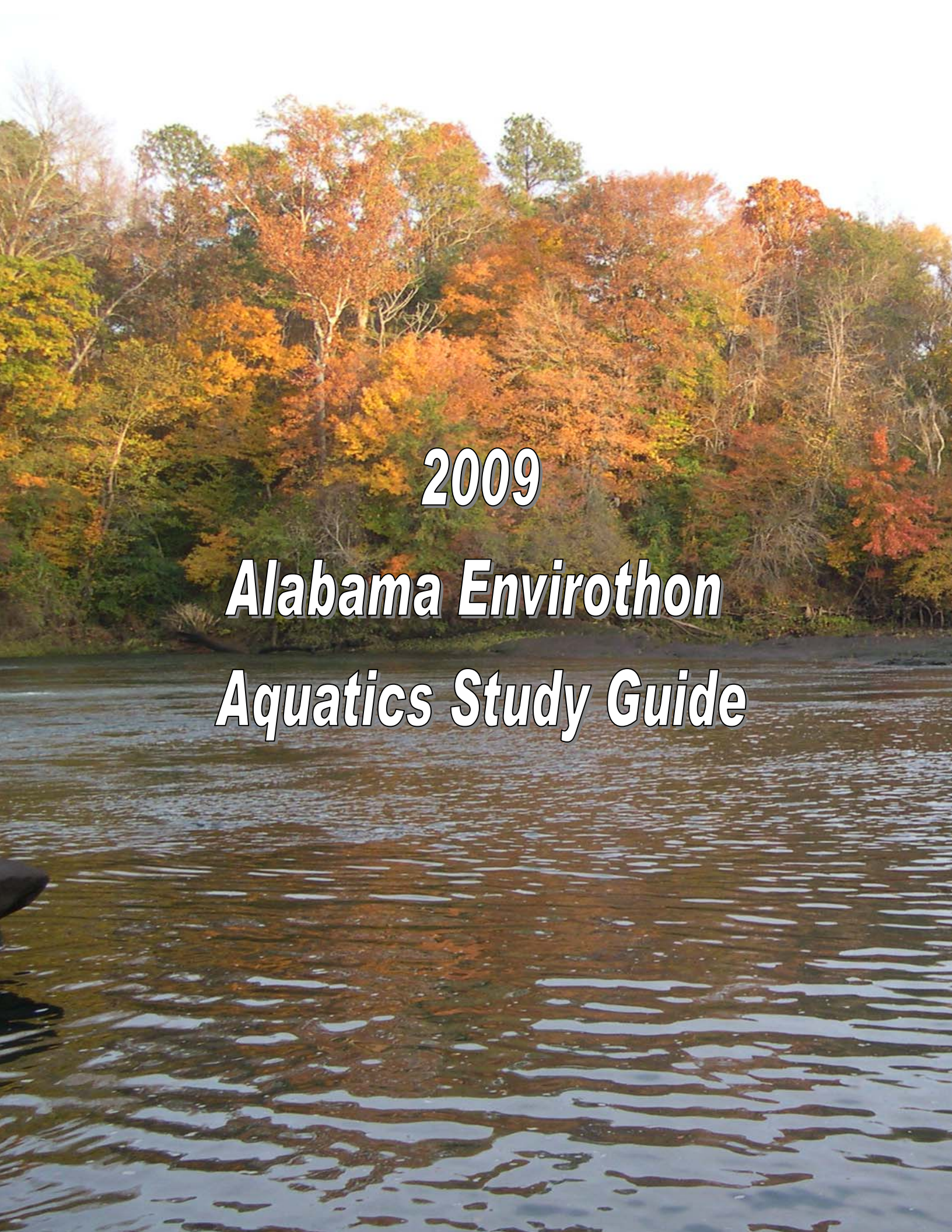


2009
Alabama Envirothon
Aquatics Study Guide

Objective 1: Identify the processes and phases for each part of the water cycle.

Words to Remember:

- **aquifer**
- **freshwater**
- **recyclable resource**
- **water cycle**
- **atmosphere**
- **groundwater**
- **reservoir**
- **water vapor**
- **condensation**
- **hydrologic cycle**
- **runoff**
- **well**
- **estuaries**
- **marsh**
- **saltwater**
- **wetlands**
- **evaporation**
- **precipitation**
- **transpiration**

Water covers three-fourths of the surface of the earth. This fact makes our planet very special. The earth has more water than any other planet. It is the only planet where water exists in all three forms: gas (vapor), liquid, and solid (ice).

Water is in many locations. It is in liquid form in rivers, streams and oceans. Water is in the form of ice at the North and South Poles. Water is in gas (vapor) form in the atmosphere as clouds. It is found underground and inside plants, animals and humans.

Earth has its own water recycling system. It is called the **water cycle**. The actual *amount* of water on our planet does not change. In fact, there is the same amount of water on earth today as there was in the time of dinosaurs! In the water cycle, water simply changes its *form* and *location*. It is a never-ending cycle. In this cycle, water travels from the ground into the atmosphere and then back down to the ground again (Figure 1.1). This is why water is known as a **recyclable resource**.

In the water cycle, water continually changes between all three of its forms (gas, liquid and solid). Water on the ground changes to a gas as it warms from the sun's heat. This process is called **evaporation**. When water evaporates, it becomes **water vapor**. It rises with warm air, expands, and cools. As water cools it changes back to liquid droplets. This process is called **condensation**. The water droplets form clouds. When enough vapor condenses, these heavy droplets will cause the clouds to release them as rain or snow. The name of moisture in the atmosphere falling to the ground is **precipitation**.

The precipitation will fall down onto the ground. The ground can absorb the water. Plants use the water in the soil. Sometimes water collects in **aquifers** underground. An aquifer is a space between underground rocks that holds water. Water in aquifers is called **groundwater**. Groundwater is the water that we get when we drill a **well**.

As heat from the sun warms the earth, water on the surface will evaporate again into the atmosphere. This process forms a continuous cycle. The sun supplies the energy needed to power the cycle. Most water that flows through the pipes of our houses has gone through the **water cycle** many times. The **hydrologic cycle** is another name for the water cycle.

Plants release water into the atmosphere. When rain falls on the earth and soaks into the ground, plant roots take up some of this water for their needs. Water helps cool plants by evaporating from leaves into the atmosphere. This process is known as **transpiration**. It is also part of the **hydrologic** (or **water**) **cycle.**

On land, water reaches rivers and streams in many different ways. When rain falls from the sky, it can become **runoff.** Runoff is water that drains directly into bodies of water due to the force of gravity. Streams combine to form rivers and rivers flow into oceans.

Ocean water, or sea water, is **saltwater**. Ocean water makes up about 97% of all water on the earth. In the **water cycle**, the water that evaporates from the oceans will leave the salt and other minerals behind. It will come back to the earth as **precipitation**. Water that returns as precipitation is **freshwater**.

Water is a very important resource. Our lives depend on water and we use water in many different ways. Alabama is fortunate to have many valuable water resources. In the state, there are 14 major river systems (Figure 1.2). There are 50 miles of coastline on the Gulf of Mexico and 47,072 miles of rivers and streams. There are 545 square miles of lakes and **reservoirs** and 3 million acres of **wetlands** and **marshes**. Alabama also has 625 square miles of **estuaries** (coastal wetlands). Alabama is 7th in the nation in number of stream miles.

When we use water for our purposes, we temporarily halt the natural water cycle. We should be careful not to use more water than can be renewed by the natural water cycle. When we finish using water, we need to clean it again (we can treat it in wastewater treatment plants). We can then release clean water back into nature to once again be recycled.

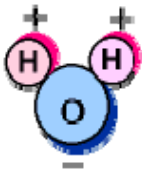
Reference

Alabama Cooperative Extension System, Alabama Water Quality Curriculum Grades 4-12. Available at http://www.aces.edu/crd/publications/wtrqlty/wq1.pdf. Accessed January 23, 2009.

Objective 2: Describe the chemical and physical properties of water and explain their implications for freshwater and saltwater ecosystems.

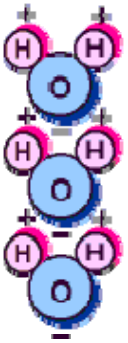
What are the physical and chemical properties of water that make it so unique and necessary for living things? When you look at water, taste and smell it - well, what could be more boring? Pure water is virtually colorless and has no taste or smell. But the hidden qualities of water make it a most interesting subject.

Water's Chemical Properties



You probably know water's chemical description is H_2O. As the diagram to the left shows, that is one atom of oxygen bound to two atoms of hydrogen. The hydrogen atoms are "attached" to one side of the oxygen atom, resulting in a water molecule having a positive charge on the side where the hydrogen atoms are and a negative charge on the other side, where the oxygen atom is. Since opposite electrical charges attract, water molecules tend to attract each other, making water kind of "sticky." As the right-side diagram shows, the side with the hydrogen atoms (positive charge) attracts the oxygen side (negative charge) of a different water molecule. (If the water molecule here looks familiar, remember that everyone's favorite mouse is mostly water, too).

- Since oxygen has a higher electronegativity than hydrogen, water is a polar molecule. The oxygen has a slight negative charge while the hydrogens have a slight positive charge giving the article a strong effective dipole moment. The interactions between the different dipoles of each molecule cause a net attraction force associated with water's high amount of **surface tension.**



Water is attracted to other water. This is called ***cohesion.*** Water can also be attracted to other materials. This is called ***adhesion.*** All these water molecules attracting each other mean they tend to clump together. This is why water drops are, in fact, drops! If it wasn't for some of Earth's forces, such as gravity, a drop of water would be ball shaped -- a perfect sphere. Even if it doesn't form a perfect sphere on Earth, we should be happy water is sticky.

Water is called the "universal solvent" because it dissolves more substances than any other liquid. This means that wherever water goes, either through the ground or through our bodies, it takes along valuable chemicals, minerals, and nutrients. A drop of rain water falling through the air dissolves atmospheric gases. When rain reaches the earth, it affects the quality of the land, lakes and rivers.

pH and water quality

Pure water has a neutral pH of 7, which is neither acidic nor basic.

Excessively high and low pHs can be detrimental for the use of water. High pH causes a bitter taste, water pipes and water-using appliances become encrusted with deposits, and it depresses the effectiveness of the disinfection of chlorine, thereby causing the need for additional chlorine when pH is high. Low-pH water will corrode or dissolve metals and other substances.

Pollution can change a water's pH, which in turn can harm animals and plants living in the water. For instance, water coming out of an abandoned coal mine can have a pH of 2, which is very acidic and would definitely affect any fish crazy enough to try to live in it! By using the logarithm scale, this mine-drainage water would be 100,000 times more acidic than neutral water -- so stay out of abandoned mines.

Water's Physical Properties

- Water is unique in that it is the only natural substance that is found in all three states -- liquid, solid (ice), and gas (steam) -- at the temperatures normally found on Earth. Earth's water is constantly interacting, changing, and in movement.
- Water freezes at 32^{o} Fahrenheit (F) and boils at 212^{o} F (at sea level, but 186.4° at 14,000 feet). In fact, water's freezing and boiling points are the baseline with which temperature is measured: 0^{o} on the Celsius scale is water's freezing point, and 100^{o} is water's boiling point. Water is unusual in that the solid form, ice, is less dense than the liquid form, which is why ice floats.
- Water has a high specific heat index. This means that water can absorb a lot of heat before it begins to get hot. This is why water is valuable to industries and in your car's radiator as a coolant. The high specific heat index of water also helps regulate the rate at which air changes temperature, which is why the temperature change between seasons is gradual rather than sudden, especially near the oceans.
- Water has a very high **surface tension**. In other words, water is sticky and elastic, and tends to clump together in drops rather than spread out in a thin film. Surface tension is responsible for **capillary action,** which allows water (and its dissolved substances) to move through the roots of plants and through the tiny blood vessels in our bodies.

Capillary action

Even if you've never heard of capillary action, it is still important in your life. Capillary action is important for moving water (and all of the things that are dissolved in it) around. It is defined as the movement of water within the spaces of a porous material due to the forces of adhesion, cohesion, and surface tension.

Surface tension is a measure of the strength of the water's surface film. The attraction between the water molecules creates a strong film, which among other common liquids is only surpassed by that of mercury. This surface

tension permits water to hold up substances heavier and denser than itself. A steel needle carefully placed on the surface of a glass of water will float. Some aquatic insects such as the water strider rely on surface tension to walk on water.

Capillary action occurs because water is sticky, thanks to the forces of **cohesion** (water molecules like to stay closely together) and adhesion (water molecules are attracted and stick to other substances). So, water tends to stick together, as in a drop, and it sticks to glass, cloth, organic tissues, and soil. Dip a paper towel into a glass of water and the water will "climb" onto the paper towel. In fact, it will keep going up the towel until the pull of gravity is too much for it to overcome.

Thermal properties

Water absorbs or releases more heat than many substances for each degree of temperature increase or decrease. Because of this, it is widely used for cooling and for transferring heat in thermal and chemical processes.

Differences in temperature between lakes and rivers and the surrounding air may have a variety of effects. For example, local fog or mist is likely to occur if a lake cools the surrounding air enough to cause saturation; consequently, small water droplets are suspended in the air.

Large bodies of water, such as the oceans or the Great Lakes, have a profound influence on climate. They are the world's great heat reservoirs and heat exchangers and the source of much of the moisture that falls as rain and snow over adjacent land masses.

When water is colder than the air, precipitation is curbed, winds are reduced, and fog banks are formed.

Structure of **Ice**. Ice (solid water) has a regular bonding arrangement between the molecules of water which actually increases the distance between molecules in certain directions. The result is that ice is not as dense as liquid water at 4°C. Therefore ice FLOATS. This is beneficial to bottom dwellers in lakes, rivers and oceans.

Sources and more information

The Nature of Water: Environment Canada,
http://www.ec.gc.ca/water/en/nature/prop/e_magic.htm

Water Science for Schools: USGS, http://ga.water.usgs.gov/edu/mwater.html

Objective 3: Analyze the interaction of competing uses of water for water supply, hydropower, navigation, wildlife, recreation, waste assimilation, irrigation, industry, and others.

How Water Is Used in Alabama

Use of Water in Alabama. Approximately 8 billion gallons of water are used in Alabama every day. The major uses of water are shown in Figure 3.1. They are:

1. Power generation: Electric power generation uses a lot of water. There are different types of power plants which produce electricity. These include nuclear power plants, coal-burning plants and hydroelectric power plants. Both nuclear and coal burning power plants generate heat which changes water to steam, a form of hot water vapor under high pressure. This steam is used to spin turbines which are connected to generators. The generators produce the electricity.

Fire boils water to produce steam in coal burning plants while the heat from atomic processes boils water in nuclear power plants. These two processes give off a lot of heat when making electricity. Large amounts of water are used to cool off the hot equipment in these plants.

Nuclear and coal power plants use about 78% of water used in Alabama. This is the largest use of water in the state. However, much of this water is not consumed and goes back to the stream from which it came. About 6.3 billion gallons of water are used in these plants each day. The largest user is the Brown's Ferry nuclear power plant in Limestone County on the Tennessee River. It uses 2.3 billion gallons of water per day.

Hydroelectric power uses flowing water to make electricity. This process uses the water in reservoirs on rivers. The water passes over water turbines that spin generators to generate electricity. Hydroelectric power does not actually withdraw or "use up" water. This water remains at its source and is still available for other uses.

2. **Business and Industry**: Businesses and industries use about 10% of the water used in Alabama. Factories use water for many types of manufacturing processes. Water is used to produce steam which runs engines in some factories. Much water is used for both heating and cooling processes. Many items, such as food, steel, tires, newspapers, and cars need water in the manufacturing process. For example, it takes about 75,000 gallons of water to make one ton of good quality paper. Just one copy of a Sunday newspaper takes approximately 150 gallons of water! (And think of all the paper we waste and simply throw away). Very clean water is needed in the production of food, drugs and chemicals.

3. **Public Supply**: About 9% of Alabama's water use comes from public supply systems. This water is used by cities and towns. Water used for public supplies can either come from surface areas (on top of the ground--such as lakes and rivers) or under the ground (called groundwater). Water treatment plants clean this water before it is used. These plants supply clean water for homes, businesses and schools. About 4 million people in the state use water from public supply systems.

4. **Agriculture**: Alabama uses only about 3% of its water for agricultural purposes. Some states use a major portion of their water for watering crops and farm animals. Irrigation uses a system of pipes or ditches to water crops. It is used when there is not enough water from natural rain to supply crop needs. The main crops irrigated in Alabama are peanuts, corn, fruit, vegetables, turfgrasses and cotton. Fortunately, Alabama usually receives abundant rainfall and

does not rely on irrigation as much as some states. Another agricultural industry important in Alabama is catfish production. This industry must use large amounts of water.

5. **Private Supply**: Less than 1% of water used in Alabama comes from private wells. Homes using water from private wells do not rely on public supply systems. About 10% of homes in Alabama use water from private supplies.

6. **Mining**: The mining industry uses water in its manufacturing processes. In Alabama, the mining industry is mainly in the Appalachian Mountains in the northern part of the state. Coal and iron ore are minerals found in these mountains. Water is used to make steel from iron ore. Earlier in this century, the steel industry was an important industry in the Birmingham area.

7. **Transportation:** Water is a valuable resource for the shipping industry. Many manufacturers rely on Alabama's river systems to transport their goods to the Gulf coast. The Tennessee-Tombigbee Waterway is one of Alabama's most important water resources. This waterway was built by joining the Tennessee and Tombigbee rivers. It made a faster route for ships to travel from North Alabama to the Gulf.

8. **Recreation**: There are many recreational uses of water in Alabama. Recreational users enjoy the many lakes, rivers, and coastal waters for boating, fishing, swimming, etc. Water used in transportation and recreation, just as the water used in hydroelectric power, is not withdrawn from its natural source when used. Instead of being "used up," it is still available for other uses.

Water Withdrawals

Our water use has been increasing about twice as fast as population growth over the past century. Uses of water may be classified in several different ways. Water withdrawal is one way. Withdrawal looks at the use of water in terms of the amount of water removed from a lake, river, or aquifer for any purpose. Important withdrawal uses are (1) municipal, (2) domestic (3) irrigation, (4) industrial, and (5) hydropower. Much of the water is not consumed or used up; it is used in nondestructive ways and is returned to a water body in a form that can be used again. If water is moved to another watershed, called an inter-basin transfer, it will not be returned to waterbodies in the watershed where it originated. Transfers of large volumes of water could harm the ecosystem in the watershed “losing” water. Competition for water between watersheds is better known in the arid west but it is becoming more common in Eastern watersheds. Water consumption is another way to analyze use. Consumption measures the fraction of water used up or lost in transmission, evaporation, absorption, and chemical transformation. Unfortunately, the amount of water on earth is fixed for all practical purposes, and there is little we can do to make more water. The only way to increase our local supplies is through wise management and conservation.

WILL THERE BE ENOUGH WATER TO GROW CROPS FOR THE PROJECTED BIOFUELS DEMAND?

In the next 5 to 10 years, increased agricultural production for biofuels will probably not alter the national-aggregate view of water use. However, growing crops for biofuel production is likely to have significant regional and local impacts. Shifting land from an existing crop (or non-crop plant species) to a crop used in biofuel production has the potential to change irrigation water use, and thus the local water availability.

Source: **Water Implications of Biofuels Production in the United States**

Water Policy in Alabama

Our State is blessed with a bounty of rivers and streams that provide a safe and sufficient drinking water supply, transportation routes for many industries, recreation, wildlife habitat, and an energy source for many Alabamians. While these demands on our water supply continue to grow each year, our water supply remains finite and the protection of these resources is of critical importance to the health, safety, and well being of the citizens of Alabama. For this reason, competing water needs of industry, public health, the environment, and recreation must be carefully monitored and analyzed so that future generations can continue to enjoy these resources. Recently, activities in Alabama have brought this issue to the forefront. The Governor has recently requested an evaluation of water policy and the large number of proposed electric generating plants in the State and their potential impact on the waters of the State. Currently, there are over 20 proposed plants in various stages of construction. The combined use of these proposed plants exceeds that of the Birmingham Metro area.

The **Office of Water Resources** (under the Alabama Department of Economic and Community Affairs – ADECA) is responsible for planning, coordinating, developing, and managing Alabama's water resources, both ground and surface water in a manner that is in the best interest of the State of Alabama. This includes recommending policies and legislation, conducting technical studies, implementing and participating in programs and projects, and actively representing Alabama's intra and interstate water resource interests.

1) As demands on our waters grow we must focus on water management
    a) Preservation of current uses
    b) Watershed management and protection
    c) Future growth and economic development
    d) Enhancements to our water policy*further complicated by:*

1) Droughts (1999 – 2000)
2) Floods (Spring of 2003)
3) Water wars

Who Owns The Water?

Water may be obtained from three sources: surface water, watercourses, and percolating water. Surface water is that water on the earth's surface which does not flow in a well-defined channel. Most of us think of surface water and watercourses as being the same thing, but in terms of water law that is not necessarily the case.

A watercourse may be defined as water flowing in a well-developed channel on or below the surface of the land. Groundwater that is moving in a well-defined aquifer may be defined as a watercourse. Water beneath the earth that is not confined to a well-defined channel is called percolating water. The separation of percolating water and underground water that is in a watercourse has been a subject of much argument because both may be classified as groundwater. The difference is that one is confined and the other is not.

In general, surface water in Alabama belongs to the individual landowner to use as he pleases, except in municipal limits of incorporated cities. Rural landowners are entitled to all the surface water they can retain and use on their land. This allows higher elevation landowners in

rural areas to deprive lower elevation landowners of water benefits from surface water. With Alabama's abundant rainfall, there is usually little concern about surface water usage but more concern about surface water discharge. In rural areas the higher elevation landowner has the right to discharge surface waters over the property of lower elevation landowners. The lower landowners cannot interrupt or obstruct this flow.

The use of watercourse water in Alabama is based on the principle of the **Riparian Rights Doctrine.** The basic premise of this doctrine is that water in its natural state, a watercourse, can be used only on that land through which it flows. Thus, a riparian landowner can use riparian water anywhere, so long as it does not extend beyond the natural watershed of the riparian source of water.

However, the use of riparian water is subject to the **Reasonable Use Doctrine.** This means that riparian water may be used for any purpose so long as quality and quantity of flow are adequate for other downstream riparian owners. Since "reasonable use" programs to monitor riparian uses so that all owners can have their reasonable share of the available sources. At this time, Alabama does not have a statewide permitting program for all riparian watercourse users, although cities and industrial users are permitted.

The right of use of percolating water in Alabama is very similar to surface water use. Individual landowners have the right to reasonable and beneficial use of these waters even to the extent that neighboring properties can be affected, as long as the water use is not wasteful and does not cause personal injury to others.

With a growing interest in preserving the natural quality of scenic rivers or other areas, the **Public Trust Doctrine** is likely to be adopted by more states in the future. It has been invoked in California. The principle of this doctrine is that private rights to use water may be limited by the need to preserve environmental, scenic, recreational, or scientific areas that benefit all. Hence, certain waters may be held in public trust to preserve their quality and use for future generations under this doctrine.

So who owns the water? It depends on the location of the water over time. For effective water management, however, there must be cooperation between federal, state, and city governments as well as individuals.

Resources:
Water Use in the U.S., http://ga.water.usgs.gov/edu/wateruse.html

Understanding Water as a Resource, http://www.aces.edu/pubs/docs/A/ANR-0790/WQ1.1.1.pdf

Objective 4: Discuss methods of conserving water and reducing point and nonpoint source pollution.

Conserving Water in AL

Although the earth is rich in water, only one percent is liquid fresh water, the form we require for our highest priority needs. The demands on this liquid fresh water are growing, and many scientists feel that a future shortage of fresh water will be eminent.

Alabama has access to a tremendous supply of fresh water, due to its long-term average annual rainfall of 55 inches, but Alabama is not immune to water shortages. A shortage of fresh water

may occur for any number of reasons including rising water demands by agriculture, industry, and cities; a rapidly increasing population; pollution; flagrant waste; and unequal distribution. Increased demands and droughts both lead to accelerated pollution, and pollution can further limit the supply of available fresh water.

Better water conservation and management has economic benefits and helps protect the environment. The more water you use, the more you pay for water and sewer service on a municipal water and sewer system. Excessive water use can overload both individual septic systems and municipal sewer systems, thereby resulting in untreated sewage contamination of fresh water supplies. Water conservation can extend the useful life of both community and individual household sewer systems.

Excessive withdrawals of ground water can lead to salt water intrusion, a subtle environmental impact with long-lasting effects. These areas are usually associated with large population centers or agriculture, where water use is high. Agriculture is our most essential industry, but it is also our largest consumer of fresh water. Water conservation and management will become bigger issues for agriculture and metropolitan areas as they compete for limited fresh water resources in the future.

--ACES_ Water Conservation

Resources:

- 49 Ways to Conserve Water, http://www.americanwater.com/49ways.htm
- EPA - How to Conserve Water and Use It Effectively , http://www.epa.gov/nps/chap3.html

Point and Nonpoint Source Pollution Overview

There are two main types of water pollution:

1. **Point Source Pollution** is pollution that is discharged directly from factories and waste-water treatment facilities. These facilities are regulated under the National Pollutant Discharge Elimination System (NPDES).

2. **Nonpoint Source Pollution** is:

- Water pollution which does not come from any specific point or location.
- Water pollution which results from rainfall runoff carrying soil, chemicals and other residues of everyday human activity into our waterways.
- Water pollution that is regulated by very few laws.

The Clean Water Act

- The Clean Water Act was enacted October 18, 1972 with its main objective being to restore and maintain the "chemical, physical and biological integrity of the Nation's Waters."
- It was the 500th public law passed by the 92nd Congress (PL 92-500).
- At this point in time, the primary water quality concerns were Point Source related.
- The Clean Water Act was amended in 1987 to address the problems of Nonpoint Pollution which is know as Title III, Section 319.

Section 319 of the Clean Water Act

- Directed States to prepare assessment reports which were to list waters not meeting standards or goals due to NPS pollution, identify the contributing polluting sources, and identify Best Management Practices (BMP's) for controlling those NPS pollutants.
- Directed States to develop management programs for controlling NPS pollution.
- Created a grants program for NPS control for such things as demonstration projects, technical assistance, planning, enforcement education and others.
- In AL, grants are managed by the AL Department of Environmental Management.

Types of Nonpoint Source Pollution

Nutrients-

Nutrients are substances which are needed for growth such as nitrogen and phosphorus, but elevated levels can cause a health hazard in drinking water and stimulate excessive plant growth, which can lower dissolved oxygen levels.
Sources: Animal Waste, Fertilizers, Septic Systems, & Auto Emissions

Pathogens

Pathogens are disease-causing bacteria and viruses associated with the presence of fecal matter.
Sources: Failing Septic Systems, Animal Waste, Marine Sanitation Devices

Sediment

Sediment is eroded soil or sand which smothers aquatic habitat, decreases plant reproduction, carries pollutants, decreases recreational and commercial values, increases drinking water costs and reduces water clarity.
Sources: Road Sand, Construction Sites, Agricultural Fields, Disturbed Areas

Toxic Contaminants

Toxic Contaminants are compounds like heavy metals and pesticides that can threaten the health of both aquatic and human life, and are often resistant to breakdown.
Sources: Industrial, Commercial, Household, & Agricultural Chemicals, Auto Emissions

Debris

Debris includes plastics and other trash that threaten aquatic life and detract from recreational and aesthetic values.
Sources: Illegal Dumping, Street Litter, Beach Litter, Boating Waste

Thermal Stress

Thermal Stress is an elevation in water temperature that can harm native species while helping nonnative species to spread. As the water temperature increases, the amount of dissolved oxygen decreases.
Sources: Runoff from Heat-absorbing Surfaces, Removal of Streamside Vegetation, Shallow Water Impoundments, Decreased Base Flow

Examples of best management practices used to protect water quality

- Minimize sedimentation by using properly constructed and maintained sediment fences and temporary ground cover at construction sites.
- Avoid removal of streamside vegetation or promote riparian or streambank restoration. Leave a buffer strip of 25-100 feet on both sides of the stream channel to serve as a natural sediment trap and to maintain natural stream temperatures.
- Minimize flooding and promote infiltration by using proper construction techniques and maintaining storm drainage systems.
- Minimize extreme changes in stream flows by temporarily storing excess stormwater and gradually releasing it
- Minimize improper use/disposal of toxic household chemicals
- Promote responsibility of pet owners to clean up and properly dispose of droppings.
- Minimize pollution of streams from nutrients, organics and bacteria by installing and maintaining septic systems at safe distances from streams.
- Exclude livestock from streams except at designated crossings, and locate livestock holding facilities away from streams.
- Apply manure fertilizer during the proper season and weather conditions, and at levels not exceeding the carrying capacity of that particular soil type.

Resources:

- Pollution Prevention, http://www.cityofbremerton.com/content/sw_waterpollutionfacts.html
- Gateway to EPA Nonpoint Source Information, http://www.epa.gov/nps/

Objective 5: • Identify common aquatic organisms through the use of a key.

Collecting and identifying aquatic organisms found in a water body is one of several ways that can be used to assess its water quality. In order for the analysis of the water quality to be accurate, the organisms must be identified correctly. Scientists use keys to help them do this.

BIOASSESSMENT USING MANCROINVERTEBRATES:

Biological Assessment or Bioassessment is the use of living organisms to tell us something about the environment. Bioassessments of water quality can easily be done by collecting from a group of organisms that live on the bottom substrates of aquatic systems called benthos (meaning "living on the bottom") or, more specifically, benthic macroinvertebrates. The word "macroinvertebrate" suggests that we are dealing with "large animals without backbones". The "macro" simply means that they are usually larger than many other invertebrates in the water such as protozoan, rotifers, copepods and cladocerans (water fleas). The community of benthic macroinvertebrates is made up of animals like aquatic insects, snails, clams, crayfish and aquatic worms. In general, they are familiar to us and are commonly called "bugs". Many people can recall catching crayfish, dragonflies, snails and other such "critters" in streams or ponds as kids, but never realized the important "story" they have to tell us about water quality.

THE USEFUL "BUGS"

Three reasons why aquatic "bugs" are useful in bioassessment are because they are usually abundant, diverse and sedentary. In terms of abundance, macroinvertebrates often "cover" the bottom of a stream, and hundreds or even thousands of them can live in and on a square meter of substrate. Secondly, the taxa richness and relative abundance (proportions of one kind to another) of these "bugs" can be used to calculate the biodiversity of the group. Thirdly, macroinvertebrates are sedentary, generally staying in one place in the stream for much of their lives. Some have body parts adapted to hold on to substrates in strong currents and others attach their shelters to the bottom and live inside. This makes them much easier to capture than fish, frogs and other, faster animals. More importantly, it means that they are exposed to the water of one place in the stream over a long period of time (weeks, months, and for some, years). Twenty-four hours a day, the macroinvertebrates serve as **"mini** meters", monitoring the water quality for you. All you need to do is figure out how to "read" their assessment.

WHERE TO FIND BUGS

Bioassessments by citizen monitors and students are best done in rocky-bottomed streams in the habitat called a riffle--that area where the surface of the water is "broken" or "choppy" because the water is shallow and flowing over gravel, cobbles, boulders and sometimes branches and leaves. The riffle is the best habitat to sample, not only because it is usually a safe place to enter the stream wearing old sneakers or boots, but, more importantly, because this habitat is where most of the macroinvertebrates that are intolerant of poor water quality normally live. The water in a riffle is turbulent, keeping the substrate relatively free of sediments and providing many crevices (nooks and crannies) for bugs to live in. It is also a habitat that usually has abundant oxygen, unless some pollutant has removed it from the water.

Resources:

- Macroinvertebrate key, http://www.discovercarolina.com/html/s05nature09a02b.pdf
- SOS Stream Study Guide, http://people.virginia.edu/~sos-iwla/Stream-Study/StreamStudyHomePage/StreamStudy.HTML
- EPA Fish Identification, http://www.epa.gov/bioiweb1/html/fish_id.html
- Fish Identification Power Point

Objective 5: • Delineate the watershed boundary for a small water body.

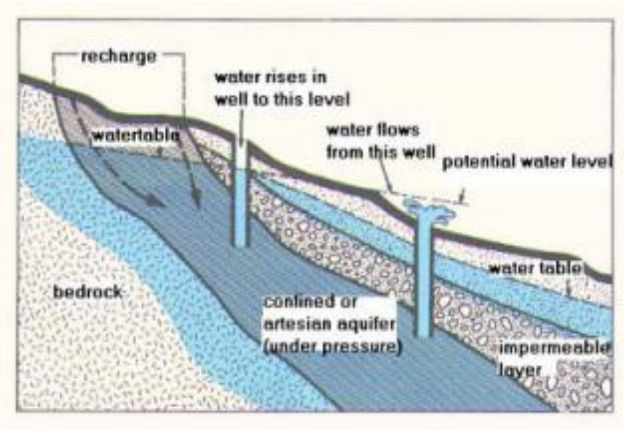
- How to Read a Topo Map and Delineate a Watershed
- Topo Map Symbols

Objective 6: Explain the different types of aquifers and how each type relates to water quantity and quality.

WHAT ARE AQUIFERS?

An **aquifer** is an underground layer of water-bearing permeable rock or unconsolidated materials (gravel, sand, silt, or clay) from which groundwater can be usefully extracted using a water well. Aquifers are underground holding tanks that play an important role for human water supply - from drinking water to irrigation.

There are two major types of aquifers, **confined** and **unconfined**. Unconfined aquifers consist of an upper unsaturated portion above the water table and a lower saturated zone below the water table. Confined aquifers are overlain and underlain by layers of significantly less permeable materials that restrict the flow of water across the aquifer boundaries. The less permeable layers that impede water movement are called **confining units**. In Alabama, confining units are generally composed of clays, **shales,** and chalk. Confined aquifers are completely saturated with water. Because the space the water occupies in a confined aquifer is restricted by the confining layer, the water can be under considerable pressure. When a well is drilled into a confined aquifer the pressure forces the water in the well to rise above the top of the aquifer itself. If the pressure is great enough the water will actually flow from the well at the ground surface without having to be pumped. Such flowing wells are common in and near the flood plains of major streams in the southern half of the state, and are sometimes called **artesian wells**.



Also, it is important to note that where the confining unit is present, confined aquifers cannot be locally replenished, or **recharged**, by rainwater filtering down from the surface. Infiltrating surface water can recharge confined aquifers only where the aquifer is exposed at the surface or where the confining unit is absent. Thus, the area of recharge for an aquifer may be a long distance from where water from that aquifer is produced. For example, the city of Dothan in Houston County pumps water from the Nanafalia **Formation**, a sandy geologic unit that, in that area, is a confined aquifer. The **recharge area** for the Nanafalia aquifer is where it crops out at the surface, more than 30 miles north of Dothan. It is important to understand this relationship because the water that future generations will rely on in Dothan can be affected by activities in the recharge area of the Nanafalia Formation, 30 miles away.

We are mostly concerned about unconfined aquifers because they are not "protected" by an impermeable layer. This means that if anything leaks or spills into the soil above the unconfined aquifer, it will seep into and contaminate the water. This is why we wouldn't want to drill our drinking water well in an unconfined aquifer.

POTENTIAL GROUND WATER CONTAMINANT SOURCES

Common sources of anthropogenic contaminants include septic tanks and privies; underground storage tanks; areas where fertilizer, pesticides, or herbicides are used or stored; landfills; and unauthorized dump sites. The most common sources of ground water contamination nationwide are underground storage tanks (**UST**s), septic systems, pesticides, and nitrates. The Alabama Department of Environmental Management (**ADEM**) considers USTs and failing septic systems to be the most serious threats to ground water in Alabama, because they are so numerous. Other sources of potential ground water contamination include unauthorized hazardous waste disposal sites, old landfills, unauthorized dumps, and abandoned wells.

Ground water contamination occurs when ground water comes in contact with naturally occurring contaminants or with contaminants introduced into the environment by anthropogenic activities. Naturally occurring substances found locally in soil and rocks that can affect ground water include lead, iron, manganese, aluminum, selenium, and arsenic, as well as petroleum, microorganisms, and brine (salty water). Contaminants associated with human activity most commonly include bacteria, petroleum products, natural and synthetic organic compounds, fertilizer, pesticides, herbicides, and metals.

--Alabama Water Down Under

Some Specific Contaminant to Groundwater

Pesticides

Pesticides are used to kill pests such as insects on farm fields. Pesticides can seep into the groundwater and cause kidney and liver damage and cancer in humans who drink the water. Over 2.5 BILLION pounds of pesticides are used in the United States.

Fecal Coliform

Human waste contains bacteria that can contaminate groundwater. Fecal coliforms can cause stomach illnesses and diarrhea and if they are present, other pathogens may be there also.

Uranium

Uranium is a radioactive element used in nuclear power plants. It also exists naturally in small concentrations in the ground. Too much uranium can cause cancer and other illnesses.

Chemical Solvents

TCE is an example of a chemical solvent. TCE is used in industries to clean parts and materials. Too much of it in the groundwater can cause cancer in humans.

Nitrates

Nitrates are chemicals present in most fertilizers. Nitrates can contaminate the groundwater, causing serious illness in young children. Over 115 million tons of fertilizer is used in the United States.

Benzene

Benzene contamination can come from leaking fuel tanks and industrial waste. Too much of it can cause cancer, nerve, lung and kidney damage, and blood disorders.

With groundwater contaminants, both chemical and biological, a very small concentration of contaminant could still lead to serious health effects. Different kinds of contaminants have different concentration limits at which they start to affect us or the environment. In dealing with groundwater contamination problems, it is necessary to find out both the specific type of contaminant and the concentration of the contaminant.

Contaminants can enter the groundwater by seeping in from the surface or by flowing in from another part of the aquifer. Once in the aquifer they move with the groundwater flow. As contamination moves it disperses. This means that the concentration decreases as it moves farther away from the source of the pollution. For that reason there are different concentrations of contaminants at different points in the aquifer.

When talking about contamination movement it is also very important to talk about the area affected by the spreading of groundwater contamination. A contaminant may be released into the groundwater for only a short time and in a very small area, but as it disperses the contaminant can affect a very large area and number of people.

--Michigan Environmental Education Curriculum – Groundwater Contamination

ALABAMA'S GROUND WATER RESOURCES

Alabama's ground water reserves are estimated at about 533 trillion gallons, or enough to last 3,300 years at the present rate of consumption. Ground water is a renewable resource that is constantly replenished by rainfall. Alabama is a relatively wet state. More than 55 inches of rain fall each year. Considering these facts, it seems that conserving our ground water supply would not be a concern, but the numbers do not tell the whole story.

Ground water, while plentiful, is not evenly distributed throughout the state. In some places the water is shallow and abundant; in other places it is deeper and harder to find. When found, ground water can be difficult to extract in the quantities needed and may differ in quality from place to place. So even though a statewide shortage is unlikely, local shortages may occur in some areas where the demand is great, causing serious problems.
Ground water availability varies from region to region and is controlled primarily by the kinds of rocks, sediments, and soils that contain the water. To understand the differences in water

availability between different areas, we must first understand how ground water moves from one area to another, as well as the rock, sediment, and soil properties that control water movement, storage, and availability.

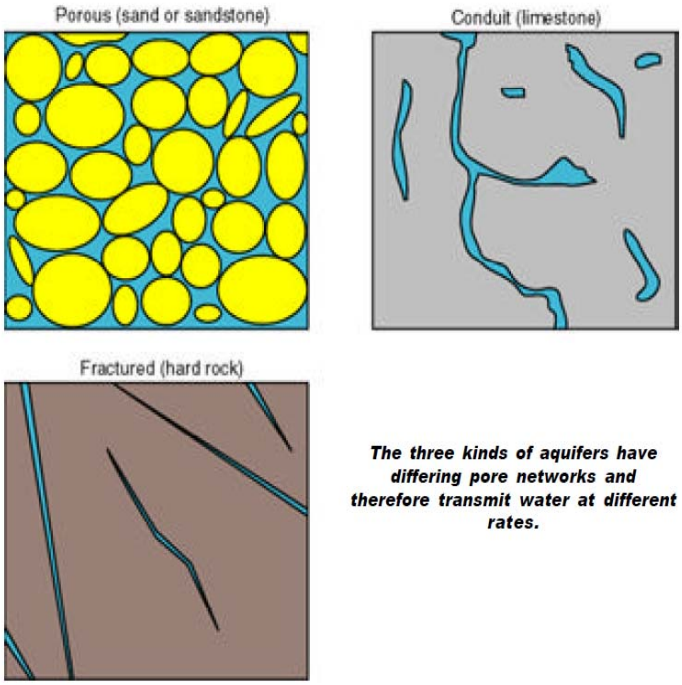
KINDS OF AQUIFERS

SAND OR SANDSTONE

Sand or **sandstone** aquifers are made up of sand-sized particles of other rocks that were broken down by erosion, transported to their present location by wind or water, and deposited. Water is stored in and moves through the open spaces, or pores, (called porous flow) between the individual sand grains. Sand aquifers are often found along rivers and streams where they formed as the stream meandered back and forth across the floodplain. These aquifers, sometimes called watercourse aquifers, can supply significant amounts of water but are restricted to the floodplains of major rivers and thus are only of local importance. The towns of Saraland and Satsuma in Mobile County use ground water from sand aquifers deposited by the Mobile River.

Sandstone is simply sand that has been hardened into rock by the heat and pressure caused by deep burial for extremely long periods of geologic time. Many sand bodies and some sandstone units are highly permeable, with porosity values that may exceed 25 percent. Typically, water moves slowly but steadily through sand and sandstone, making many sand and sandstone aquifers reliable sources of large amounts of ground water.

Sand and sandstone aquifers are the most important aquifers in many parts of Alabama and generally produce large amounts of water. Because water moves slowly through the aquifer, there is more time to respond if the ground water becomes contaminated. Also, sand and sandstone aquifers tend to filter out some contaminants as the water moves slowly through the pore spaces. Disadvantages include slow recharge if a sandstone aquifer becomes depleted, and the tendency of some sandstone aquifers to produce water containing too much iron, which can stain fixtures and fabric and give the water a bad taste. One important sand aquifer in Alabama is the Eutaw Formation. Sands of the Eutaw produce fresh water from Aliceville to Eufaula.



The three kinds of aquifers have differing pore networks and therefore transmit water at different rates.

LIMESTONE

A second way that water moves through an aquifer is by conduit flow. In conduit flow, water actually flows through underground channels, or conduits, in the rock. Conduit flow is commonly associated with carbonate rocks, such as limestone and dolomite. Most conduits are formed over thousands of years by dissolution, a

chemical reaction between limestone and fresh water in which the limestone is dissolved. Sometimes, large volumes of rock can be dissolved, forming cavities and caves. Although cave formations can be fascinating and sometimes spectacular most dissolution cavities in limestone aquifers are small, even microscopic. Most ground water in limestone occurs in these cavities and channels. Because these openings are irregular in shape and distribution, ground water flow can be unpredictable and extremely fast, sometimes up to several thousand feet per day through the larger channels. Springs are common in limestone aquifers, discharging water where water filled channels meet the surface.

Limestone aquifers have several potential disadvantages. For example, **sinkholes** tend to occur in areas underlain by limestone. A sinkhole forms when the ground surface collapses into an underlying dissolution cavity. Sinkholes are like huge drains and water entering them is immediately introduced into the ground water system. If contaminated water enters a sinkhole connected to a channel or cavity system capable of transporting large volumes of water, ground water can become contaminated very quickly, leaving little time to take action to protect it. Also, the water table in limestone aquifers may fall rapidly in response to an increase in pumping or a decrease in precipitation. As a result, some wells in limestone aquifers may stop producing altogether during dry summer months or periods of over-pumping. Fortunately, most of these wells recover quickly when the fall rains come. Another potential disadvantage of many limestone aquifers is the hardness of the water. This means it contains large quantities of dissolved carbonate, and does not readily produce lather with soap. In spite of these disadvantages, limestone aquifers are important sources of ground water in many parts of Alabama. The Tuscumbia-Fort Payne aquifer in north Alabama, for example, serves more than 100,000 public water supply system customers, although it is prone to all the problems which characterize limestone aquifers.

FRACTURED ROCK

The third way aquifers transmit water is through fractures. Aquifers characterized by porous flow or conduit flow can also be fractured, which enhances the permeability of these aquifers. In nonporous and insoluble rocks, fractures may provide the only way in which fluids can be transmitted. Examples of such rocks include sandstone in which the pores have been filled by some secondary material; shales; and most igneous and metamorphic rocks such as granite and gneiss (pronounced “nice”). These rocks are very dense and contain few open spaces except for fractures. Typically, fractures are concentrated near the surface and are not distributed evenly over a large area. Fractures also may or may not be well connected, and fracture dependent aquifers rarely contain enough water to make them reliable sources of water. They are typically used only when more suitable aquifers are not present. Small springs are common in fractured terrain wherever saturated permeable fracture systems intersect the land surface. In Alabama, fractured aquifers are most important in the Piedmont region (see next section), where hard granitic rocks, remnants of the core of the Appalachian Mountains, yield modest amounts of water from fracture systems. Fractured granites and granitic rocks are major aquifers in large parts of Coosa, Tallapoosa, and Chambers Counties, and smaller parts of several neighboring counties.

--Alabama Water Down Under

Resources:

- Ground Water Contamination
- AL Ground Water Conditions

Objective 7: Briefly describe the benefits of wetlands, including both function and value.

The term "wetlands" means those areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands include areas like freshwater and saltwater marshes, wet meadows, swamps, lagoons and bogs. All wetlands, whether coastal or inland, provide special habitats that serve areas far beyond their boundaries.

Wetlands act as nurseries. Wetlands are often referred to as "nurseries" because they provide critical breeding and rearing habitats for countless numbers and kinds of wildlife.

Wetlands act as natural filtering systems and have been shown to be extremely effective; for example, they can trap and neutralize sewage waste, allow silt to settle and promote the decomposition of many toxic substances. After being slowed by a wetland, water moves around plants, allowing the suspended sediment to drop out and settle to the wetland floor. Nutrients from fertilizer application, manure, leaking septic tanks, and municipal sewage that are dissolved in the water are often absorbed by plant roots and microorganisms in the soil. Other pollutants stick to soil particles. In many cases, this filtration process removes much of the water's nutrient and pollutant load by the time it leaves a wetland. Some types of wetlands are so good at this filtration function that environmental managers construct similar artificial wetlands to treat storm water and wastewater.

Of great importance to humans are the **flood control characteristics of wetlands**. When runoff from rains and spring thaws is at its peak, wetland areas absorb excess water until it gradually drains away. Acting as buffers, healthy wetlands prevent flooding and erosion. In dryer periods, wetlands hold precious moisture after other bodies of water have dried up.

Wetlands provide nutrients. Wetland plants cycle nutrients through food webs, keep nutrient concentrations from reaching toxic levels and release oxygen and provide food. Aquatic plant life flourishes in the nutrient-rich environment, and energy converted by the plants is passed up the food chain to fish, waterfowl, and other wildlife and to us as well. This function supports valuable commercial fish and shellfish industries.

Wetlands play an integral role in the ecology of the watershed. The combination of shallow water, high levels of nutrients, and primary productivity is ideal for the development of organisms that form the base of the food web and feed many species of fish, amphibians, shellfish, and insects. Many species of birds and mammals rely on wetlands for food, water, and shelter, especially during migration and breeding. Wetlands' microbes, plants, and wildlife are part of global cycles for water, nitrogen, and sulfur. Wetlands can be thought of as "biological

supermarkets." An immense variety of species of microbes, plants, insects, amphibians, reptiles, birds, fish, and mammals can be part of a wetland ecosystem.

Furthermore, **scientists are beginning to realize that atmospheric maintenance may be an additional wetlands function.** Wetlands store carbon within their plant communities and soil instead of releasing it to the atmosphere as carbon dioxide. Thus wetlands help to moderate global climate conditions.

Wetlands provide Water Storage and Flood Protection. Wetlands function like natural tubs or sponges, storing water and slowly releasing it. This process slows the water's momentum and erosive potential, reduces flood heights, and allows for ground water recharge, which contributes to base flow to surface water systems during dry periods. Although a small wetland might not store much water, a network of many small wetlands can store an enormous amount of water. The ability of wetlands to store floodwaters reduces the risk of costly property damage and loss of life—benefits that have economic value to us.

Wetlands provide Fish and Wildlife Habitat. More than one-third of the United States' threatened and endangered species live only in wetlands, and nearly half use wetlands at some point in their lives. Many other animals and plants depend on wetlands for survival. Estuarine and marine fish and shellfish, various birds, and certain mammals must have coastal wetlands to survive. Most commercial and game fish breed and raise their young in coastal marshes and estuaries.

Menhaden, flounder, sea trout, spot, croaker, and striped bass are among the more familiar fish that depend on coastal wetlands. Shrimp, oysters, clams, and blue and Dungeness crabs likewise need these wetlands for food, shelter, and breeding grounds. For many animals and plants, like wood ducks, muskrat, cattails, and swamp rose, inland wetlands are the only places they can live. Beaver may actually create their own wetlands. For others, such as striped bass, peregrine falcon, otter, black bear, raccoon, and deer, wetlands provide important food, water, or shelter. Many of the U.S. breeding bird populations-- including ducks, geese, woodpeckers, hawks, wading birds, and many song-birds-- feed, nest, and raise their young in wetlands.

Migratory waterfowl use coastal and inland wetlands as resting, feeding, breeding, or nesting grounds for at least part of the year. Indeed, an international agreement to protect wetlands of international importance was developed because some species of migratory birds are completely dependent on certain wetlands and would become extinct if those wetlands were destroyed.

Wetlands are important for shoreline erosion control. The ability of wetlands to control erosion is so valuable that some states are restoring wetlands in coastal areas to buffer the storm surges from hurricanes and tropical storms. Wetlands at the margins of lakes, rivers, bays, and the ocean protect shorelines and stream banks against erosion. Wetland plants hold the soil in place with their roots, absorb the energy of waves, and break up the flow of stream or river currents.

Wetlands are important to our economy. We use a wealth of natural products from wetlands, including fish and shellfish, blueberries, cranberries, timber, and wild rice, as well as medicines that are derived from wetland soils and plants. Many of the nation's fishing and shellfishing

industries harvest wetland-dependent species; the catch is valued at $15 billion a year. In the Southeast, for example, nearly all the commercial catch and over half of the recreational harvest are fish and shellfish that depend on the estuary-coastal wetland system. Louisiana's coastal marshes produce an annual commercial fish and shellfish harvest that amounted to 1.2 billion pounds worth $244 million in 1991. Wetlands are habitats for fur-bearers like muskrat, beaver, and mink as well as reptiles such as alligators. The nation's harvest of muskrat pelts alone is worth over $70 million annually

Wetlands provide an important recreational and aesthetic value. Wetlands have recreational, historical, scientific, and cultural values. More than half of all U.S. adults (98 million) hunt, fish, birdwatch or photograph wildlife. They spend a total of $59.5 billion annually. Painters and writers continue to capture the beauty of wetlands on canvas and paper, or through cameras, and video and sound recorders. Others appreciate these wonderlands through hiking, boating, and other recreational activities. Almost everyone likes being on or near the water; part of the enjoyment is the varied, fascinating lifeforms.

References and Resources:

- EPA Wetlands Page
- EPA, Functions and Values of Wetlands

Objective 8: Describe the benefits of riparian areas, including both function and value.

Importance of riparian zones

In headwater streams, bank vegetation (**riparian zone**) is a very important part of the stream ecosystem. The bank vegetation shades the channel from sunlight. This reduces photosynthesis in the stream and causes water temperatures to be cooler in summer and warmer in winter. This is important because many of the fish, salamanders, and other critters that live in headwater streams are adapted to living in these temperature conditions, and need it that way to survive.

Nutrients provided by streamside vegetation are important for stimulating the aquatic food web and overall productivity of a stream. When a leaf falls into a stream, it begins to decompose. Most of its nutrients are dissolved (leached) within the first few hours. Over the first few days, the leaf becomes colonized by fungi and bacteria. These leaves with fungi and bacteria are a nutritious meal for small aquatic critters who like to eat them. The small critters than provide food for larger organisms and fish. The fish then provide larger animals such as otters, raccoons, bears, and even us with a good meal.

Streamside vegetation is also important in terms of reducing pollution loads. A healthy riparian zone can often intercept and filter polluted rainfall runoff. Polluted runoff can carry any number of pollutants like sediment, chemicals and heavy metals from parking lots and other urban areas, and excess fertilizers from agricultural fields and lawns.

Benefits of riparian areas include:
1. Sediment Filtering
2. Bank Stabilization
3. Water Storage and Release
4. Aquifer Recharge

A healthy riparian system would have some or all these characteristics:
1.) High water table and increased storage capacity,
2.) Strong and productive plant communities,
3.) Good shade-Cool water,
4.) Good fish habitat-Good water quality,
5.) High wildlife habitat diversity,
6.) Vegetation and roots present that help protect and stabilize banks,
7.) Higher stream flows during dry periods.

An unhealthy system would have some or all these characteristics:
1.) Low water table and decreased storage capacity,
2.) Sparse, unproductive plant communities,
3.) Little shade-Warm water,
4.) Poor fish habitat-Poor water quality,
5.) Little diversity in wildlife habitat,
6.) Little vegetation and few roots to help protect and stabilize banks,
7.) Reduced stream flows during dry periods.
More information on riparian areas:

- ACES - Riparian Areas

Objective 9: Describe the changes to the aquatic ecosystem based on alteration to the aquatic habitat.

THE STREAM AS AN ECOSYSTEM
An **ecosystem** includes living organisms, their nonliving physical environment and all the interactions among them. These interactions include predation, competition, and effects of physical factors on biological organisms. Physical aspects of a stream include stream size, shape, gradient (slope), substrate (bottom) type, water quality, water quantity, and streamside vegetation. The physical environment of a stream ecosystem strongly influences the types of organisms that are able to live there, what they look like (adaptations), and their life histories. The physical environment of streams is naturally influenced by factors such as rainfall, temperature, geology, soil type and **topography**. Human activities may also have profound effects on streams and stream organisms. Aquatic organisms are sensitive to any changes that may occur in their habitat and, like most other ecosystems on Earth, aquatic habitats are now changing with greater frequency due to the effects of human land use.
Additional Resources:

- Major Causes of Habitat Loss
- Effects of Erosion on Aquatic Habitat

- Effects of Urbanization on Stream Ecosystems
- ACES - Urbanization and How it Affects Water Quality
- Habitat Alterations on Coastal and Freshwater Ecosystems, starting w. p. 171

Table 5.2: Major threats to coastal and freshwater ecosystems and services

Ecosystem	Goods and services	Threats
Rivers	Many environmental, economic (e.g. fish, water supplies, transport, disposal, biological cleaning, climate regulation, etc.), religious and spiritual values	Reclamation, drainage, regulation of flow including dam construction, hydroelectric power, pollution, deforestation, soil erosion and degradation, climate change and alien invasive species
Estuaries	High biodiversity, fish, waterfowl, sedimentation, buffer zones, biological cleaning, recreation	Reclamation, drainage, irrigation, hydroelectric power, regulation of water flow, dams and dykes, pollution, agricultural intensification, deforestation, soil erosion/degradation, overexploitation of fish and other food species, climate change, waterborne disease control, and alien invasive species
Coral reefs	High species diversity, coastal protection, biological cleaning, tourism	Climate change, suspended solids from coastal construction, upstream agriculture and logging, tourism; nutrients from untreated sewage and agricultural runoff; pollution from industrial discharges, urban, agricultural and landfills runoff, mining
Mangroves	High species diversity, coastal protection, water purification, CO_2 absorption, breeding and nursing grounds for commercial fish species, source of firewood and timber, coastal protection, tourism	Cutting for firewood and building materials, timber industry, road construction, reclamation for aquaculture, agricultural, urban and industrial areas, tourism developments, and sea-level rise
Sea-grass beds	High species diversity, nursing grounds for commercial fish species, coastal protection, water purification, CO_2 absorption, sediment stabilization	Dredging for harbours, ports and shipping lanes, fishing by benthic trawling, aquaculture, coastal pollution, and clearance for beaches and other tourism developments and facilities
Inland deltas	Water supplies, sediment and nutrient retention, recreation	Drainage, irrigation, regulation of water flow, pollution, agricultural intensification, deforestation, soil erosion/degradation, overexploitation of fish and other food species, climate change
Floodplains	High productivity, high fish and fibre productivity, flood buffers, fire protection, carbon storage, recreation, groundwater recharge	Reclamation, drainage, irrigation, hydroelectric power, regulation of water flow, dams and dykes, pollution, agricultural intensification, deforestation, soil erosion/degradation, overexploitation of fish and other food species, climate change, waterborne disease control, and alien invasive species
Lakes	Water supplies, fibre, fish, waterfowl, recreation, groundwater recharge, religious and spiritual values	Pollution, agricultural intensification, eutrophication, deforestation, soil erosion/degradation, overexploitation of fish and other food species, climate change, waterborne disease control, and alien invasive species
Freshwater marshes	Flood buffers, carbon storage, reed, willow, food and fibre, purification	Drainage, regulation of water flow, dams and dykes, pollution, agricultural intensification, soil erosion/degradation, overexploitation of fish and other food species, and waterborne disease control
Raised bogs	Carbon storage, fossil fuels, purification	Reclamation, drainage, regulation of water flow, pollution, agricultural intensification, eutrophication and climate change
Fen mires	Carbon storage, pastoralism, willow, reed, groundwater recharge	Reclamation, drainage, regulation of water flow, pollution, agricultural intensification, and climate change
Alpine meadows	Species diversity, husbandry, pastoralism, recreation, groundwater recharge	Drainage, agriculture and climate change
Tundra wetlands	Carbon storage, climate regulation, water flow, subsistence hunting and herding, groundwater recharge	Pollution, climate change, overexploitation of fish and other food species
Forest swamps/ shrubs	Timber and fibre, biological cleaning, sanitation, flood buffers, groundwater recharge, purification	Deforestation, soil erosion, degradation and pollution
Groundwater aquifers	Water reservoirs, water storage, storage of nutrients	Irrigation, pollution, agricultural intensification, eutrophication, deforestation, soil erosion/degradation, overexploitation of food species and waterborne disease control
Freshwater springs and oases	Water and food supplies, stop-over sites for migratory species, recreation, religious and spiritual values	Irrigation, agricultural intensification, pollution, overexploitation of fish and other food species, and alien invasive species
Wet grasslands	Carbon storage, food supply, flood buffers (mostly on floodplains), groundwater recharge	Regulation of water flow, drainage, agricultural intensification, eutrophication, overexploitation of food species, and climate change
Ponds, gravel pits, drainage channels	Water supplies, recreation	Pollution, eutrophication and overexploitation of fish and other food species

Source: UNEP and UNEP-WCMC, 2004.

Objective 9: Know methods used to assess and manage aquatic environments and be able to utilize water quality information to assess the general water quality of a specific body of water. This includes sampling, technique, and water quality parameters used to monitor point and non-point source pollution.

Biological assessments, Chemical assessments, and Visual assessments are three methods used to assess aquatic environments and determine the quality of a given body of water. These different types of assessments provide valuable information but in different ways.

Chemical assessment provides data regarding specific parameters related to water quality such as dissolved oxygen, pH, or total suspended solids. This information can be very useful in pinpointing a specific pollutant or polluter, yet each chemical test on a sample only provides a "snapshot" of the condition of the body of water being tested. Since the sample taken only reflects the conditions at the exact location and time at which the sample was taken, long-term trends in water quality may be overlooked unless a regular schedule of tests is applied.

Biological sampling evaluates the populations of living organisms within a body of water in efforts to assess quality. Benthic macro-invertebrates and fish are two commonly sampled populations used in biological assessments. Since aquatic organisms spend most, if not all, of their lives in the water they are very dependent on its quality for survival. Some organisms show greater tolerance to pollution than others, thus the composition of a population can reflect the quality of the habitat including the quality of the water. The information collected through biological assessment can tell us more about the long-term conditions of a body of water, but it is difficult to determine a specific limiting factor.

Visual assessments generally accompany a biological and/or chemical assessment. They provide information on the surrounding landscape as well as information about the habitat of the aquatic environment. Information documented in a visual assessment may include anything that could have a potential impact on the monitoring site such as discharge pipes, surrounding land use, recent weather conditions, turbidity (cloudiness), flora and fauna, or stream substrate. The links below will provide you with additional of information regarding this topic.

- Alabama Water Watch
- Water Quality Parameters – Chemical Assessments
- Macro-invertebrate and fish sampling techniques.
- Volunteer Monitoring - Rapid Bioassessment
- FL - What is Bioassessment?
- Bioassessments in Urban Streams
- USGS - Common Water Measurements
- Stream Visual Assessment Protocol Focus on glossary (page 33) and general knowledge of what to look for in a visual assessment (pages 13-24)
- Streamwalk Activity

Objective 12: Be familiar with major methods and laws used to protect water quality (surface and ground water) and utilize this information to make management decisions to improve the quality of water in a given situation.

The Clean Water Act of 1972 is the Federal legislation that guides all local legislation. Be sure to focus your analysis on ways to apply the rules and regulations in management decisions. For example, if you were a member of a planning commission for a municipality what would you need to consider before approving or denying development plans?

As authorized by the Clean Water Act, the **National Pollutant Discharge Elimination System (NPDES) permit program** controls water pollution by regulating point sources that discharge pollutants into waters of the United States. Point sources are discrete conveyances such as pipes or man-made ditches. Individual homes that are connected to a municipal system, use a septic system, or do not have a surface discharge do not need an NPDES permit; however, industrial, municipal, and other facilities must obtain permits if their discharges go directly to surface waters. In Alabam, the NPDES permit program is administered by ADEM.

IMPAIRED WATERS: A GOVERNMENT PERSPECTIVE
The Alabama Department of Environmental Protection (ADEM) classifies all of Alabama's waters into one of eight designated use categories (water use classification). Each category has specific water quality standards that are established by the Environmental Protection Agency (EPA), and are used to guide management decisions.
The water use classifications are:
1-Outstanding National Resource Water
2-Outstanding Alabama Water
3-Public Water Supply
4-Swimming and other Whole Body Water Contact Sports
5-Shellfish Harvesting
6-Fish and Wildlife
7-Limited Warm Water Fishery
8-Agricultural and Industrial Water Supply

Section 303(d) of the federal Clean Water Act requires states to identify waterbodies that do not meet the water quality standards assigned to their designated use category. This group of waterbodies comprises the "**303(d) list of impaired waterbodies**". This list provides a framework for ADEM to manage water resources. Knowing the location of impaired waterbodies in your area is an important consideration when selecting a monitoring site. The EPA requires "**total maximum daily loads**" or **TMDLs** to be developed by state regulatory agencies for waterbodies on the 303(d) list. A TMDL is the maximum quantity of a particular pollutant (from point and nonpoint sources) that can enter a waterbody without adversely affecting the designated use of the waterbody. The ADEM Water Division is responsible for keeping up-to-date water quality information for the public. The Alabama 303(d) list, use classifications, TMDL program information, and more can be found on the Water Quality section ofthe ADEM Water Division website at:
www.adem.state.al.us/WaterDivision/WaterDivisionPP.htm

The Safe Drinking Water Act Amendments of 1996 - Requires each public water system to develop a source water assessment system to:

1) Delineate the boundaries of the areas providing source waters for the public systems,
2) Identify (to the extent practicable) the origins of the regulated and certain unregulated contaminants (this will include nonpoint source pollution sources), in the delineated area to determine the susceptibility of the public water system to such contaminants, and
3) Make the results of the source water assessments available to the public.

What does the AL Groundwater Program Regulate?
The Groundwater Program directly regulates underground storage tanks and deep well injection but relies on other environmental laws/programs to protect groundwater.

Other Environmental Programs Protecting Groundwater:

- Solid and Hazardous Waste regulations for landfills are written to protect groundwater.
- Regulations for above ground tanks for petroleum products and hazardous waste storage are written to protect groundwater.
- NPDES permits for certain industrial sources seeks to minimize source of pollution exposed to the environment protecting groundwater and surface water.
- The nonpoint source program educates the public about nonpoint pollution and provides grants for demonstration projects protecting ground and surface water.
- The State Health Department regulates septic tanks to protect groundwater and ultimately surface water (see Appendix for decentralized systems).

Resources:
Clean Water Act – Summary of the Law
Regulating Nonpoint Source Pollution
AL Regulations and Laws
Groundwater Protection in the Southeast