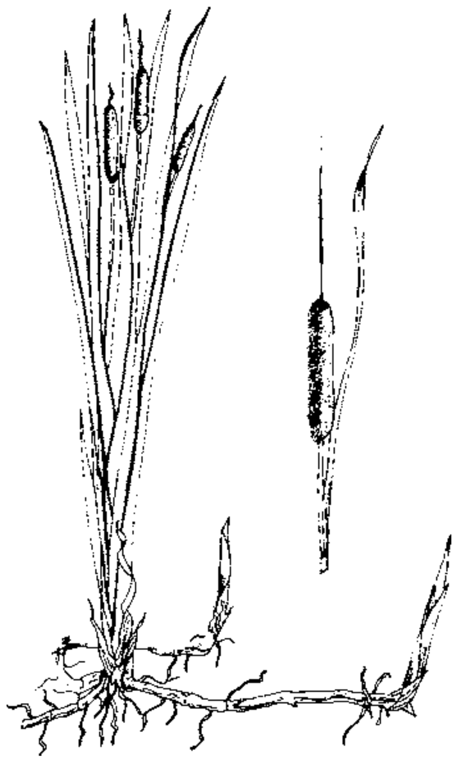
Habitat: Milfoil grows in a variety of habitats, ranging from fresh to slightly brackish water. This plant is hardy and over-winters in some areas.

Submerged Plants *continued*



Spatterdock

Description: Grows from a large, spongy rootstock that sends roots down into the hydrosoil and the leaves up to the surface on stout, tough, fibrous stems. These leaves are rolled underwater and ascend to lie flat on the surface. The dark green, leathery, eight to 10-inches-wide, heart-shaped leaves are characteristic of the plant. The yellow flower is about two inches in diameter and has an applelike odor. This plant produces many seeds capable of maturing underwater.



Cattails

Description: Two species of cattails, the narrow leaf and the flat leaf, are found in Texas. Similar in appearance, they are tall, erect, jointless plants, best recognized by long and cylindrical, dense seed spikes. When mature, these seed cylinders wilt and disintegrate. The seeds can be carried by the wind for miles to land and grow in a moist environment. Cattails have a long, extensive, stoloniferous root system with nodes at every joing. New plants can grow at these nodes, often 20 to 25 feet from the parent plant.

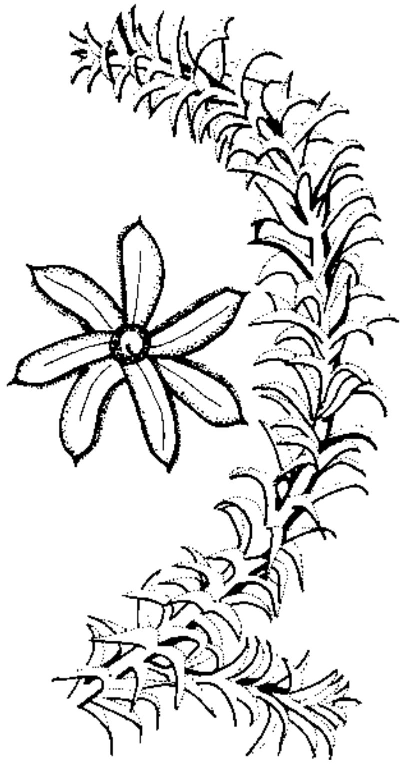
Habitat: Cattails inhabit shallow banks, shorelines, ditches and canals. They have great reproductive potential, by seed and node plants, and can soon cover a large area.

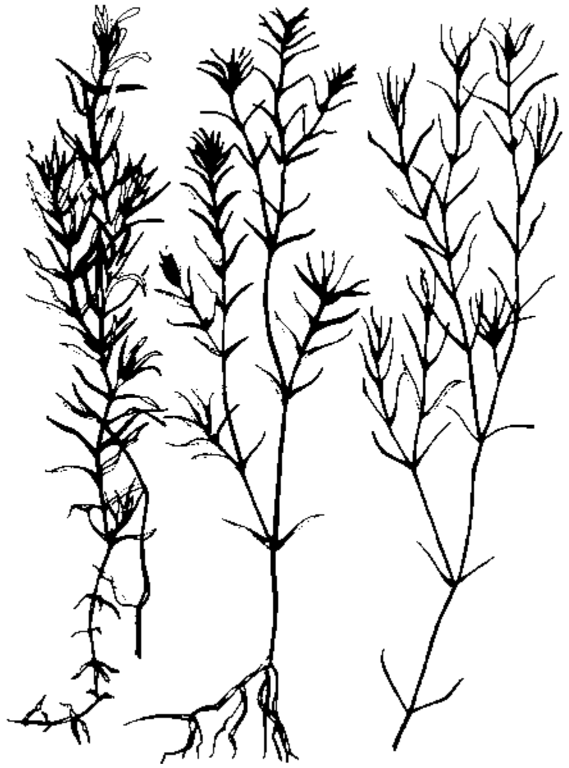
Submerged Plants *continued*

Elodea

Description: This plant is known in the aquarium trade as "Florida Ana" and "Oxygenator," but the most common name is Anacharis. Elodea is submerged and heavily rooted. The bright green, dense leaves arranged in whorls along the stem have no prominent mid-rib; the leaf margin and surface is smooth. The plant often is mistaken for hydrilla.

Habitat: Because of its heavy rooting system, this plant can occur in habitat ranging from fast-moving streams to still waters, and to depths of 10 feet. Broken branches can float, and will root along shoreline areas.



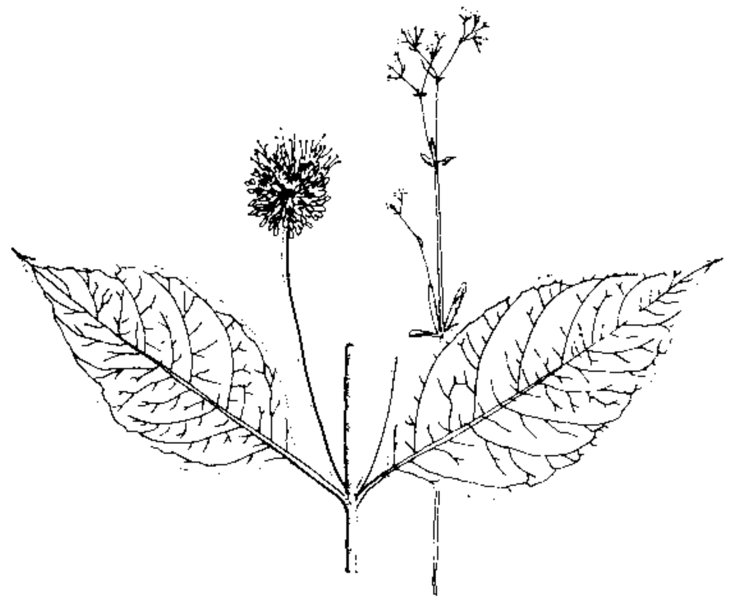


Bushy Pondweed

Description: This is a rooted, submerged plant with slender, often branching, greenish-purple stems. The leaves are deep green 1/2 to 3/4 inches long and very narrow with tiny spines along the edges. Bushy pondweed can grow thickly and occupy the major portion of a lake. It is one of the most common problem plants in Texas ponds and lakes.

Habitat: Bushy pondweed grows in almost any type of water, from fresh to brackish.

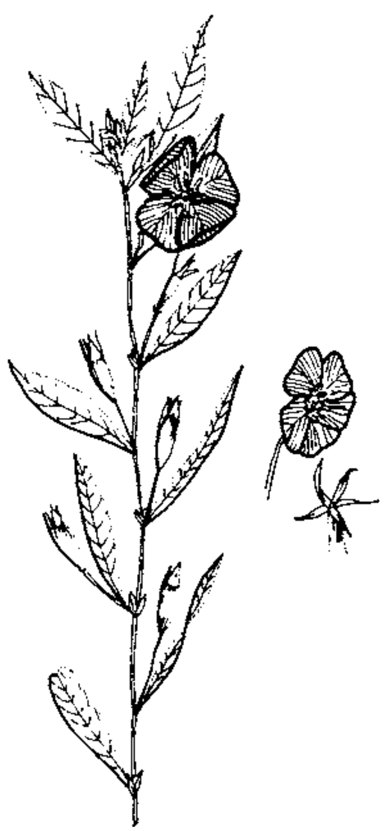
Shore and Ditchbank Plants



Button Bush

Description: This plant is a low-growing shrub bush often approaching the size of a small tree. Leaves are long, round and elliptical. It is best identified by the white flowers which resemble buttons.

Habitat: Button bush is found along the shorelines of lakes and ponds. It grows rapidly and abundantly and quickly can fill receding shorelines.

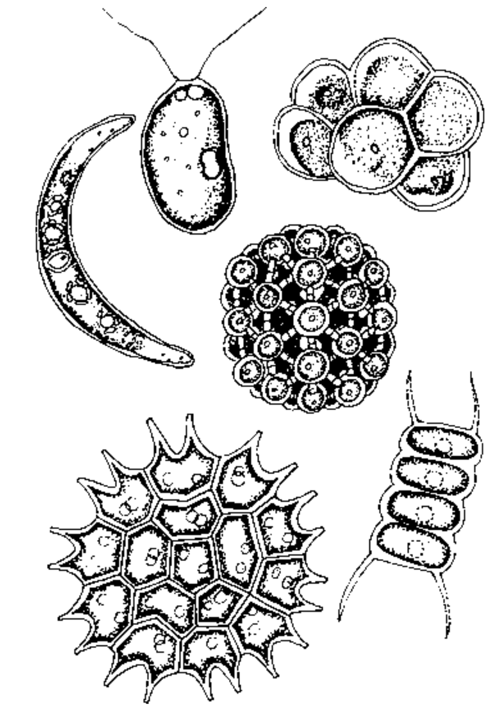


Primrose Willow

Description: A medium-size tree-bush, primrose willow often reaches 10 feet tall. It has many side branches and is prolific. Its leaves are long and lance-shaped, with tiny soft hairs on both sides. Flowers are yellow with four petals.

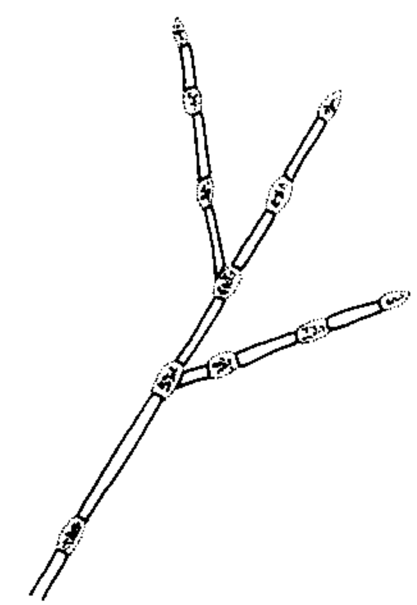
Habitat: The plant grows aggressively along ditchbanks, canals and streams.

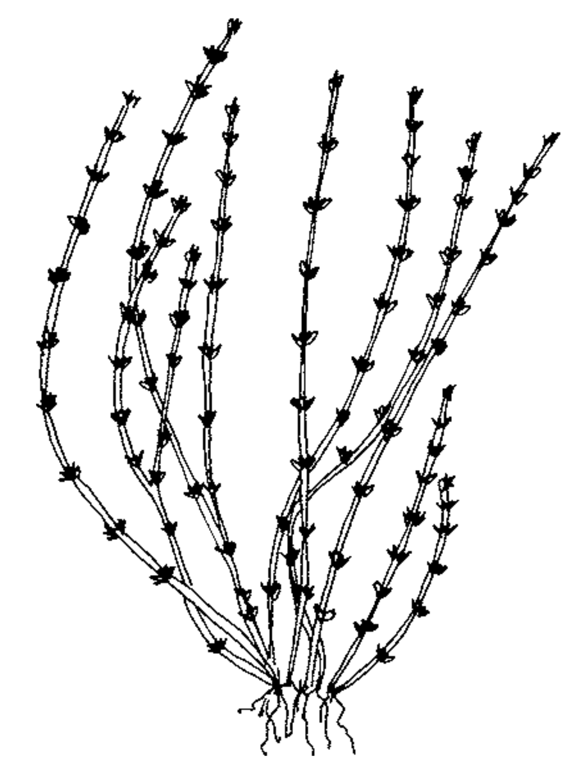
Algae



Algae

This group of plants is composed of three types: plankton algae, which are microscopic, free-floating cells single or colonial in habitat; filamentous algae, whose cells are in the form of threads; and the plantlike forms. Obviously, algae are quite diverse in their structure, habit and habitat.



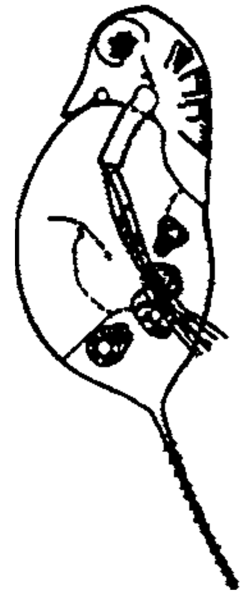


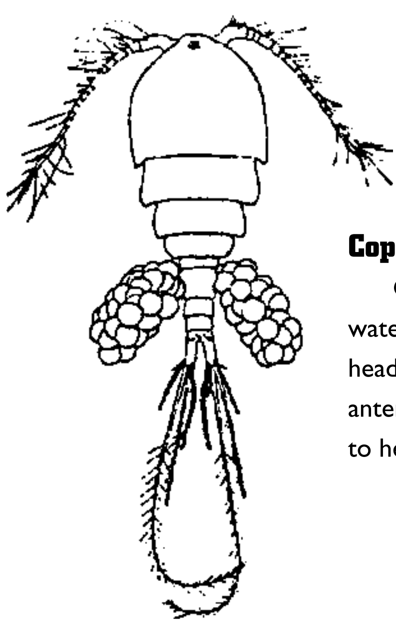
Aquatic Animals

Note: Approximate size is indicated beside name of organism.
Use of magnifying lens will aid in identification.

Daphnia *(barely visible with naked eye)*

Daphnia (Cladocera)—Commonly called a "water flea." The daphnia is found in all kinds of fresh water. It uses a second pair of antennae to swim jerkily through the water. It eats algae, microscopic animals and organic debris. This little crustacean is virtually transparent and is best recognized by its branched antennas, robust body and sharp-tail spine. The daphnia is an important food for fishes.





Copepod *(barely visible with naked eye)*

Copepod (Copepoda)—A fresh water crustacean abundant in all slow-moving waters and in ponds and lakes. Called "cyclops" because of a small eyespot on its head, the copepod is characterized by a very transparent body with two forked antennae and a branched tail. The female usually has two groups of eggs attached to her body just ahead of the tail.

Planaria *(1/4 - 1/2")*

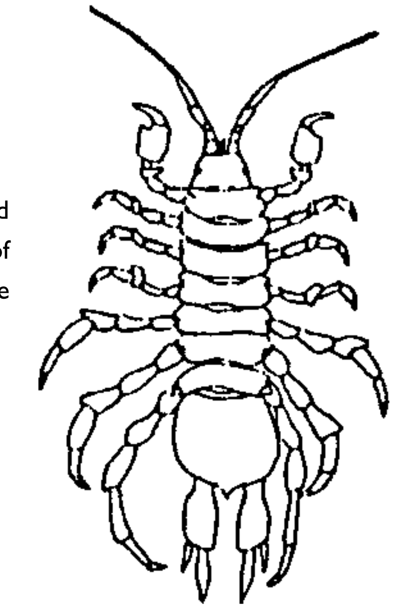
Planaria (Turbellaria)—Also known as a "flatworm." The planaria is fairly common in ponds, lakes, springs and other fresh waters and can be found among vegetation, beneath stones, or crawling on the bottom in an effort to avoid light. It eats small animals, living and dead. It is usually arrow-shaped and comes in various colors from white to black depending on the species and the environment. The young look just like adults, except that they are smaller.

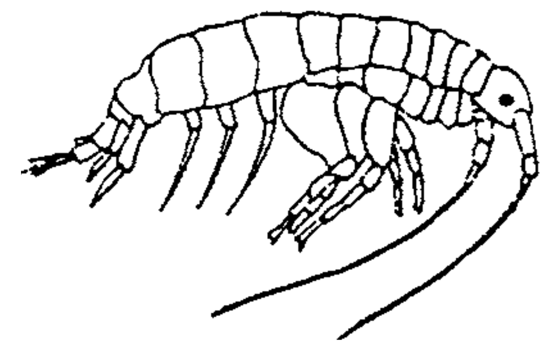
Water Education Field Guide

Aquatic Animals *continued*

Isopod *(1/4 - 1/2")*

Isopod (Isopoda)—Commonly called a "water sow bug." The isopod is found among fresh water vegetation and in oozes in the bottom of lakes and stagnant pools. It is a scavenger and an important food source for other animals.





Scud *(1/8 - 1/4")*

Scud (Amphipoda)—Also called a "side swimmer." The scud is widely distributed in ponds and even in the deep waters of large lakes. Flattened sideways like a flea, it lives close to the bottom or among submerged objects to avoid light. The scud is a scavenger that is eaten by fishes that feed among plants or off the bottom.

Leech *(1/4 - 1")*

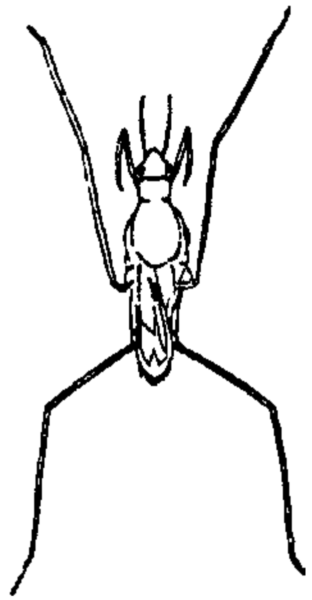
Leech (Hirudinea)—A flattened, segmented worm. The leech is often abundant in calm, shallow, warm waters that have bottoms cluttered with debris. It is predatory or parasitic, and has sucking discs that are used in attachment, movement and feeding. The leech is usually dark brown to black in coloration.

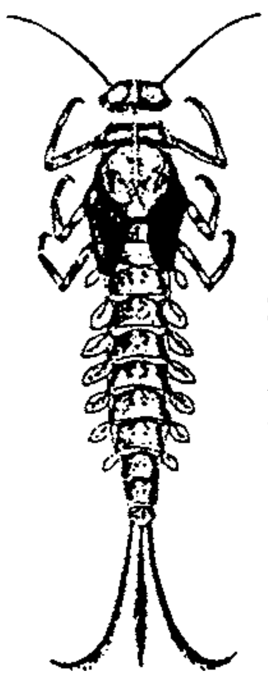
Aquatic Insects

Note: Approximate size is indicated beside name of insect. Use of magnifying lens will aid in identification.

Water Strider *(1/8 - 1/2")*

Water Strider (Order Hemiptera)—A very common sight on the surface of slow-moving waters, ponds, and lakes. The water strider resembles a long-legged spider. It has wings but rarely uses them. Its color is usually brown to gray. Many people call it a "water skipper." The water strider is a predaceous insect.



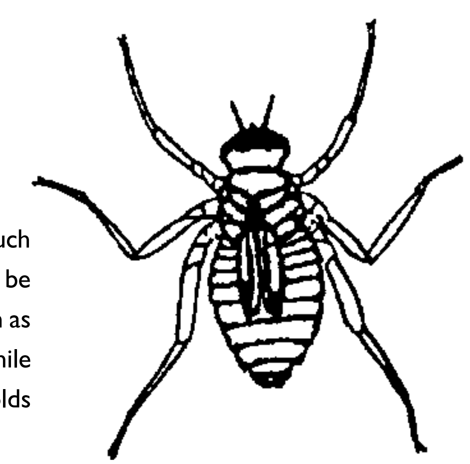


Mayfly *(1/8 - 3/4")*

Mayfly (Ephemeropyera)—Abundant in clean streams and lakes. The mayfly has two or three tails. The wings of the adult are held in an upright position while resting. The nymph is found on the undersides of rocks or other underwater objects.

Dragonfly *(1/4 - 2")*

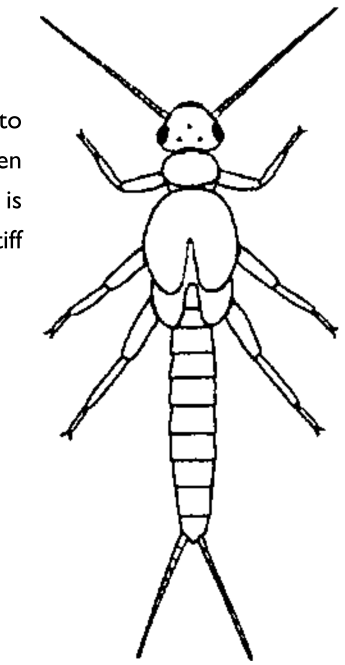
Dragonfly (Odonata)—Found in all types of fresh water areas such as ponds, lakes, streams and swampy areas. The dragonfly nymph can be found crawling around on the bottom. It is dark brown to greenish as a juvenile and changes to a brighter color as an adult. Both the juvenile and the adult are predaceous. When resting, the adult dragonfly holds its four wings outstretched.

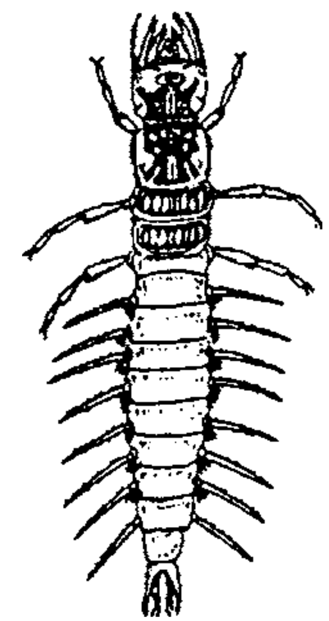


Aquatic Insects *continued*

Stone Fly *(1/4 - 1/2")*

Stone Fly (Plecoptera)—Seems to require running water in which to live. The stone fly is never found in lakes except in inlets and outlets. When the adult is resting, its wings lie lengthwise upon its back. The nymph is found in abundance among the rocks in a stream. It has two long and stiff tails. Fishes and other animals feed on the stone fly nymph.





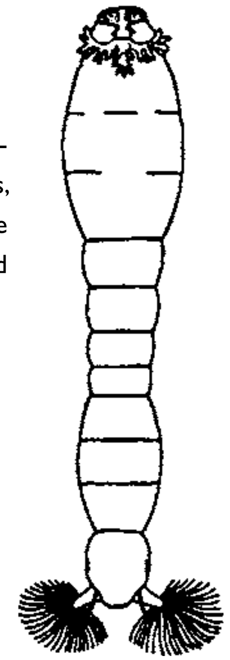
Dobson Fly *(1/2 - 3")*

Dobson Fly (Megaloptera)—Has brown and white splotched wings measuring up to five inches in spread. The male has a long curved mandible. The predaceous larvae, called hellgrammites, may be as long as three inches.

Caddis Fly *(1/8 - 1/2")*

Caddis Fly (Trichoptera)—Found in all fresh waters. During its underwater life, the caddis fly lives in a case made from sticks and small particles of rock. This can usually be seen moving about on the bottom. When the adult is at rest, the wings are held roof-like over the body and sloping down at the sides. The adult is generally dull brown or black in color. Larvae are sometimes called "periwinkles" or "penny winkles."

Aquatic Insects *continued*



Black Fly *(1/8 - 1/4")*

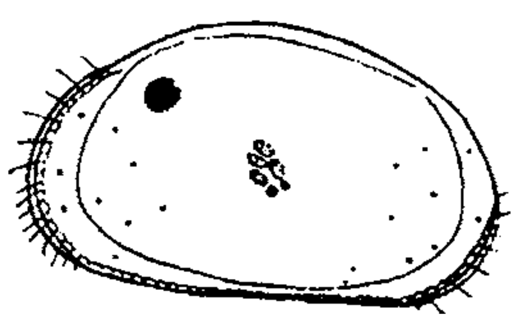
Black Fly (Diptera)—Has larvae found in flowing water on stones, vegetation or other objects, usually in the swiftest part of the stream. In many cases, the larvae are so numerous that they appear moss-like over the surface of the attached object. The black fly is usually dark and compactly built with rounded short, black, broad wings. The adult can be found great distances from water.

Midge *(1/8 - 1/4")*

Midge (Diptera)—Has larvae that are abundant in the shallow water areas of lakes, ponds and streams. The midge prefers soft, mucky bottoms, as it is a bottom-dwelling species that needs this type of environment for constructing its tube-like home. The adult looks like a mosquito. The midge antennas look like two feathers on the front of its head. The midge has no beak.

Ostracod *(barely visible with naked eye)*

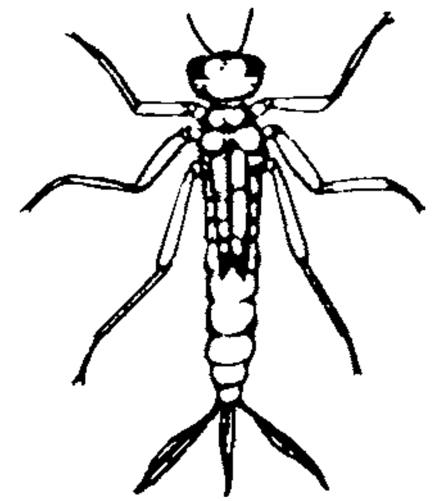
Ostracod (Ostracoda)—Often called a "seed shrimp." The ostracod is a tiny crustacean that crawls or swims about over the bottom of lakes, ponds and streams. It eats particles of food that it gathers from its environment. It is covered by a shell and looks like a small seed.



Aquatic Insects *continued*

Oligochaeta *(1/8 - 1/2")*

Worm (Oligochaeta)—Found on the bottom of all types of water bodies. The oligochaeta feeds on small food particles and bacteria as it burrows through the mud. It sometimes becomes very abundant where water is polluted.

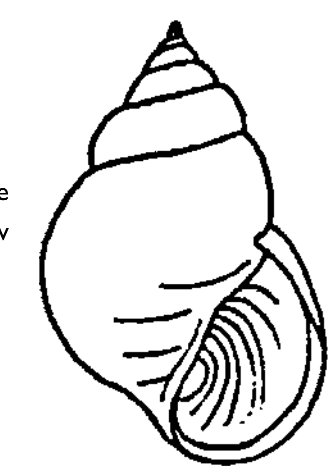


Damselfly *(1/4 - 1")*

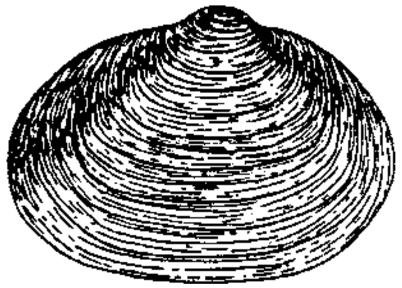
Damselfly (Zygoptera)—Has nymphs that live underneath rocks and logs in streams, lakes and ponds. The damselfly nymph can be recognized by the presence of three plate-like gills at the end of its abdomen, which help it to breathe oxygen from the water. The nymph resembles the adult damselfly except that it is smaller, has a thinner abdomen, and holds its wings together over its back (instead of out to the sides). Both the nymph and the adult are predaceous, feeding on small organisms.

Snail *(1/8 - 1")*

Snail (Gastropoda)—A soft-bodied animal living inside a coiled shell. The snail glides about on rocks and logs, feeding on diatoms and algae that grow on the surface of underwater objects. It is found in all types of waters.

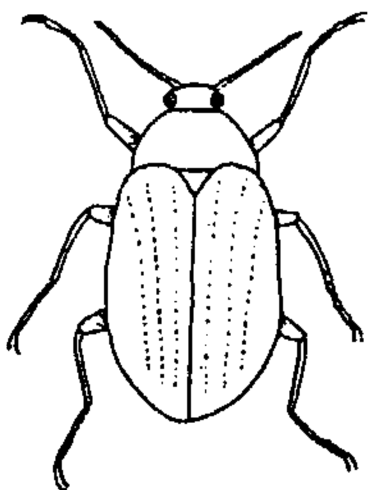


Aquatic Insects *continued*



Clam (*1/4 - 4"*)

Clam (Pelecypoda)—A soft-bodied mollusk living inside a shell with two halves, and muscles for opening or closing the shell. The clam burrows in the mud on the bottom of rivers, lakes and ponds. One end sticks up so the clam can draw in water and filter out small particles, which serve as its food.



Beetle (*1/8 - 1/2"*)

Beetle (Coleoptera)—Has larvae that are worm-like, except they have six legs. The adult beetle is oval-shaped with a hard outer skin, and is usually black or dark brown. The larvae and adults live in all types of waters and have varying feeding habits depending upon the species. Some beetles are predaceous, while others feed on algae or decaying organic material.

Glossary

acid rain: rainfall that has reacted with airborne pollutants such as sulfur dioxides and nitrogen oxides, thereby reducing the pH (or increasing the acidity) of the rain.

acute toxicity: ability of a substance to cause poisonous effects resulting in severe biological harm or death soon after exposure.

algae bloom: an overgrowth in aquatic plants and algae caused by an increase in nutrients.

algal mat: a thick layer of filamentous algae floating at the surface of lakes, ponds, and slow-moving areas of flowing water.

alluvial deposit: deposits of clay, silt, sand, gravel or similar detrital material deposited by running water.

aquifer: stratum of the earth composed of water and layered between permeable rock, sand, or gravel.

benthic: living on the bottom of a lake or sea; pertaining to the ocean bottom.

best management practice (BMP): the most effective practice or combinations of practices to control nonpoint source pollution. See also Structural BMP and Nonstructural BMP.

bioaccumulate: to accumulate larger and larger amounts of a toxin within the tissues of organisms at each successive trophic level.

biomagnify: a process in which a substance moves through the biological food chain by being passed from one organism to another as the contaminated organism is preyed upon by another organism.

boulder: rock greater than 10 inches in diameter.

buffer zone: an area along the streamside whose vegetative integrity is maintained in order to prevent erosion, trampling by livestock, and to reduce the amount of chemicals entering the creek.

classified waters: Texas rivers and their major tributaries, major reservoirs and lakes, and marine waters that the TCEQ has studied and rated for suitability to various uses—for example, swimming, fishing, drinking water supply.

clay: feels slick, sticks together.

channelization: the straightening and sometimes deepening of stream or river channels to speed water flow and reduce flooding.

chronic toxicity: substance causing long-term poisonous human health effects.

Clean Water Act: water pollution control law passed to restore and maintain the nation's waters: the nation's primary source of federal legislation that specifies the methods to be used in determining how much treatment is required for discharges from publicly owned treatment works.

cobble: rock between 2 to 10 inches in diameter.

dissolved oxygen: oxygen gas (O_2) dissolved in water.

drainage basin: another term commonly used to describe a watershed.

dredging: the use of machinery to widen or deepen a channel, or to remove debris.

effluent: wastewater (treated or untreated) that flows out of a treatment plant or industrial outfall (point source) before entering a body of water.

E. coli: associated with human waste, not necessarily harmful. E. coli, found in various water sources, is considered an "indicator bacteria" of possibly harmful bacteria.

ecosystem: the interacting system of a biological community and its non-living environment.

estuary: regions of interaction between rivers and near shore ocean waters where tidal action and river flow create a mixing of fresh and salt water.

eutrophic: as in a lake containing a high concentration of dissolved nutrients: often shallow, with periods of oxygen deficiency.

fecal coliform: bacteria commonly found in the small intestines of humans and warm-blooded animals.

filamentous algae: a type of algae that is attached to rocks, submerged logs, vegetation or floating mats.

first-order stream: a stream that does not receive the flow of a tributary.

food chain: the dependence of organisms upon others in series for food. The chain begins with producers (plants) and ends with the largest of the consumers (carnivores).

food web: an interlocking pattern of several or many food chains.

gravel: rock between 0.1 to 2.0 inches in diameter.

groundwater: water that remains below the land surface and travels below ground, such as an aquifer.

habitat: area and conditions in which an organism lives.

herbaceous: having no woody tissue.

herbicide: an agent used to destroy or inhibit plant growth.

hydrology: a science dealing with the properties, distribution, and circulation of water on and below the earth's surface and in the atmosphere.

impervious cover: areas of ground cover, typically in urban areas, which limit the amount of water that soaks into the ground, such as parking lots, roads, and sidewalks.

invertebrate: an organism lacking a spinal column.

infiltration: the penetration of water through the ground's surface into subsurface soil.

insecticide: an agent that destroys insects.

macroinvertebrate: multicellular organisms without a spinal column that live in, on, or under the water and are large enough to be seen without a microscope. Examples: immature or larval forms of insects, snails, clams, leeches, and crayfish.

nonpoint source (NPS): pollution sources without a specific point of origin, usually due to rainwater runoff from urban areas or agriculture/rangeland.

nonstructural BMP: best management practice that takes advantage of the land's natural features to remove pollutants; such controls include wetlands, grassed waterways, and buffer zones.

phosphate: an ion composed of a phosphorus atom with 4 oxygen atoms attached (PO_4^{-3}). It is an important plant nutrient.

pH: a measure of the concentration of hydrogen ions in a solution.

phosphorus: essential nutrient to the growth of organisms and can be the nutrient that limits the primary productivity of water.

photosynthesis: the manufacture by plants of carbohydrates and oxygen from carbon dioxide and water in the presence of chlorophyll using sunlight as an energy source.

phytoplankton: microscopic plant species that consist of single cells or small groups of cells that live and grow freely suspended in the water near the surface.

plankton: microscopic plants and animals in water which are influenced in mobility by the movement of water (i.e., as opposed to nekton (fish) which can swim.)

playa: small, shallow, circular lakes found scattered on the southern High Plains of Texas; an outlet for a watershed.

plume: an area where a contaminant has spread out.

point source: an identifiable source of pollution that involves a direct discharge of wastes, such as a wastewater treatment plant.

porosity: a description of the total volume of rock or soil not occupied by solid matter.

reservoir: any natural or artificial holding area used to store, regulate, or control water.

riparian: an area, adjacent to and along a stream, that is often vegetated and constitutes a buffer zone between nearby lands and the stream. Considered important in controlling sediment and nutrient delivery into the channel.

river system: the network of streams in a single watershed.

runoff: the part of precipitation or irrigation water that runs off land into streams and other surface water.

saddle: low-lying area between two ridges.

sand: particles less than 0.1 inches in diameter—feels gritty.

scum: a thin, filmy layer floating on the surface of a body of water, made up of biological material (dead plankton, bacteria, and other microscopic organisms) or man-made substances (oil or gasoline).

second-order stream: a stream that receives the flow of two or more first-order streams.

settling basin: structures that allow sediments and nutrients to settle out of water, or fall to the bottom of the structure, to prevent them from getting into the stream.

silt: particles less than 0.05 inches in diameter.

storm drain stenciling: messages that are stenciled onto storm drains warning that anything dumped into the drain flows, along with storm water, directly into a specific creek.

structural BMP: best management practice designed to capture surface runoff and remove pollutants through settling or other processes including, but not limited to, water diversions, retention devices, detentions basins, or filter systems.

surface water: water that remains on the land surface and contributes to lakes, streams, and reservoirs.

third-order stream: a stream that receives the flow of two or more second-order streams.

tributary: a stream that merges into another, thereby creating a larger stream.

turbidity: optical property of a water sample that causes light to be scattered and absorbed rather than transmitted in straight lines through the sample.

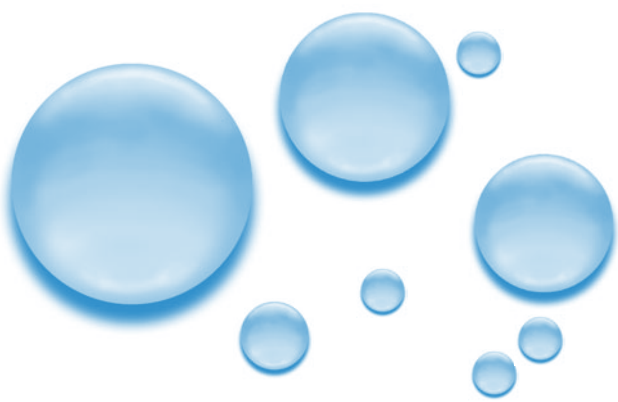
watershed: geographic area in which water, sediments, and dissolved materials drain into a common outlet.

wetland: an area that is regularly saturated by surface water or groundwater and subsequently is characterized by a prevalence of vegetation that is adapted for life in saturated soil conditions.

zooplankton: microscopic animal life of the plankton.

ADDITIONAL NOTES

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY



GI-026 (10/06)

TCEQ

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