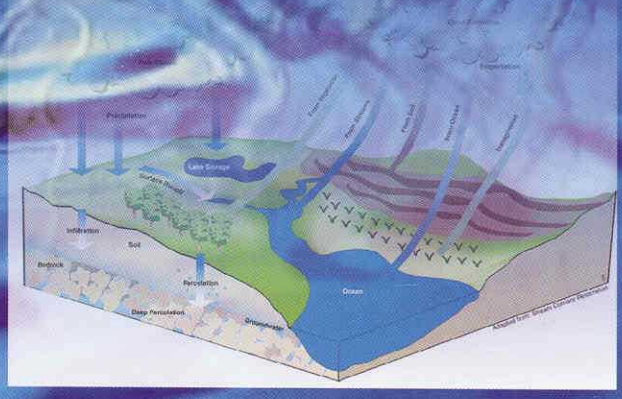
Forest Water Quality

Making Every Drop Count



North Carolina Non-point Source Program

forestry nps unit

NONPOINT SOURCE MANAGEMENT PROGRAM
Section 319(h) of the Clean Water Act
319 GRANT

Water in the Forest

What's in a forest? TREES, of course!
But what helps those trees grow? WATER

Forests are very special because they not only need water to grow, just like you and me, but forests also help to protect, filter and absorb water.

Where does all the water go?

First, anytime it rains, the water lands on the ground and can do one of two things:

1. The water can soak into the ground - this is called infiltration.
Once the water infiltrates into the ground, the trees soak up water out of the ground through the roots. This is called absorption. **It is very important to not cut, trample, or damage tree roots, because this is the main way that trees take in the water they need to grow.**

2. The water can run along the top of the ground surface - this is called runoff. Runoff can carry dirt, trash, chemicals and other pollution along with the water and flow into a stream or pond. This runoff process creates Non-Point Source pollution. **Non-Point Source pollution can be prevented by slowing down or trapping runoff before it starts to flow across the ground.**

But not all of the water gets absorbed by the tree roots. Sometimes, the extra water will slowly trickle down into the deep soil. This is called percolation. The soil in the ground is like a giant sponge, and can hold a large amount of percolated water. All of this extra water in the soil is stored, deep below the ground surface and is called ground water. In many places of North Carolina, families use wells to tap into ground water near their homes for drinking and taking a bath.

Because of this, it is very important that you don't pour out oil, chemicals, paints, or other polluting fluids onto the ground - - these dangerous ingredients can pollute the groundwater, or could become part of Non-Point Source pollution.

Activities:

Find out what kind of water you use at home, and ask an adult to help you see if there are any dangerous items that might be polluting your water.

Take a large, dry sponge and slowly drip water onto the top of it.
Watch as the water infiltrates into the sponge, then percolates down and across the sponge. When the water soaks all the way through the bottom, it has become groundwater. When the sponge is totally soaked through, the water will start to runoff along the top.

Water in the Forest

How do trees clean and protect our water?

Trees help clean and protect our water by doing many things:

- **Slowing down raindrops as they fall**
- **Filtering runoff**
- **Holding the soil in place**

Slowing down raindrops

If you have ever been outside when it rains, you know that raindrops can fall very fast. When raindrops fall onto the bare ground surface, the impact of these millions of raindrops can quickly wash away soil that is not protected or being held down by grass and other vegetation. When this soil starts to wash away, it is called erosion.

Erosion causes the most Non-Point Source pollution problems in North Carolina because there is so much bare soil and so much rain, that it's very hard to make sure all the bare soil is protected. This is especially true when land has to be cleared for building new homes, stores, roads, schools or other structures.

A forest of healthy trees can help prevent erosion by acting like a giant umbrella that blocks or slows down the falling raindrops before they impact the soil. This is called interception.

Even during the winter, when the leaves fall from the trees, a forest will intercept a lot of rain or snow, allowing the water to slowly infiltrate into the soil, instead of hitting the ground and becoming runoff. A forest not only has trees, but it has low-growing bushes, weeds, flowers and a thick layer of old leaves or pine needles on the ground. All of these put together are known as ground cover. Ground cover is a natural cushion to soften the impact of falling raindrops, even when the leaves come off the trees. A well-maintained layer of ground cover will allow the raindrops and runoff to infiltrate into the soil, instead of running off and creating Non-Point Source pollution.

Filtering runoff

When the rainwater starts to runoff the ground surface, the forest can still help protect our water. A forest has ground cover, and a very broad area of tree roots. This ground cover and the tree's roots will filter any mud, trash and other Non-Point Source pollution that may be in the runoff before it flows into the streams or ponds.

Whenever a stream, creek or pond is nearby, it is important to leave a buffer zone of trees and ground cover along the sides of that stream to allow the trees to filter any runoff before it pollutes your water.

Holding the soil in place

Tree roots grow so wide and so deep that they actually hold the soil in place so it won't wash away. This is very important in the mountains or in other places where the ground is steep. North Carolina has a lot of mountains in the western part of the state that depend on healthy forests to protect the streams and lakes.

The roots of a tree form a large underground netting that goes all through the ground and holds the soil together. This root netting still holds the soil together, even after a tree is harvested. These old roots stay in place long enough for the roots of the new tree seedlings to become established.

What is Non-Point Source Pollution?

Non-Point Source (NPS) pollution is **pollution** that comes from many different places. It is caused by **water** moving over and through the ground. Water moving over the ground is also known as **runoff**. The process of water moving through the ground is referred to as **percolation** or **infiltration**. As the runoff moves, it picks up and carries away natural and man-made **pollutants**, such as mud, fertilizers, pesticides, oil, grease and toxic chemicals. These pollutants are eventually transported to lakes, rivers, wetlands, oceans and even our underground wells used for drinking water.

Forestry NPS pollutants primarily include **sediment**, **fertilizers**, **pesticides**, **oil** and other vehicle fluids. Sediment is the main pollutant from forestry activities and is caused by the **erosion** of bare land surfaces. Best Management Practices (**BMP**) are used to minimize **NPS** pollution that comes from **forestry operations**. In North Carolina, all **harvest** operations must follow the nine rules of the Forest Practices Guidelines (**FPG**). Using BMPs can help a logger comply with the FPGs. Forestry BMPs include using temporary **bridges** to cross streams, putting **slash** (tree tops and limbs) on bare soil, such as **skid trails** and roads, and leaving a **buffer** of vegetation along streams, known as a **streamside management zone**.

The North Carolina Division of Forest Resources (**NCDFR**) helps **loggers** and landowners protect **water quality** by recommending BMPs and making sure that the FPGs are followed.

Find all of the bolded and underlined words in the Find-A-Word Game. There are 26 words to find.

S B M C F N C D F R K T W S L I A R T D I K S P
E T Q U Z W A T W L A S A M O B Q F D N V I L F
D O R P I U T J O I L N T R G T U A S D F O A O
I Y U E W V Z M O P L O E R G F H F K N A E S R
M E V C A O I K T W G S A L E H K Y P P N B H E
E P O U T M I B C R A O L I R R E V J G M P N S
N E R T E T S E V R A H N G S J K L Z X C P B T
T N M L R P W I I U A F O T K Z M O N F S E A R
R T L E Q J E N D F L O N C S A T O I R E S D Y
A N I E U H D F R E B M P O C Z I U L U I T D O
D T W I A L M C B A M T O C M T D T Y N P I Y P
N R T O L M R Y I N F A I O A Q Y U L O U C H E
O P L U I U B F V S W E N R O C E C M F T I L R
I A O L T Y U E E U N O T A O Z O R U F M D B A
T U O L Y K O R E Y I L S W G O L O O P U E F T
A J Y E L I D T K J I L O U M E B W U S Z S O I
L Q O N B U C I E F J G U J O P M N F S I Y I O
O O M E N B T L N O N B R I G D E E B V Z O W N
C T M T B N P I L R E T C C V M M L N H D C N S
R C N P S A E Z O Y U O E S W T A W A T E R R C
E V C K D O N E F N R Q Y J H M O P D H Z X Z T
P O N R R I H R V S M F O R E S T R Y T R O P X
C B R I D G E S U P T P L O M G S O D N V T N I
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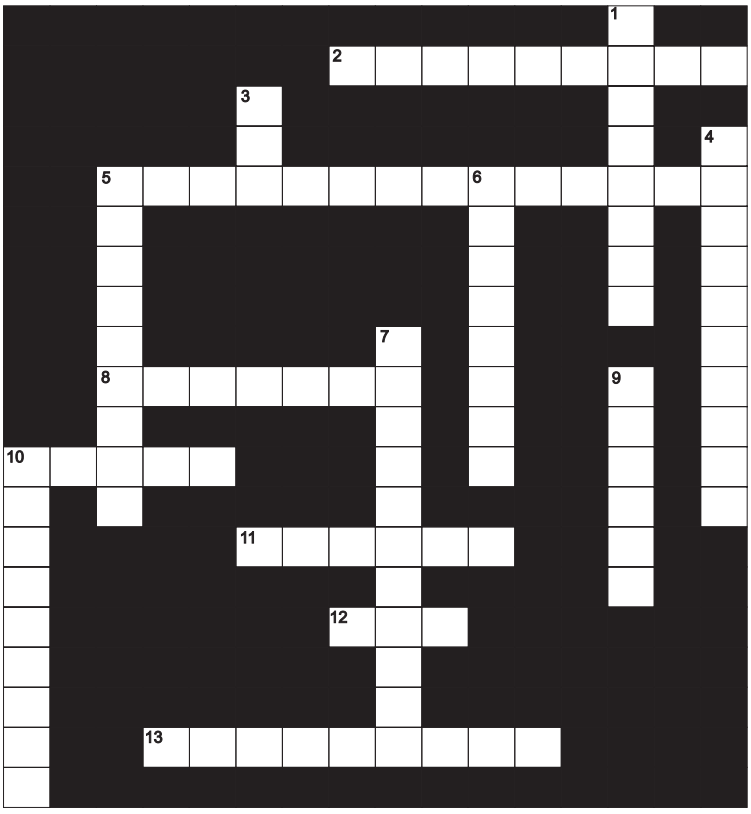
Non-Point Source Crossword Puzzle



Across
2. Any chemical used for controlling insects, weeds, or rodents.
5. Pollution that originates from many different sources, and not a single point.
8. Wearing away of the land surface.
10. The ocean is made up of mostly _____.
11. Water that flows over the land surface.
12. Short for "Streamside Management Zone".
13. The presence of chemicals or soil in water.

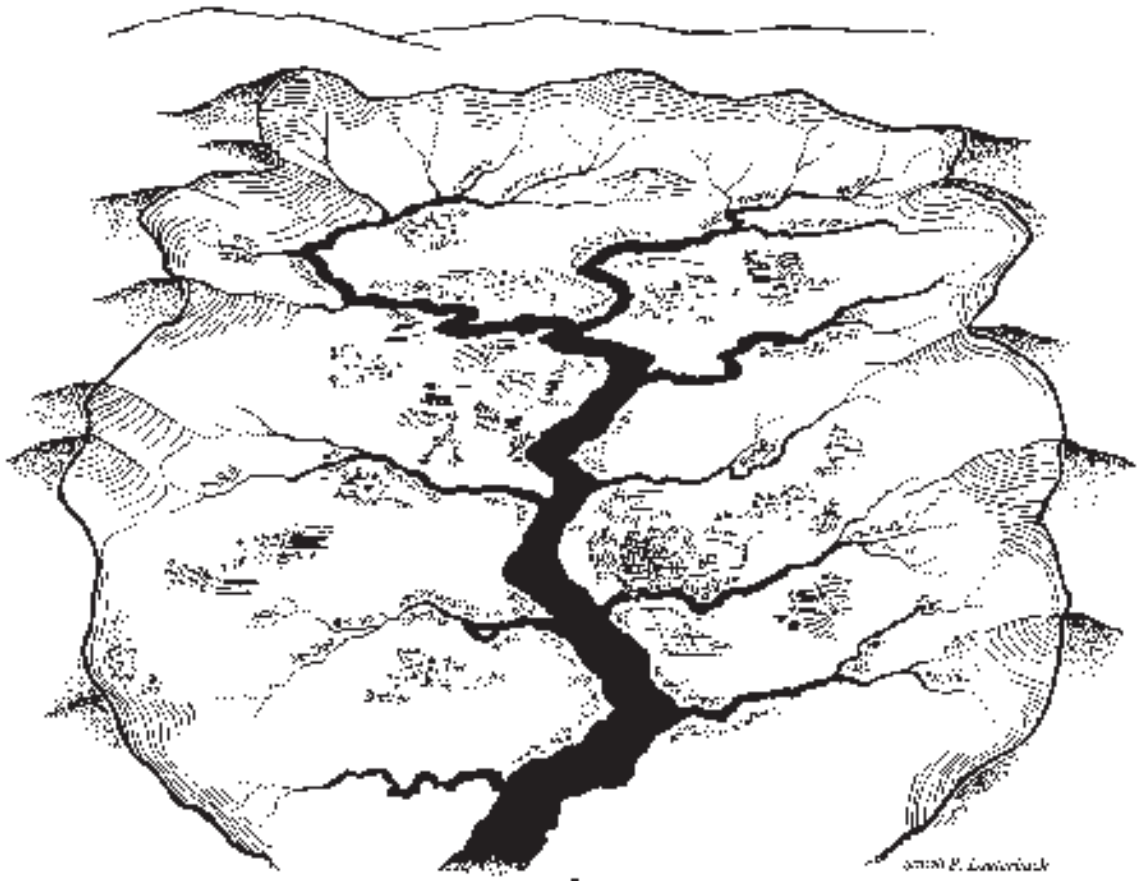
Down
1. Pertaining to the banks of streams, rivers or lakes
3. Short for "Best Management Practices".
4. Substances used for plant food or soil improvement.
5. Fertilizers add _____ to the soil to increase plant growth rate.
6. Dissolved soil in the water
7. External conditions affecting the life, development and survival of all organisms.
9. Water flowing in a natural channel.
10. Area of land drained by a single stream or river

Watersheds

Think of a watershed as a large, natural sink in the environment. If there are two sinks, side by side, the water that is poured into one sink will stay in that sink and drain down its outlet pipe. The water poured into the other sink will stay there and drain out of its own outlet pipe.

However, both of those outlet pipes are connected, underneath the sink. This is just like two streams that are wide apart from each other, but they both flow into the same river or lake. These two streams have their own separate watersheds, but are also part of the watershed for a much larger outlet.

The outlets commonly found in the environment are streams, creeks, ponds, lakes or rivers. Watersheds can be very large and are called river basins. A watershed can also be very small, such as the area around your school or neighborhood.



Because watersheds usually are connected with each other, it is important to understand that even the smallest amount of NPS pollution in one watershed can affect another. Remember to always keep water clean and don't pollute. That way you will help to keep everyone's water clean!

Since forests and trees are so good at protecting, filtering and cleaning our water, it is recommended that forests be used in a watershed as a tool to help protect our water from runoff and Non-Point Source pollution. Forests can be managed, harvested, re-planted and maintained as a natural buffer for runoff near areas that have new buildings or roads built close to them.

River Basins in North Carolina

Place a star on the river basin where you live

In North Carolina, there are 17 river basins, with some rivers flowing to the Atlantic Ocean, and some rivers flowing towards the Gulf of Mexico. Point to your river basin where you live on the map. If you are a drop of water in your river basin, where will you flow to?

North Carolina River Basins

River Basin Questions

1.The _____ River Basin is the largest covering 9,149 square miles.

2.The City of Raleigh is located in _____ River Basin.

3. In which river basin is the Qualla Boundary (Cherokee Indian Reservation) located?

_____

4.The City of Asheville is located in _____ River Basin.

5.The _____ River basin is the smallest.

Areas of North Carolina's River Basins
In square miles

Cape Fear	9,149
Yadkin-PeeDee	7,213
Neuse	6,192
Tar-Pamlico	5,440
Pasquotank	3,697
Roanoke	3,600
Lumber	3,336
Catawba	3,274
French Broad	2,842
Little Tennessee	1,800
Broad	1,506
Chowan	1,315
White Oak	1,233
New	765
Hiwassee	640
Watauga	184
Savannah	151

Topographic Maps

Where Do We Go From Here?

Use a Map!

When working in a forest, special maps are needed so a person can understand where the high locations and low locations of the land are found. These maps are called topographic maps, or “topo maps,” for short.

Topographic maps come in many different sizes, and are drawn by the U.S government for every place in the country.

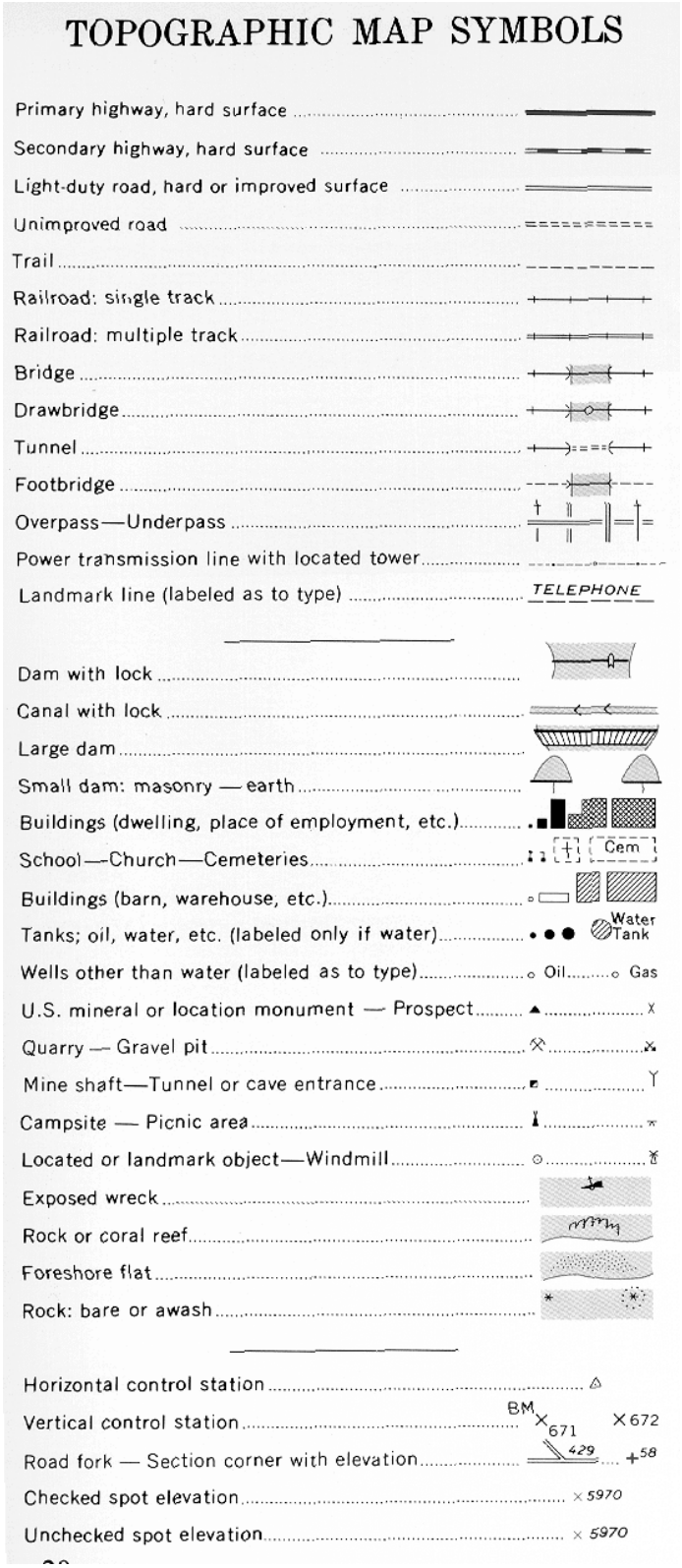
These maps have thin brown lines drawn onto them that are used to estimate how high the ground is along that line. These lines are called contour lines, because they follow the contour of the land. Contour is a word used to describe the rise and fall of the ground.

Contour lines are drawn along each other and do not cross. They run parallel to each other to show different levels of steepness on the ground. The closer together the contour lines are drawn, the steeper the ground is.

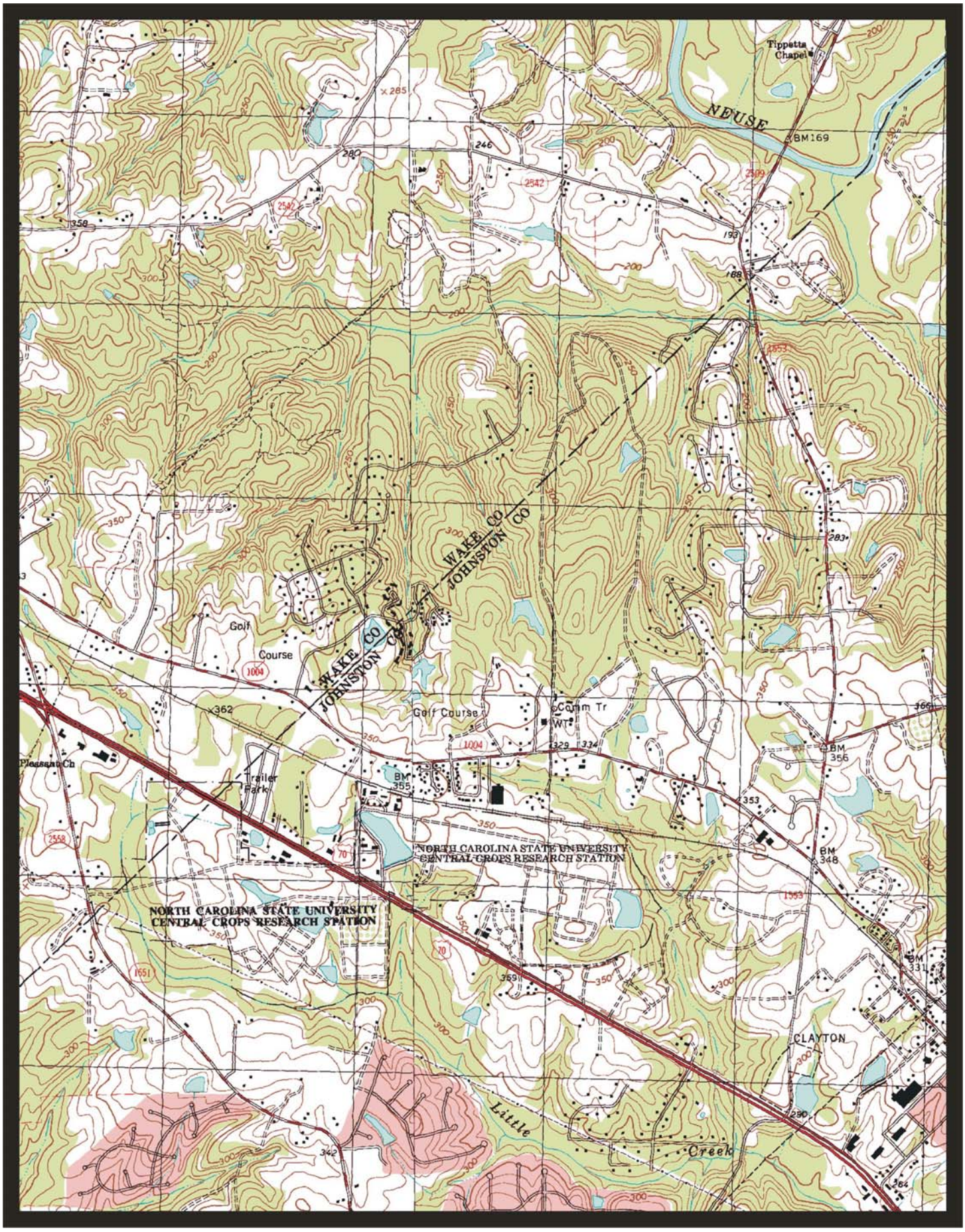
When the lines form a V-shape, or a U-shape, this shows places that are gullies or valleys between the hills or mountains. The highest ground on the map is shown when the contour line forms a small circle.

Maps like these are useful to not only show you what direction to go and how to get there, but they can also show important locations and land features.
A land feature is something special about that piece of land such as a mountain, stream, gully or swamp. These features are indicated on a map using symbols, letters, numbers or a combination of each.

When it's time to work in the forest, or harvest trees, topographic maps can be very helpful to locate streams and low areas and to understand how steep the ground is. Knowing this information will help a forester and logger know what kind of special care is needed to protect the water and prevent Non-Point Source pollution from entering the streams.



Activity: Using the map symbols provided, draw your own map of the area around your school or home. Draw at least one stream and give it a name. If time allows, draw some contour lines on your map and draw a steep valley.



Portion of a Topographic map containing Clemmons Educational State Forest.

Water-What's in it?

Water: we can drink it, cook with it, and wash or swim in it.
Is it important to know what is in the water before we use it?

YES, it is very important!

If you live in a town or city, the water that comes out of your bathroom or kitchen faucets was likely prepared or specially treated to use for drinking, cooking and bathing. This water is piped from a treatment plant operated by the town. If you live in the country or on a farm, you may drink water that comes from a well, deep inside the ground. It is called ground water.

The groundwater that comes into your home is usually very clean and does not need much special treatment. But the water in ponds, lakes, streams and rivers is not treated. These types of waters are called surface waters and might have pollutants that can be harmful to people, animals, fish and aquatic insects. That is why it is very important not to drink the water from a pond or stream unless it has been treated so that you don't get sick.

The pollutants entering surface waters can also affect the fish and aquatic insects that live in the water. For this reason, scientists measure the water for pollutants. Scientists measure the physical and chemical characteristics of the water. The physical measurements can include how fast the water is flowing (called the flow rate), how large the body of water is and how much water is in a stream or lake. Physical measurements also include how clear the water is and the water temperature. By knowing these physical measurements, we can find out how much water is present and how much dirt or sediment is in the water.

The amount of water flowing past a point is known as the total discharge for a stream. Let's calculate the total discharge with a simple math formula. We will use a ruler to measure water depth and a flow meter to measure water speed. Now we can use the formulas below to calculate total discharge.

Measure and Record Water Depth and Speed and then figure out the Total Discharge

Stream Depth: _____ ft. X Stream Width: _____ ft.= _____ $ft.^2$ Stream Area

Water Speed: _____ ft./sec; then Stream Area _____ $ft.^2$ X Water Speed= _____ ft./sec.

=Total Discharge _____ $ft.^3$/sec (cubic feet per second or "cfs")

Now let's learn about water temperature. Water temperature is important to fish and aquatic insects because they cannot control their own body temperature like people do. When the water temperature changes, fish and insects' body temperatures change too. If the water is cold, the fish and insects move very slowly and if the water is warm, they move more quickly. If the water is too hot or cold or if the temperature changes very quickly, the fish and insects will be stressed or shocked, to the point that they can die. Thankfully, this does not happen very often in North Carolina streams and lakes.

Measure and Record Water Temperature Here: _____

Water-What's in it?

The last physical measurement we will use today is to figure out much dirt or fine sediment is mixed in the water. This measurement is called the **turbidity** measurement. When there is a lot of dirt or sediment in the water it will make the water appear cloudy and will also cause the turbidity measurement to increase. We measure the water's turbidity with a special meter called a **turbidimeter.** Fish and insects can be stressed if too much dirt is in the water.

Measure and Record Turbidity Here:

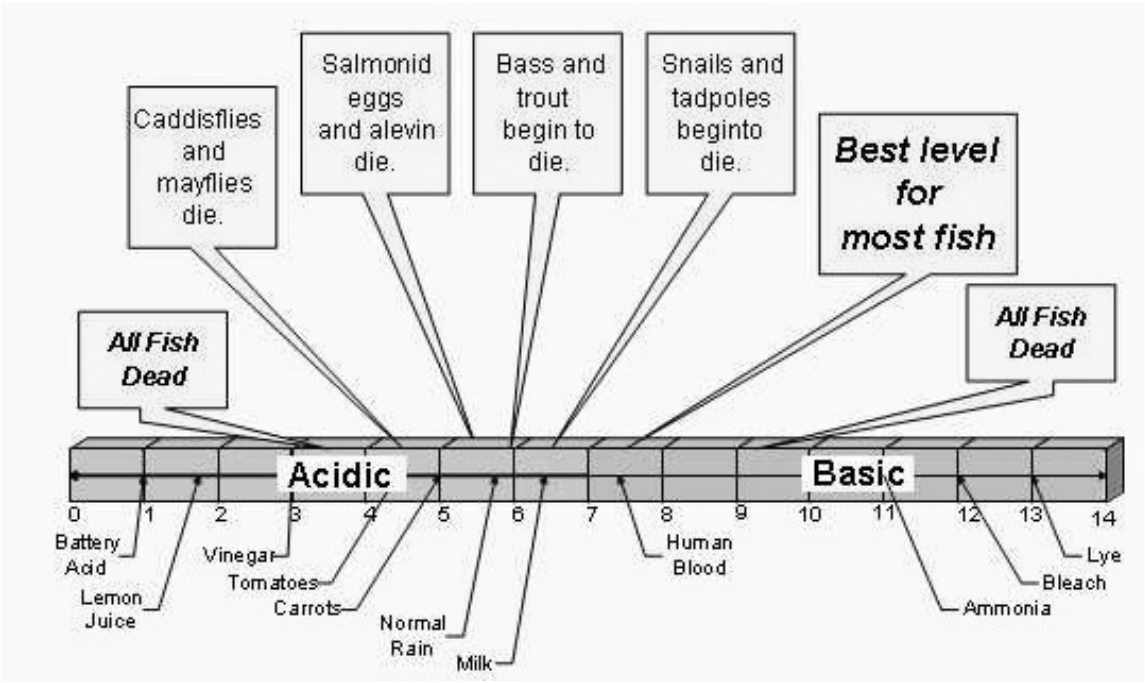
Now we will take **chemical** measurements of stream water. First, we will measure the amount of **dissolved oxygen** found in the stream. Just as we use our lungs to breathe in oxygen from the air, fish and aquatic insects use gills to breathe in dissolved oxygen from the water surrounding them. Too much or too little dissolved oxygen will also cause stress and shock to the fish and insects.

Measure and Record Dissolved Oxygen Here:

The last chemical measurement we will make today will be the hardest to understand so you will have to pay close attention. Watch and listen carefully!

We will measure the **acidic content** or **pH** of the water. All surface waters contain natural acidity, so it is not a bad thing for some acid to be in the water. A problem can occur when the amount of acid in the water is too high, too low or changing very quickly. Pollutants can change the acid content of the water making it unsafe for fish and aquatic insects.

Now we are going to measure the pH of the forest stream and some other liquids known for having high and low acid levels.



Macroinvertebrates

These are some common macroinvertebrates. They are divided into three categories: Intolerant, Moderate and Tolerant of Pollution.

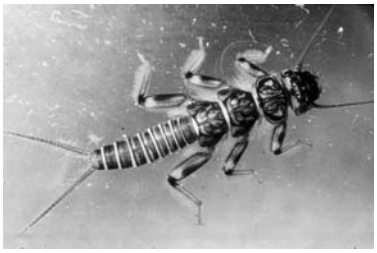
Intolerant:	Unable to live with pollution.
Moderate:	Able to live with some pollution.
Tolerant:	Able to live with pollution.

Aquatic macroinvertebrates are good examples of stream health.

If you find Intolerant macroinvertebrates while sampling, then you know the health of the stream is good. If you find only pollution Tolerant macroinvertebrates, then you know there is pollution present.

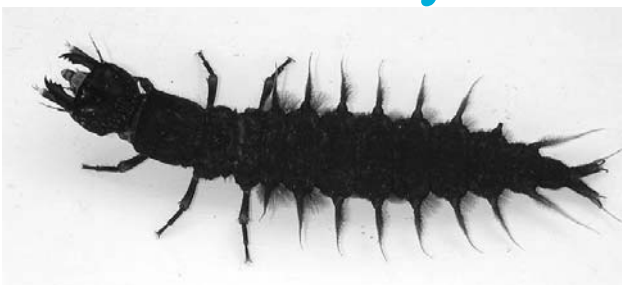
Intolerant of Pollution

Stonefly



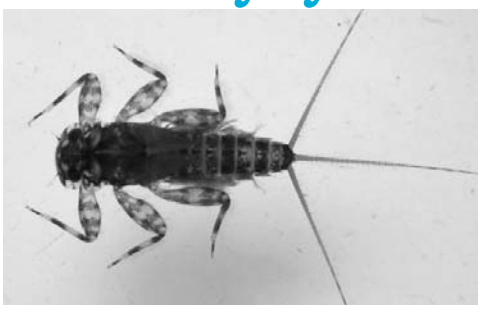
Stoneflies are found in clean, cold streams with high levels of dissolved oxygen in them. They have two long antennae, gills behind each leg (to breathe with), two long hair-like tails, and two hooks on the end of each leg to hold on to the bottom of a stream, even in swift water.
Stoneflies usually develop in the stream between three months to three years, depending on the species.

Dobsonfly



Dobsonfly larvae are often found clinging to rocks in the swifter areas of the stream. These larvae spend much of their time hunting for prey. They have stout bodies with tough skin. If you find a dobsonfly larva in your collection net, grasp it directly behind the head to pick it up. This makes it impossible for the larva to pinch you.
Dobsonfly larvae develop in the stream between one to three years and eventually emerge as adults. Adults only live a few days.

Mayfly



Mayflies usually live on exposed rock surfaces in fast clean streams, or they might even live buried in soft streambeds for protection.
Mayflies are a common food for fish, because large numbers of flying adults often emerge from the stream at the same time.
They can stay in the streams for as short as two weeks or as long as two years, depending on the species.

Caddisfly

Caddisfly larva are interesting bugs because they make their own homes. There are many of different kinds of caddisflies, and each kind makes a different house for themselves out of different building materials, including small rocks, sticks, and mud. These "tube-homes" offer the caddisflies protection and camouflage and are sometimes used to help them catch their food.

Waterpenny

Water Pennies live in cold, fast-moving streams. They eat algae and are often found on smooth rocks. Their smooth, flattened bodies allow them to resist the pull of the current and stay on the rocks.

Moderate of Pollution

Crayfish

Crayfish are a common crustacean. Crayfish look more like lobsters than insects. Crayfish live on the bottom of streams and ponds during the day and stay hidden under rocks or burrows. A crayfish moves quickly backwards if it is threatened.

Crane Fly

Crane flies are big flies that look like big mosquitoes with long skinny legs and long skinny wings but their larva are very different looking!
A crane fly larva is almost like a fat worm. It has no legs, and its head is just a rounded extension of the round fleshy body. They can get big, up to 4 inches long!
There are about 300 species of crane flies in North America and depending on the species, they can stay in the water between six weeks and five years before they develop into that long-legged, skinny-winged fly!

Damselfly

Damselflies have large eyes and long spindly legs.
They develop in one to four years.
Their three fan-shaped tails are actually gills!

Dragonfly

Dragonfly nymphs are short and chunky with wing pads and internal gills. They breathe by sucking water into their stomach and moving water over their inside gills. Once it has enough oxygen, the nymph squeezes the water out fast, so it does not have to come up for air like most pond insects. This also helps jet boost them forward in the water. They are helpful because they eat mosquitoes.

Tolerant of Pollution

Leech

There are more than 600 different kinds of leeches. Most of them suck blood from their food source. That means that they live in or on other living things. Some types of leeches feed only on insects and small worms while others are blood feeders on fish or mammals. They can live as long as one and a half years.

Midges

Midges are found in all but the most polluted waters. They are small up to ½ a inch in length and have worm-like body. There are nearly 2,000 midge species in North America.

Blackfly

Black fly larva have small suckers on the end of their abdomen (main body segment), by which they are able to anchor themselves to rocks. A head 'fan' sweeps food material from the stream into their mouth. If they want to move, they drift downstream, but stay connected to their rock with silken threads that extend from the tip of their abdomen.

Aquatic Sampling Score Sheet

Fill out this sheet when you visit the Educational State Forest during the aquatic sampling activity.

Macroinvertebrates Found	Number Found	Pollution Tolerance

Glossary

Pollutant: Something that pollutes, and makes the water unhealthy.

Ground Water: Water that comes from deep inside the ground.

Surface Water: Water in ponds, lakes, streams and rivers.

Total Discharge: Water Speed x Stream Area (Stream Depth x Stream Width).

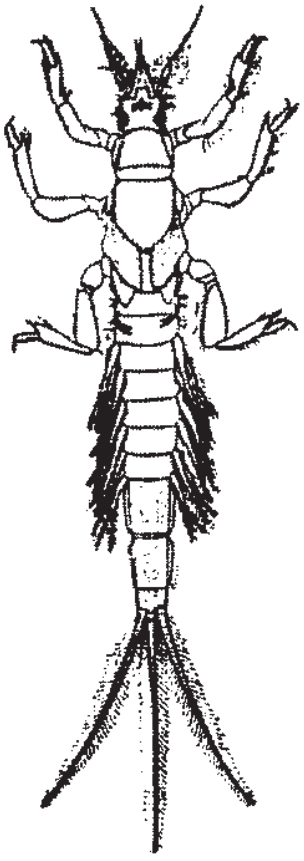
Emerge: Come out of a surrounding environment.

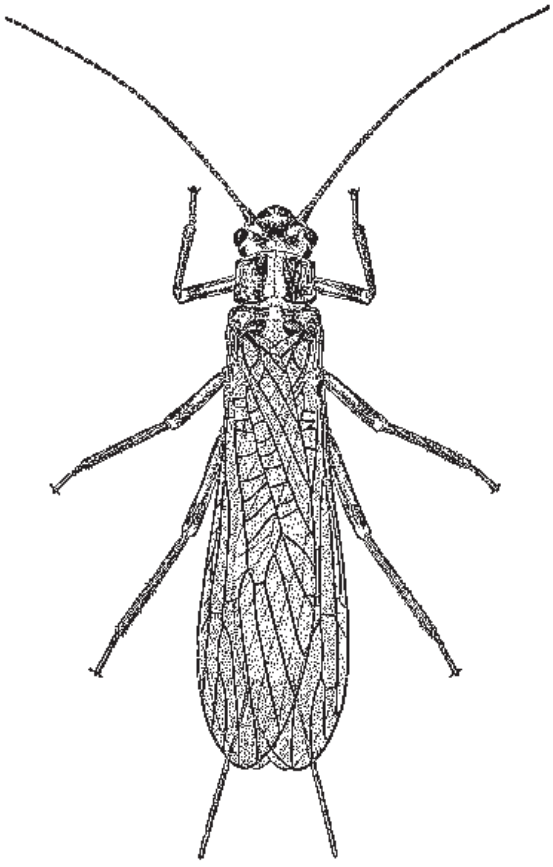
Larva: A newly hatched, wingless insect, often in the form of a worm, before it changes into its adult form.

Macroinvertebrates: Animals without backbones that are big enough to see with the naked eye.

Nymph: The young of an insect that is different from the adult, mainly in size.

Gills: The breathing organ of fish and other animals that live in water.





Guide for Implementing the Educational Workbook
"*Forest Water Quality - Making Every Drop Count*"
NC Forest Service publication #WQ/NPS0105

How to use the workbook:
This work book was designed to be used in two ways:

1. Familiarize students with the environmental material before visiting Clemmons Educational State Forest; and
2. Use as a teaching aid during the field trip. In addition, a pre- and post- test has been included to measure the effectiveness of the program.

In the classroom:
Pre-test (10 minutes)
Please administer the pre-test and bring the test along on your visit; our rangers will compare the pre-test with the post-test results. This will help us determine how to improve our NPS pollution prevention message delivery message delivery in the future.

Workbook (1 - 2 hours)
The first six pages of the workbook should be completed in the classroom before the field trip. This guide is designed to help instructors prepare for and use the "Forest Water Quality - Making Every Drop Count" educational workbook module. This guide contains references on use of the instruments for each section, as well as what supplies you will need and other pertinent information.

Page 1: Water in the Forest

Have students read Page 1 while you prepare the "Earth Sponge Activity."

- A potted plant, or even the sponge idea suggested at the bottom of the page might help drive home the message, but none are necessary.

Here are some narrative points that may help you explain what is happening and how it relates to natural processes:

- The ground outside may feel solid but there are actually very small holes in the soil called **pores** that allow water to soak into the ground. Actually, these pores act just like a sponge - which also has many small holes.
- When it rains, water soaks into the ground just this water is soaking into the sponge. This is called **infiltration** - you can think of it as water "filtering-in" to the ground.
- What happens to the water once it is inside the sponge? Gravity continues to pull the water down deeper into the sponge, this is called **percolation**. Some of the rainfall that falls on the ground outside does the same thing.
- Eventually, the water **percolates** right through the sponge and collects in the pan. When water collects deep in the soil, we call it **groundwater**. The water stored underground is what provides our wells with water.
- Now when the sponge gets completely full or "saturated," water can no longer infiltrate into the sponge and begins to run off the surface of the sponge. When this happens to the ground during a rain storm, this is called **runoff.** The water we call **runoff** flows downhill and eventually drains into our streams and rivers.

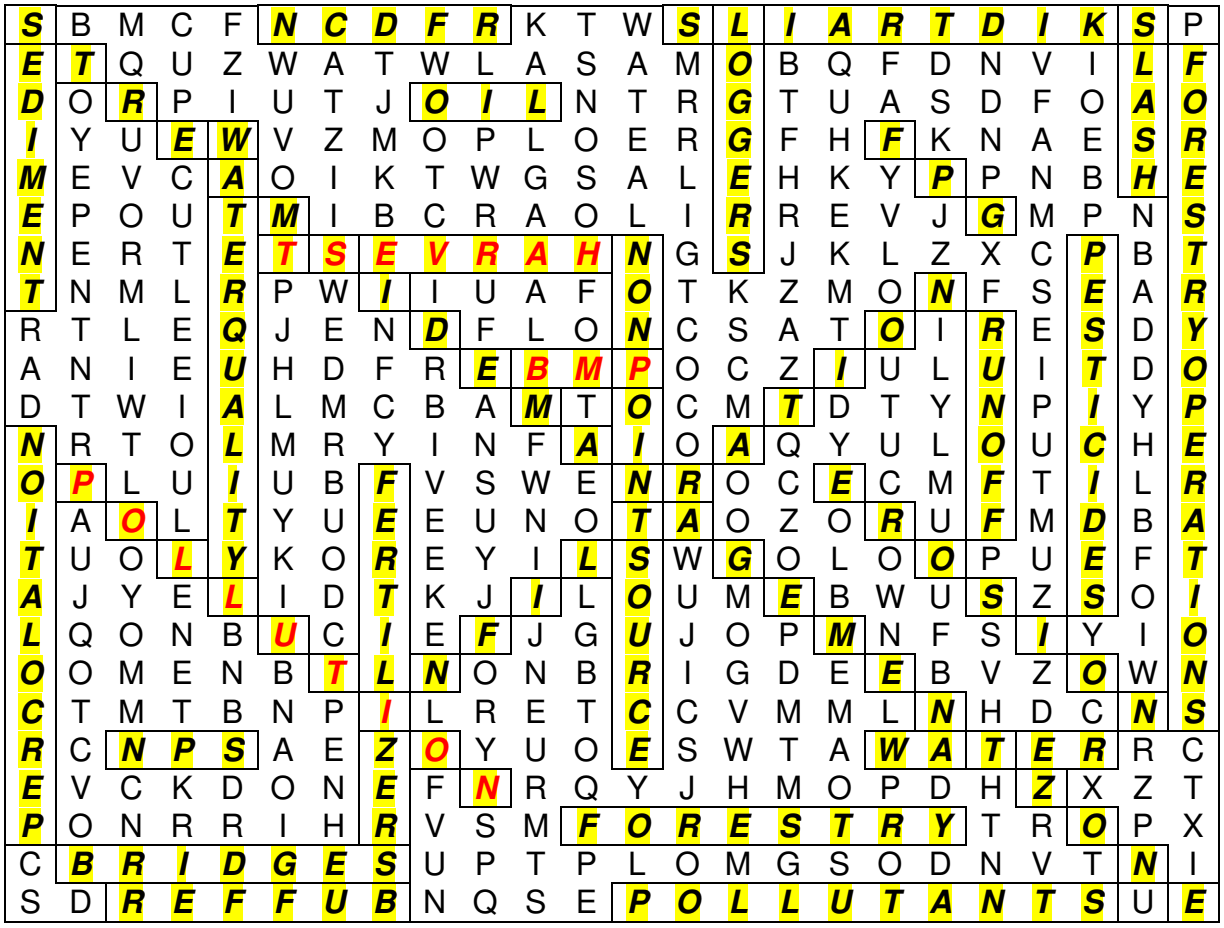
Page 2: Water in the Forest

Read this page aloud to your class or have students team up to read.

- A hillslope and a water hose or watering can would be very helpful here.

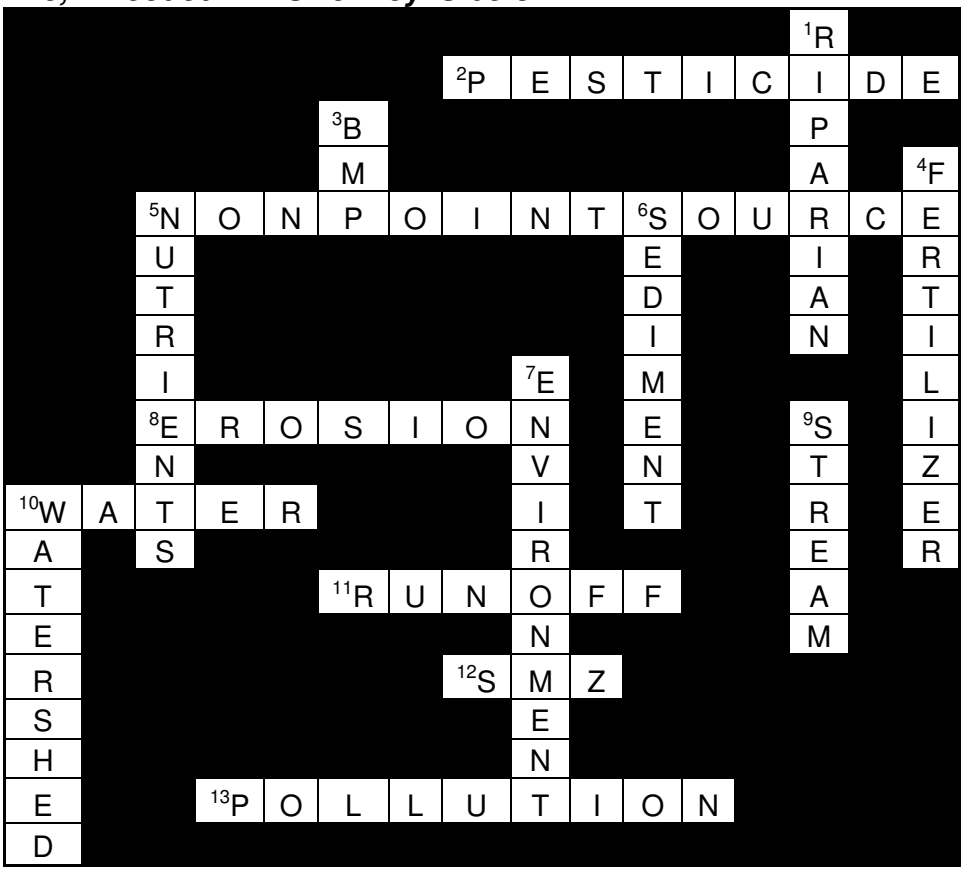
Page 3: What is Nonpoint Source Pollution Find-A-Word

- Self-directed. Be sure to encourage them to actually read the paragraph.
- It will take upwards to 30-minutes to find all of the words. Answer key is below.



Page 4: Nonpoint Source Crossword Puzzle

ERROR NOTE: ***There may be an extra mistaken empty square at the beginning (top) of the [7-Down] puzzle column. Column #7 should only have 11 squares. You may wish to instruct the students to blacken-out the square block that contains the #7, before they begin the puzzle, if needed. Answer key is below.***



Across

2. Pesticides are chemicals used to control nuisance animals, insects and plants. The term includes insecticides, fungicides, herbicides and rodenticides.
5. Nonpoint Source pollution is pollution that enters a waterbody from widespread sources in the watershed. Non-point Source pollution cannot be traced back to a single point of origin.
8. Erosion is the wearing away of the land surface by rain, running water, wind, ice, gravity or any other natural or man-made causes.
10. Water can exist as a solid (ice), liquid (streams) or gas (steam or clouds). As a liquid, it covers much of the Earth in the form of rivers, lakes, oceans, rain, etc…
11. Runoff is excess rain unable to be absorbed by the ground that flows over the land surface or in open channels.
12. A streamside management zone (SMZ) is an area of vegetated land adjacent to a stream or river and is managed for water quality protection and other benefits.
13. Pollution is the presence of substances in water, air, or soil that impairs the environment and renders it harmful to life.

Down

1. Riparian is an area on or pertaining to the banks of streams, lakes, ponds, or rivers.
3. Best Management Practice (BMP) is a practice or combination of practices that are determined to be the most effective and practicable means of controlling point and non-point source pollution.
4. Fertilizer is any material put on or in the soil to improve the quality or quantity of plant growth.
5. Nutrients are substances necessary for the growth and reproduction of organisms. Nutrients are mineral elements, such as nitrogen, phosphorous, or potassium that are naturally present in the soil or may be added to the soil.
6. Sediment is solid material, both mineral and organic, that is in suspension and is being transported from its site of origin by water, air, gravity, or ice.
7. Environment is the sum of all external conditions affecting the life, development, and survival of an organism.
9. A stream is a current or flow of water running along the surface of the earth in a natural channel.
10. A watershed is a region or land area drained by a single stream, river, or drainage ditch system.

Page 5: Watersheds

Read page 5 with your class. Be sure they understand the significance of a watershed.
You may find the following helpful in explaining the concept of a watershed:

- Water naturally flows in what direction? {A - downhill}
- And, if you keep walking downhill, what will you eventually find? {A - water: a stream or a pond}
- No matter where water falls on the Earth's surface it will eventually move to a stream and eventually flow into the ocean.
- And every stream has its own watershed -- an area of land where the water that falls on that area will flow downhill and enter a stream.
- A **river basin** is just a large watershed for an entire river. So, every drop of water that lands on the area we call the Neuse River Basin could flow downhill and end up in the Neuse River.
- The important thing to remember is that whatever happens to the land in a particular watershed will affect the stream that drains that watershed.

Page 6: River Basins

Help your class answer the five questions on this page. A full size river basin map that shows the major cities is recommended.

- As an alternative, you may wish to use a NCDOT state highway map, for the students to cross-reference between the river basin map when searching for the city locations.
- To help describe how big a "square mile" is, related to the river basin areas, consider using this explanation: It would take almost 640 football fields to make up the area of 1 square-mile.

Answer Key:

1. Cape Fear
2. Neuse
3. Little Tennessee - Though it doesn't appear on either map it is in the eastern part of Swain County - just south of Mount Hardison.
4. French Broad
5. Savannah

Computer activity option: If your classroom has access to the Internet, here is an excellent interactive river basin map that you can use to learn more about your river basin:
http://www.eenorthcarolina.org/public/ecoaddress/riverbasins/riverbasinmapinteractive.htm

Pages 7 & 8: Topographic Maps

Colored pencils and paper will be necessary if the students will be drawing their own maps.

Pages 9 & 10: Water - What's In It?

NOTE: This portion of the workbook is intended to be completed in a structured outdoor teaching class hosted by a natural resources professional, at one of the NCDFR Educational State Forests that conduct this water quality program. However, you may find the information useful for your local adaptation.

Supplies you will need for water sampling:

- A retractable measuring tape, fiberglass-type if preferred
- A yard stick
- Some kind of water velocity measuring device:
    - A Gurley Meter – This includes the meter, the mounting rod and the handheld digital readout; or
    - An orange (or other floating object), a stopwatch and a calculator
- A Turbidimeter (The NC Forest Service uses model OH966)
- A Dissolved Oxygen (DO) Meter (The NC Forest Service uses model YSI55)
- A pH meter
- A thermometer, or you can just get the temperature from the DO meter
- A calculator
- Several common liquids for the pH measurement (vinegar, soda, lemon juice, etc)
- Several jars filled with varying degrees of turbid (cloudy) water for demonstration.

Discharge Measurement:

1. Locate a straight section of channel to measure.
2. Measure the width of the actual water in the stream.
3. Estimate an average water depth.
4. Measure the average velocity of the water at that point. The velocity measurement can be done one of two ways:

    Option 1: You can use the Gurley meter. You must attach the meter to the wading rod and then attach the wire to the meter. Next you must attach the cable from the handheld digitizer (the device with the button and LCD screen). Turn it on and select the button for the feature you want (ft/s). Now here's the tricky part – the stream velocity is different everywhere in the stream: it is slower along the bottom and along the edges; it is faster along the surface and in the middle. The general rule is that mid-depth and mid-stream represents the average velocity (the US Geologic Survey actually uses $6/10^{ths}$ of the depth). The wading rod actually automatically figures the 0.6 depth for you. All you have to do is determine how deep the water is where you want to measure (in feet) and set that depth on the handle of the rod using the trigger. The Gurley meter should be pointed upstream to measure the velocity. Use feet/second as the measurement.

    Option 2: You can use an orange and a stopwatch. Measure off a known distance along the stream channel: 10, 20 or 30 feet works fine. It is preferred to measure a relatively straight and unobstructed section of stream. At the beginning of your measured distance, drop the orange into the stream (or any other floating object that won't get pushed around by the wind) and simply time how long it takes it takes to float along your measured distance.

    - For example: Measuring a 30-foot long section of stream, the floating object (orange) took 20 seconds to travel that 30-foot length. Divide 30 feet / 20 seconds = 1.5 feet/second (ft/s) of stream velocity.

        Adjust for the Average: The floating object (orange) in the middle of the stream is actually traveling faster than the stream's average velocity. A good rule of thumb is to multiply the calculated result by 0.7 to estimate average velocity. Therefore, in our example above: 1.5 ft/s (x) 0.7 = 1.1 ft/s average stream velocity.

A good exercise if you have time is to compare the two measurements. You could be surprised on how close the two measurements will result, considering that a Gurley meter costs in excess of $1,000 while a stopwatch and orange are much more affordable!

Another add-on to the Discharge Measurement part of the lesson plan is provided below. It attempts to demonstrate to the students how much water a person uses each day, and how much water is actually coming from the environment.

How Much Water Can This Stream Provide for You to Use?

	Gallons per Second	(x)	60 seconds per 1 Minute	(x)	60 minutes per 1 Hour	(x)	24 hours per Day	(=)		Gallons per Day

Assume that on average, 1 person uses 50 gallons per day. If this stream produces _____ gallons per day:

	gal/day from stream	(÷)	50 gal/day per person	(=)		*Number of people that could use this stream as a daily source of water.*

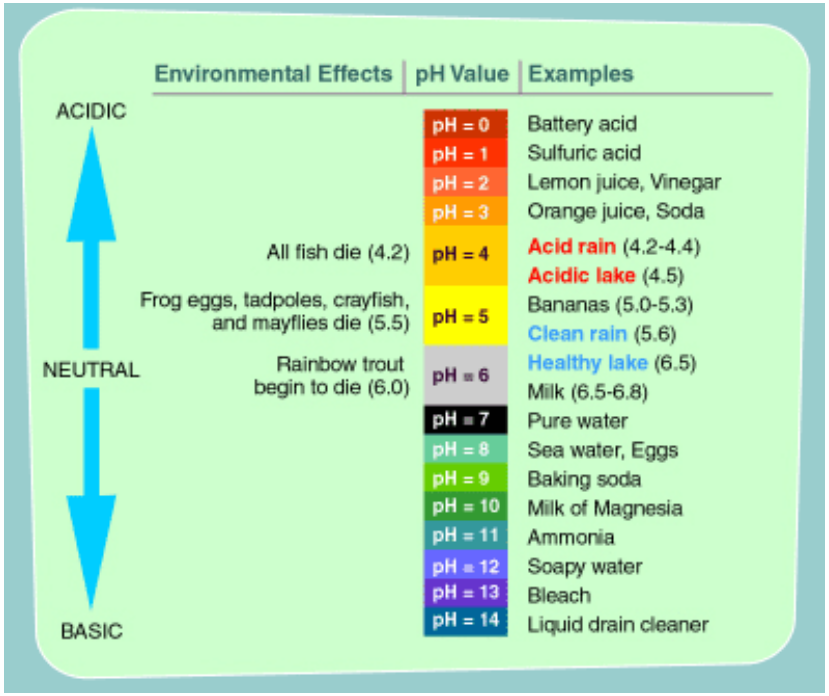
NOTE: If the # of people is < 1, you can re-phrase the result by stating *"This stream only provides _____% of 1 person's daily need for water."* For example: 20 gal/day from stream (÷) 50 gal/day per person (=) 0.40 persons, meaning this stream only provides 40% of 1 person's daily water need.

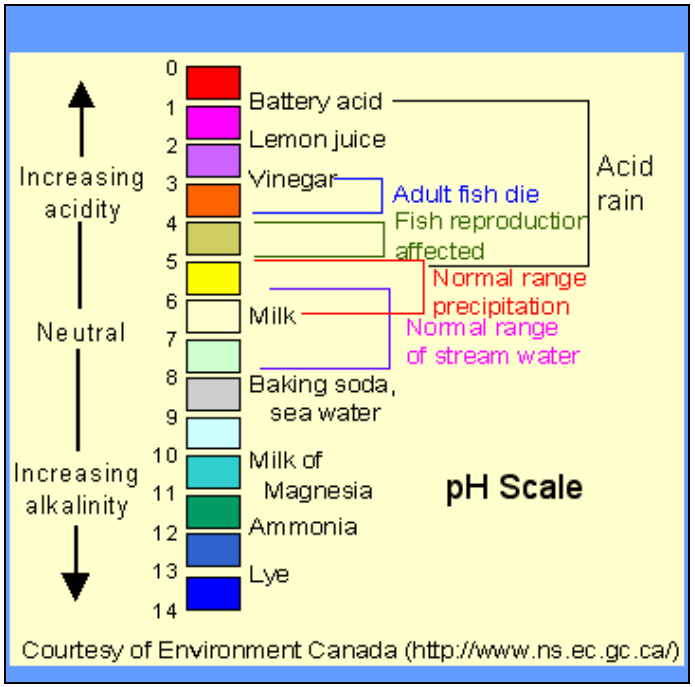
Water Temperature:
The DO meter can also measure water temperature. Simply turn it on and place it in the water.

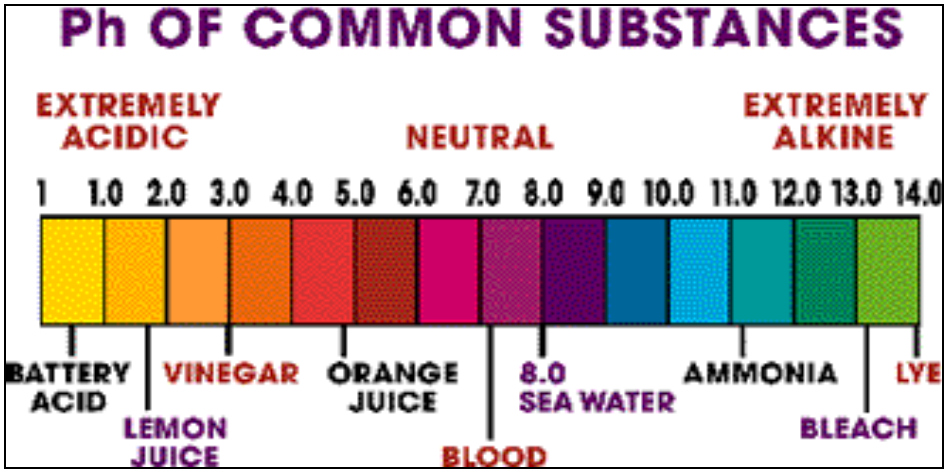
Turbidity:
This is a measurement of how cloudy or murky the water is, as a result of microscopic silt particles suspended in the water. It would help to have a couple of jars with clear, slightly muddy and really muddy water to really drive home the point of turbidity.

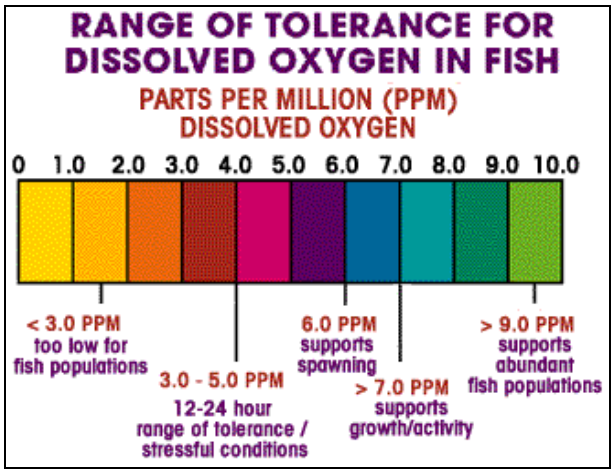
Dissolved Oxygen:
For normal use, the membrane on the end of the probe will need to be changed frequently. However, if you are just using the meter for education, just change the membrane every couple of months as long as the probe doesn't dry out - the holster has a small sponge in the back that should be kept wet. Also, generally speaking a DO meter needs to turned-on about 15 minutes before using, so it can calibrate itself. The unit is basically calibrated to the atmosphere right before you are ready to use it (see operator's manual).

pH (acidity):
- Calibrate the meter using the 7.00 (yellow) and 4.00 (pink) buffer.
- Calibrate it weekly for educational purposes.
- See the pH diagrams on the following page for discussion purposes.


Environmental Effects
pH Value
Examples
ACIDIC
NEUTRAL
BASIC
All fish die (4.2)
Frog eggs, tadpoles, crayfish, and mayflies die (5.5)
Rainbow trout begin to die (6.0)
pH = 0 Battery acid
pH = 1 Sulfuric acid
pH = 2 Lemon juice, Vinegar
pH = 3 Orange juice, Soda
pH = 4 Acid rain (4.2-4.4) Acidic lake (4.5)
pH = 5 Bananas (5.0-5.3) Clean rain (5.6)
pH = 6 Healthy lake (6.5) Milk (6.5-6.8)
pH = 7 Pure water
pH = 8 Sea water, Eggs
pH = 9 Baking soda
pH = 10 Milk of Magnesia
pH = 11 Ammonia
pH = 12 Soapy water
pH = 13 Bleach
pH = 14 Liquid drain cleaner


Increasing acidity
Neutral
Increasing alkalinity
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
Battery acid
Lemon juice
Vinegar
Milk
Baking soda, sea water
Milk of Magnesia
Ammonia
Lye
Acid rain
Adult fish die
Fish reproduction affected
Normal range precipitation
Normal range of stream water
pH Scale
Courtesy of Environment Canada (http://www.ns.ec.gc.ca/)


Ph OF COMMON SUBSTANCES
EXTREMELY ACIDIC
NEUTRAL
EXTREMELY ALKINE
1 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0 11.0 12.0 13.0 14.0
BATTERY ACID
LEMON JUICE
VINEGAR
ORANGE JUICE
BLOOD
8.0
SEA WATER
AMMONIA
BLEACH
LYE


RANGE OF TOLERANCE FOR DISSOLVED OXYGEN IN FISH
PARTS PER MILLION (PPM) DISSOLVED OXYGEN
0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0
< 3.0 PPM too low for fish populations
3.0 - 5.0 PPM 12-24 hour range of tolerance / stressful conditions
6.0 PPM supports spawning
> 7.0 PPM supports growth/activity
> 9.0 PPM supports abundant fish populations

Pages 11 to 14: Macroinvertebrates (aquatic insects)

NOTE: This portion of the workbook is intended to be completed in a structured outdoor teaching class hosted by a natural resources professional, at one of the NCDFR Educational State Forests that conduct this water quality program. However, you may find the information useful for your local adaptation.

Supplies that you will need:

- A D-frame net, or a couple of nets if you want
- A 5 gallon bucket
- A couple of casserole dishes, or some kind of shallow dish to sort through the litter for bugs
- Tweezers, spoons etc. to sort and pick up the bugs.
- Small petri dishes, cups, or plastic containers to hold interesting bugs in to pass around

You can obtain aquatic insects several ways:

- Option 1: Pick up rocks that are situated within the stream, and look on the rock's bottom (wet) side.
- Option 2: Set the D-frame net upright on the bottom of the stream. A few inches on the upstream side of the net, use hands, feet or sticks to shuffle around the bottom of the stream, and stir up the rocks, twigs, leafs, and stream-bottom a little bit. Insects will be dislodged, flow with the water into the net, and be captured.
- Option 3: Jab the D-frame net into leaf packs and under stream banks to dislodge debris and try to capture insects.

Periodically remove the net and dump its contents into the 5-gallon bucket. Then repeat the collection process a few more times.

Once you get enough leafs, pine needles, stones, and other loose debris in the bucket, remove the debris and place it in the pans for the kids to pick through. When they locate an insect, set the insect into a small dish or jar for identification, using the workbook module.

Discussion About Sampling Stream Water:

Testing the water's chemistry is good for taking a "snapshot" look at the water, as it exists right now, when the water was sampled. But, taking chemical samples may not show a long-term or historical pollution impact.

Taking aquatic insect samples can give a better long-term analysis of the stream's overall "health", since insects must reproduce, live and survive during a relatively longer period of time. Aquatic insect sampling is also must lower cost and easy, when compared with getting a chemical test in a laboratory.

Forest Water Quality - Making Every Drop Count: Student Test

Answer the 10 questions to the best of your ability. ***Your Name:***_____

1. What is a *watershed*?
   a. a small building where water is stored
   b. an area of land that is drained by the same stream
   c. a new device used for floor cleaning that uses no water and will make mops obsolete
   d. a brand of bottled water

2. What is *runoff*?
   a. what you do when you are afraid
   b. what happens when water doesn't soak into the ground and flows across the surface
   c. the last name of the Russian scientist who invented the turbidimeter
   d. another brand of bottled water

3. What is *turbidity*?
   a. a measure of particles in water
   b. a fast moving aquatic insect
   c. a type of cloud
   d. the name of Raleigh's river basin

4. How do trees protect water quality?
   a. by filtering runoff, slowing down raindrops and holding soil in place
   b. by providing a place for birds to nest
   c. by hiding streams from people who want to pollute them
   d. trees don't do anything to protect water quality

5. What is *ground cover*?
   a. a blanket that you sit on for picnics
   b. a large tarp that baseball players use to keep the field from getting wet during a rainstorm
   c. a layer of vegetation and leaf litter that protects bare soil from erosion
   d. a fine powder made from old bedspreads

6. What is a *stonefly*?
   a. a fish that lives in shallow rocky streams
   b. a kind of rock that is very light weight
   c. a bird that camouflages itself to look like a stone so predators won't eat it
   d. an insect that only lives in clean, unpolluted water

7. What does the "*NPS*" in NPS Pollution stand for?
   a.Not Particularly Safe b.Non-Point Source c.National Park Service d.Near Perfect Stream

8. What is a *riparian buffer*?
   a. a new device used for floor cleaning that uses no water and will make mops obsolete
   b. an instrument that measures the acidity of water
   c. a small fish found in South American streams and rivers
   d. a strip of vegetation or ground cover left along a stream to filter pollutants and protect water quality

9. How many river basins does North Carolina have?
   a. 0 b. 1 c. 17 d. 100

10. Why is dissolved oxygen in water important?
    a. because aquatic bugs and fish need it to breathe
    b. because it makes the water taste better
    c. because it makes the water smell better
    d. it makes no difference; there is plenty of oxygen in the air

Forest Water Quality - Making Every Drop Count: ***(TEST ANSWER KEY)***

It is recommended to give the test to the students before the workshop and again after, to assess the student's degree of comprehension of the subject matter.

1. What is a *watershed*?
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Teacher Feedback Survey: *Forest Water Quality - Making Every Drop Count*

This booklet was developed as a tool to help educators teach students about forest water quality. We welcome your feedback and suggestions about our product and how the N.C. Forest Service can offer tools and programs of value. We appreciate your comments and responses to the questions below.

(A) This information was presented at a level that was:

☐ Too simple to keep students attention.

☐ Appropriate for students at this age.

☐ Too complex for students at this age.

Please state the age range for the children that used this workbook:_____

Comments:_____

_____

(B) How would you rate the reaction of your students to this material on a scale of 1 to 5?

1- bored 2-indifferent 3-interested 4-enthusiastic 5-excited

Comments:_____

_____

(C) How well did the material in this workbook correlate or supplement your curriculum?

☐ Very well

☐ Satisfactory

☐ Not well at all

Comments:_____

_____

(D) What did you like the most about this workbook? _____

_____

(E) What did you like the least about this workbook? _____

_____

(F) Will you utilize this book or similar ones from the NC Forest Service as an educational tool again?

☐ Yes ☐ No

Comments:_____

_____

(G) Any other Comments:_____

_____

_____

_____

After completing this survey you can Email to forestry.npsunit@ncmail.net; Or fax to (919) 857-4804; or Mail to Forestry NPS, NC Forest Service, 1616 MSC, Raleigh NC 27699.