2022 Louisiana Envirothon

Aquatics Study Guide

Louisiana Department of Environmental Quality
Office of Environmental Assessment
Water Planning and Assessment Division

Aquatic Ecology

This study guide is adapted in part from the National Conservation Foundation-Envirothon Website

(https://envirothon.org/)

Students will study marine and freshwater ecology, learn how to assess the quality of delicate aquatic ecosystems, identify aquatic organisms, manage watersheds, mitigate the effects of non-point source pollution and more.

1. Protect Water
2. Water Cycle
3. Local Environmental Issues and Water
4. Provide an informed opinion about current issues in water quality and water resources.
5. Think critically about solutions to current water quality and water resource issues.
6. Work collaboratively in a team to synthesize and apply knowledge.
7. Make connections between the concepts in Aquatic Ecology and the subjects of Soils and Land Use, Forestry, Wildlife, and the Current Issue.

Overview of Aquatic Ecology Learning Objectives for the NCF-Envirothon

From vast oceans and tiny streams to irrigation systems and kitchen sinks, water touches every aspect of our lives. This essential compound makes life on Earth possible, and to continue to sustain this life, we must protect our water resources. Aquatic ecosystems are diverse, as are the creatures that inhabit them. All water on Earth, whether it is flowing in a river or deep underground in an aquifer, is connected through the water cycle. As a result, human impacts on our water resources can have far reaching effects, and careful consideration must be taken when making management decisions.

Just like the ecosystems we study, human society and culture are incredibly diverse. In the same way that biodiversity makes ecosystems more resilient, these differences in human perspective and experience make us stronger as a global community. Every person's story and relationship with the environment is important, and we must work together to ensure that everyone's stories are heard, including the historically marginalized and economically disadvantaged. We invite you to seek out stories from your own communities – to discover the unsung conservation heroes, to learn the histories that aren't typically taught in classrooms, to highlight local environmental issues, and to explore what types of natural resource conservation are occurring in your local community, state/province, and nation.

Students should be able to:

- Provide an informed opinion about current issues in water quality and water resources.
- Think critically about solutions to current water quality and water resource issues.
- Work collaboratively in a team to synthesize and apply knowledge.
- Make connections between the concepts in Aquatic Ecology and the subjects of Soils and Land Use, Forestry, Wildlife, and the Current Issue. Students will be able to:

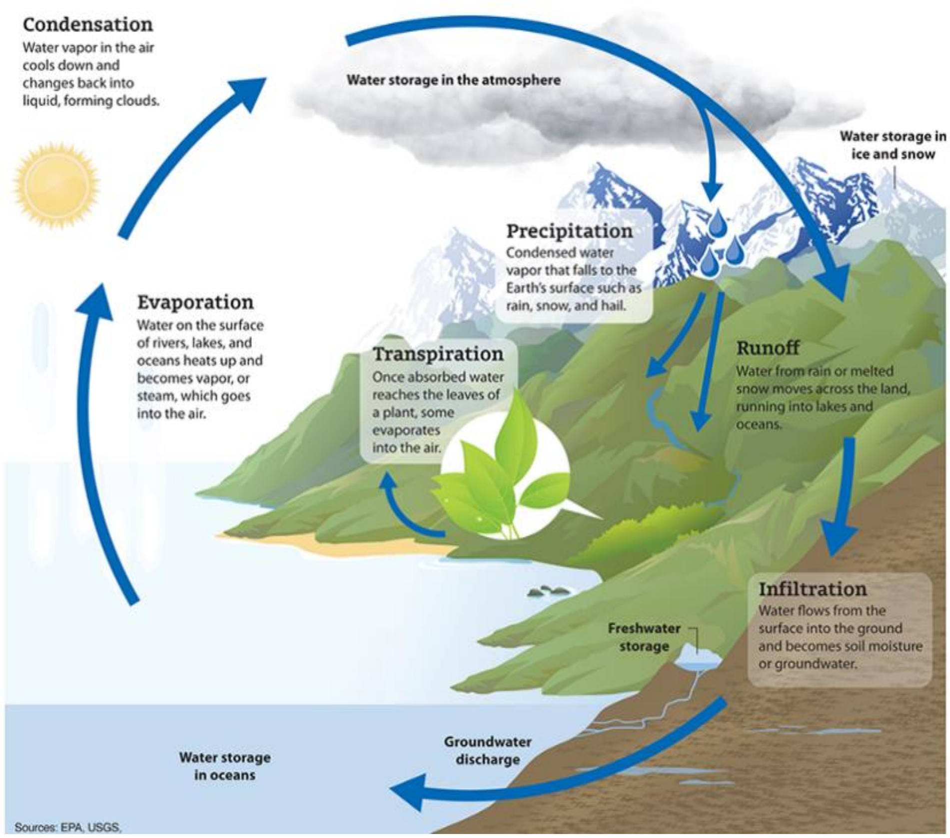
Hydrosphere:

1. **Describe the physical and chemical properties of water that affect aquatic ecosystems and how they do so.**

   Water exists in three different forms or states in the world, sometimes all at the same time, depending on the temperature around you. Each of these states affect the way water interacts with aquatic ecosystems. Water can be either a liquid, a gas, or a solid. In its liquid state water is essential to life all around us. In its gaseous state, water vapor, water is able to move from the surface of the earth to the atmosphere around us forming clouds and humidity. In its solid state of ice, water can be stored for centuries or even millennia in glaciers. On a smaller scale, ice acts to break apart even the hardest rocks, slowly breaking them down into the mineral substance of soil; which is essential to plant life.

2. **Diagram the water cycle and describe each component in detail.**

   Water is constantly moving from one form to another. Starting with clouds in the sky, water falls as rain or snow to gradually accumulate in small streams, bayous, and creeks. Some of the water may accumulate in lakes, then continue to flow downstream in still more waterways. These waterways eventually merge to form larger rivers like the Mississippi, Sabine, Ouachita, Red and Pearl rivers in Louisiana. Eventually most, but not all, rivers reach the ocean where the water evaporates and returns to the atmosphere to form new clouds. Water can also evaporate anywhere along the way, returning to the atmosphere before falling again as rain or snow.



https://pmm.nasa.gov/education/videos/water-cycle-animation

http://www.jcscience.ie/es-5.html

3. **Identify the global distribution of water (saltwater, freshwater, ice, et cetera).**

   About 71 % of the earth's surface is covered with water. There is an estimated 332 million cubic miles of water on earth. But of that huge amount, some 97% is unfit to drink because it is too salty. This salty water can be desalinated, but the process is expensive and only currently used in extremely arid (and wealthy) regions of the world.

   Of this remaining water, about 80% is frozen at the poles and not readily available for consumption. Out of the remaining portion, about 99.5% is too far underground to be of use, is trapped in soil, or is too polluted to be drinkable. Another way to look at it is that only 0.003% of all the water in the world is potable (drinkable) water.

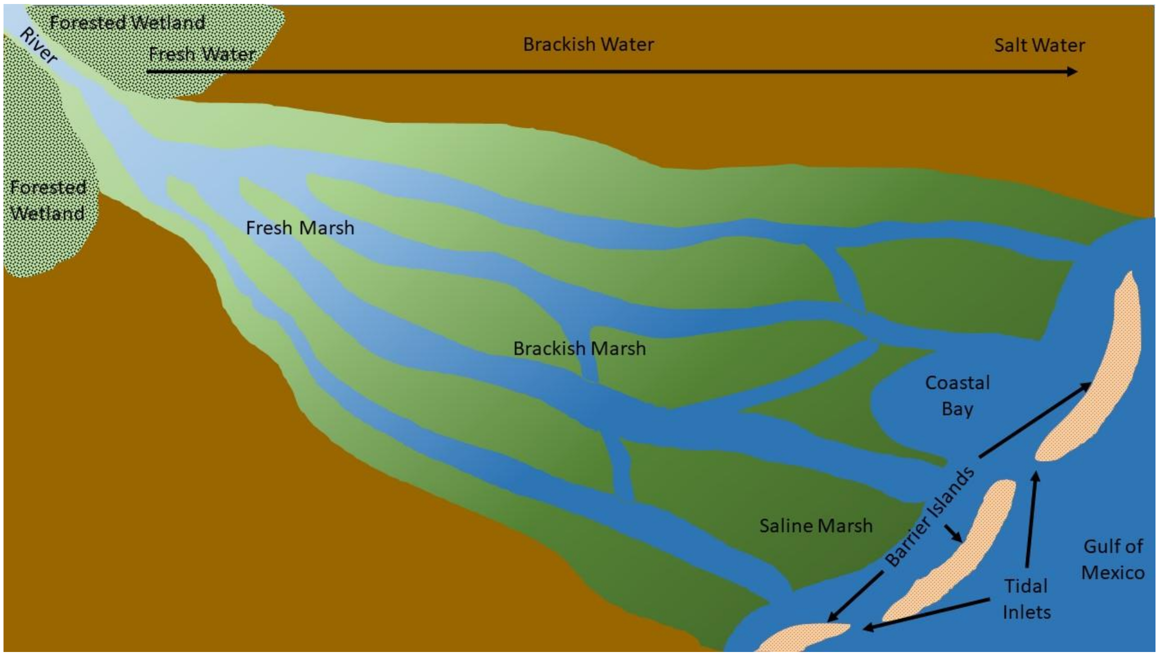
4. **Describe the major differences between freshwater and saltwater ecosystems.**

   Freshwater systems generally have water that is less than 2 parts per thousand salinity. That's about 0.2% salt minerals in 99.8% water. In contrast, saltwater ecosystems have water that is over 16 parts per thousand or about 1.6% salt minerals in 98.4% water. That may seem like a very small difference but it means a lot to the plants and animals that live in the water. Most animals cannot drink saltwater without getting sick and possibly dying. While most saltwater fishes cannot live in freshwater for very long, if at all.

5. **Identify the characteristics of estuaries and explain the importance of brackish water systems.**

   In between freshwater and saltwater systems is an area known as brackish systems. These are often found in what are known as estuaries or estuarine systems. Estuaries are areas where freshwater from the land mixes with saltwater from the ocean. They create an area with a vast mixture of plants and animals adapted to the gradations from fresh to saline marshes, with different plants and animals occupying different salinity ranges or niches. Salinity in brackish systems ranges from about 2 parts per thousand to about 10 parts per thousand.

   - Typical freshwater marsh vegetation includes: cattail (*Typha angustifolia*), bulltongue (*Sagittaria* spp.), maiden cane (*Panicum hemitomon*), water hyacinth (*Eichhornia crassipes*), pickerelweed (*Pontederia cordata*), alligator weed (*Alternanthera philoxeroides*), and pennywort (*Hydrocotyle* spp.).
   - Brackish marshes have: bulltongue (*Sagittaria* spp.), wild millet (*Echinochloa walteri*), bullwhip (*Scirpus californicus*), sawgrass (*Cladium jamaicense*), wiregrass *(Spartina patens)*, three-cornered grass *(Scirpus olneyi)*, and widgeongrass *(Ruppia maritima)*.
   - At the upper end of an estuaries salinity gradient, salt or saline marshes have: oystergrass (*Spartina alterniflora*), glasswort (*Salicomia* spp.), black rush (*Juncus roemerianus*), saltwort (*Batis maritima*), black mangrove (*Avicennia germinans*), and saltgrass (*Distichlis spicata*).



6. **Identify different types of water bodies, how they are formed, and where they are found.**

   Water bodies come in a variety of forms, most of which you are probably familiar with. These include the small creeks, streams, and bayous; lakes and reservoirs; rivers; and finally oceans, which can include things like bays, inlets, seas, and gulfs. Wetlands, which were discussed above, are pretty much what they sound like, lands that are wet at least part of the time. Scientists help identify wetlands even when they are dry based on soil characteristics and the type of plants growing in the area.

7. **Differentiate the types of wetlands, describe their characteristics, and identify common species found in each.**

   Not all wetlands are the same. In addition to the fresh, brackish and saline marshes discussed above there are two main types of wetland: forested wetlands and marsh wetlands. Forested wetlands are what they sound like, wetlands with trees like cypress, tupelo, buttonbush and willow growing in them. Louisiana and other states also have a few areas known as oligotrophic seasonally flooded pine forests. These are areas that are generally dry but may be inundated with water from time to time. Oligotrophic means there are few nutrients in the soil or water.

   Vernal pools are a small but important form of wetland that only hold water for short periods of time. But in that short period many animals like frogs, toads, salamanders, and insects can rapidly locate the pool, breed, hatch, and grow into adults before once again dispersing into the surrounding areas when the pool dries up.

<u>Aquatic Ecosystems:</u>

8. **Identify the biotic and abiotic components of aquatic ecosystems.**

   The biotic component of an aquatic ecosystem includes the various living organism, "bio" meaning "living or life." This includes all of the fishes, aquatic mammals, amphibians, and reptiles, macroinvertebrates (mostly insects but many other things), microorganisms, algae, larger plants, and the detritus (dead stuff) remaining after these organisms die. The biotic components form dense food webs that start with the abiotic components such as water chemistry, nutrients, and especially sunlight, which allows the plants, algae and microorganisms to grow. These in turn feed the higher level biotic components of the overall aquatic ecosystem.

9. Describe the structure of an aquatic ecosystem, including:

a. Species and communities

A simple example of an aquatic community ecosystem starts with the sun allowing photosynthesis in plants. The plants in an aquatic ecosystem may be either terrestrial (grow on land) or aquatic (grow in the water). Leaves, branches or twigs from terrestrial plants frequently fall into the water or are washed in when it rains. Aquatic plants are of course growing directly in the water. All of this plant material is then either eaten directly by aquatic macroinvertebrates (mostly insect larvae-"baby bugs" and crayfish), or are decayed by bacteria and fungi. The macroinvertebrates, bacteria, and fungi are in turn eaten by small fish like minnows and shiners or by amphibians like frogs, toads, and salamanders. This level of animals is then eaten by larger fish, amphibians, and reptiles or even by terrestrials animals like otters, muskrats, egrets, and herons. Eventually the larger animals are eaten by still larger ones like alligators and humans. Along the way there is usually not a clear chain from one animal to the next. Instead, some large animals may eat something small, or a small animal may eat the remains of a larger animal that has died. Eventually, everything dies and decays, renewing the nutrients in the water and sediment where they are picked up by plants to start the cycle again. There are many combinations of species and communities, depending on the water body type, salinity, and oxygen levels in the water. Species interactions in any kind of aquatic or terrestrial ecosystem is one of the things that makes biology, the study of life, so fascinating to scientists of all kinds.

b. Abiotic components

Abiotic components include the basic water chemistry factors such as: dissolved oxygen, nutrients, (especially nitrogen and phosphorus), sediment or turbidity in the water, temperature, pH, metals, minerals (such as chlorides, sulfates, total dissolved solids, and many others), and sunlight reaching the water.

Dissolved Oxygen

Oxygen enters water from the atmosphere and is released by plants that grow in the water. Fish and other organisms that live in water need dissolved oxygen to survive and reproduce. If dissolved oxygen levels drop to very low levels, aquatic organisms become unable to reproduce and can die. Dissolved oxygen levels normally range between 3 and 12 mg/L or parts per million (PPM) (same measurement, different ways of saying it). The typical criterion or standard for dissolved oxygen in Louisiana is 5 mg/L; however, in many cases the standards have been reduced to 2 – 3 mg/L due to natural conditions.

Some of the factors that affect the amount of dissolved oxygen in water include:

- Temperature (warmer water contains less oxygen)
- Velocity (rapidly flowing water absorbs more oxygen)
- Turbulence (higher turbulence = higher oxygen content)
- Plants in the water (photosynthesis releases oxygen)
- Decaying materials in the water (decomposition of dead algae, leaf matter, and wastes uses up oxygen)

- Shading of a stream (affects temperature and photosynthesis, thus oxygen level)
- Depth (deeper water = lower oxygen content)

Nutrients

The nutrients commonly found in water are nitrogen and phosphorus. These are the same nutrients found in plant fertilizers, and algae and aquatic plants also utilize these nutrients. High nutrient concentrations in surface waters can cause excessive algae and grass production, which in turn can cause unwanted conditions in a water body. Excessive algal growth produces the pea soup color in lakes and ponds. In addition, when these algae die and begin decomposing in the water, a sudden decrease in dissolved oxygen levels can occur, causing fish kills.

The sources of nitrogen in water include the air, sewage, animal wastes, artificial fertilizers, and plant and animal matter. Sources of phosphorous are sewage, animal wastes, artificial fertilizers, and soil that washes into the water. The concentration of inorganic nitrogen in relatively unpolluted streams in Louisiana ranges from 0.03 to 0.18 parts per million, and in polluted streams it can be as high as 0.50 parts per million. The concentration of phosphorous in unpolluted Louisiana streams ranges from .05 to .10 parts per million, and in polluted streams phosphorus can be as high as 1.0 part per million. Louisiana has not yet established numerical water quality standards for nutrients.

Sediment or Turbidity

Turbidity refers to the cloudiness of water and is a measure of the amount of light that penetrates the sample of water. The cloudier the water, the more substances there are suspended in the water. High turbidity can inhibit photosynthesis in aquatic plants and makes the water look dirty. In addition, high amounts of suspended particles in water can be harmful to fish and other aquatic organisms. Turbidity is often made up of sand, silt and clay but can also be caused by fine plant detritus.

In Louisiana water, turbidity varies widely. In the least turbid streams and in lakes turbidity ranges from below 10 Nephelometric turbidity units (NTU) to 25 NTU. In the Mississippi River, the average turbidity is near 50 NTU but can go much higher. The criterion for turbidity in scenic streams and lakes of Louisiana is 25 NTU, while the criterion for the Mississippi and Atchafalaya Rivers is 150 NTU.

Temperature

All aquatic organisms require certain temperatures for health and reproduction. If the temperature of the water falls below or rises above the ideal range, organisms may become stressed and unable to reproduce. In very warm temperatures, fish may become more vulnerable to disease and other pollutants. In addition, other aquatic organisms upon which they feed may become less plentiful during extreme temperature changes.

In Louisiana waters, temperature ranges between 32 degrees Fahrenheit in the winter and 90 degrees Fahrenheit in the summer. The maximum temperature allowed by Louisiana water quality standards is between 86 and 95 degrees Fahrenheit.

pH

pH is an indicator of whether water or a solution is acidic or basic. pH is a measure of hydrogen ion activity in water, and can range from 0 to 14, with normal measurements ranging from 6 to 9 standard units. A pH below 7 is acidic, and a pH above 7 is basic.

As with temperature and dissolved oxygen, aquatic organisms have specific requirements with regard to pH. pH can play a role in determining the size and makeup of the aquatic community. In general, low pH waters have fewer species and smaller populations of aquatic organisms. pH also affects other chemical processes that occur in water. For instance, in low pH waters, metals become toxic to aquatic organisms. Although not common in Louisiana, coal and other mines can cause acid mine drainage. In Louisiana the criteria or standard for pH typically ranges from 6.0 – 8.5.

Metals

Metals commonly measured in water include arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc. These metals are natural elements of the earth, but they also enter surface waters from anthropogenic (human-caused) activities. In elevated concentrations, these metals can be harmful to fish and other aquatic organisms. These metals can also accumulate in fish in polluted waters and cause health problems in humans that eat those fish.

c. Symbiotic relationships

Symbiotic relationships occur when two or more organisms live together to benefit one or both organisms. Frequently such relationships have evolved to be very specific between two species, with each organism requiring the services the other provides. There are different types of symbiosis including mutualism, commensalism, and parasitism. The relationship can be beneficial or harmful depending on the species involved. Mutualism is a relationship in which both species benefit from the other and usually involve species with very different needs and living requirements. Commensalism is a relationship in which one species benefits from the other but doesn't harm or benefit its partner organism. Parasitism is a relationship in which one species harms or even kills the other.

https://prezi.com/t3aalze-zw40/pond-ecosystem/

d. Carrying capacities

Carrying capacity is simply the number of animals or plants a particular area can accommodate. If there is plenty of space, nutrients, and suitable habitat, then more animals or plants can survive. But if one or more of these requirements is missing, then the carrying capacity is reduced. Under natural conditions this interaction of many factors helps to keep ecosystems running smoothly. But if a system experiences excessive or harmful anthropogenic impacts then carrying capacity can be unnaturally reduced.

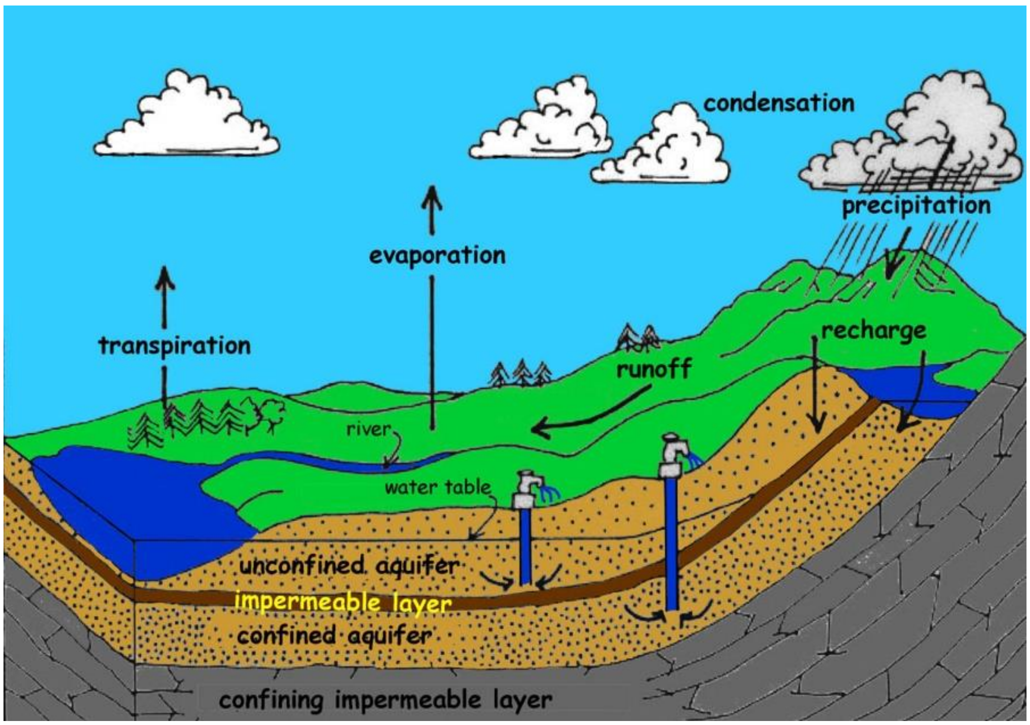
e. Productivity

Productivity is similar to carrying capacity in that is measures how well or how fast organisms can grow in an ecosystem. High productivity means a lot of plants or animals are able to grow in an area. Low productivity means conditions are not ideal for them and few new growth can occur. As with carrying capacity, nature seeks to find a balance between too much and too little productivity.

10. Define an aquifer and elaborate on how aquifers relate to the local and global water supply.

Aquifers are areas beneath the surface of the earth that receive and hold water within the rocks and sands making up the strata, or layers, below us. Aquifers can be either unconfined or confined. Unconfined aquifers tend to be near the surface of the land and do not have confining rock or clay. They can be easily contaminated by surface water runoff or by shallow wells.

Confined aquifers are located between water resistant rock or clay that prevents water from moving into or out of the layer. So then how does the water get into a confined aquifer? Water generally enters confined aquifers at higher elevations, either through direct connections with lakes and rivers or by seeping into the ground between the confining rock or clay. Unconfined aquifers may form or contribute to lakes and rivers where they reach the surface. Artesian wells from confined aquifers can occur at the surface where the land around the well is at a lower elevation than the land where water first entered the aquifer. The higher pressure underground pushes the water up to the surface.



http://coastgis.marsci.uga.edu/summit/k12-groundwater.htm

Aquifers are vital to much of the world's water supply for agriculture, drinking water, industry, and the natural environment. When aquifers are over-pumped, as occurs in many places in Louisiana, the U.S., and around the world, the land surface may subside or collapse altogether, natural systems may be altered by a lack of water, humans may not have enough water to drink, and farmers may not have enough water to grow their crops and animals. Likewise, contamination of aquifers can also have serious consequences to all of these uses of the water. Once an aquifer is contaminated it can be very difficult, if not impossible, to remediate (clean) it sufficiently for normal uses.

11. **Identify the role of the water table in an ecosystem and how water tables affect human activity and water use.**

    Water tables are the boundaries between the soil surface and the area that is saturated with groundwater. They occur when the surface of an unconfined aquifer is close to the surface of the land. When the water table is below the surface it can be reached by relatively shallow wells for use as drinking water or for agriculture; however, there is a drawback. Such shallow water can be easily contaminated from the surface making the water in the water table unfit for normal use. The water table can also come all the way to the surface of the land as springs which feed streams and rivers or as entire lakes. As with deeper aquifers, over pumping of shallow water tables can lead to loss of a valuable water resource or contamination making it unfit for use. Thinks like poorly capped water or oil and gas wells, leaking underground storage tanks, and poorly contained landfills can lead to contamination of shallow water tables.

12. **Explain how seasonal changes in temperature, water level, flow rate, nutrient sources, nutrient availability, runoff, and inputs occur in aquatic ecosystems.**

    Ideally, aquatic ecosystems are well balanced, meaning the amount of water flow, sunlight, temperature, abiotic components, sediments, nutrients, and aquatic organisms are all sufficient to keep the water, plants, and animals in a health condition. But if one or more parts of the system are changed, either naturally or by humans, the system can get out of balance. Natural seasonal changes will occur as a cold stream or pond begins to warm up and more sunlight is available in the spring. The warming and increased light causes plants to grow more rapidly. This in turn provides more nutrients (food) for the base of the ecosystems food web. At the same time, increased rainfall in the spring can lead to increased surface runoff from surrounding fields and forests. This can lead to increased plant detritus and sediment entering the system. Up to a point this is a good thing, bringing valuable nutrients and sediment to the system. But too much of a good thing can quickly turn bad. Excess nutrients can lead to excess plant and algae growth causing rapid eutrophication of the system. Excess sediments can block sunlight thus reducing plant growth, smother and kill fish and amphibian eggs in the water, or clog up spaces between the rocks on the bottom that fish, amphibians, and aquatic insects use to lay their eggs. As fall and winter come along, the water cools and less sunlight is available. The metabolism of the plants and animals slows down, breeding slows or stops, and the overall system enters a quiet phase with reduced activity.

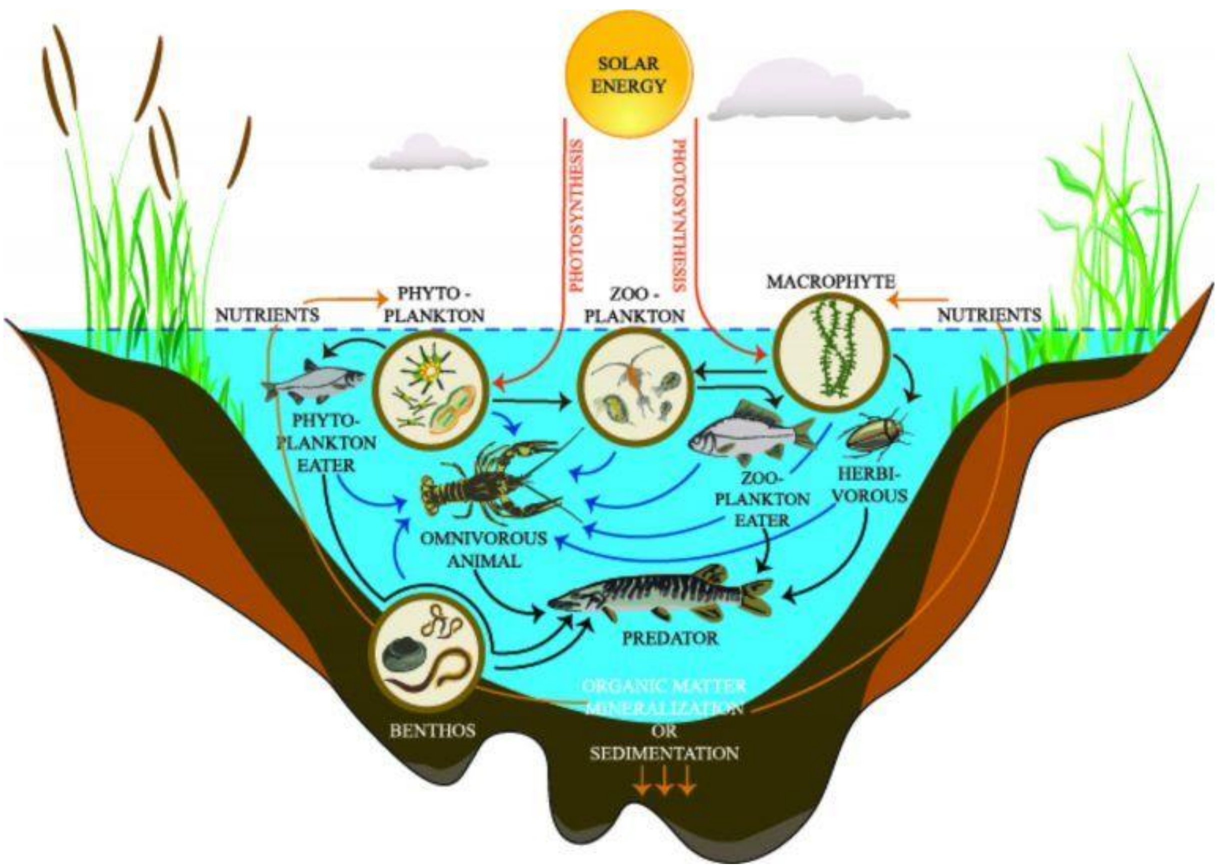
    Any inputs to the aquatic ecosystem, either natural or anthropogenic, changes the conditions in the water and thus changes the balance of the ecosystem. If such changes are not too significant, like normal seasonal changes, then the overall ecosystem continues with minor, manageable fluctuations. However, if the change is significant like global warming, which increases water temperatures and can cause too much or too little rain, then aquatic ecosystems can be quickly overwhelmed and cease to function normally. Likewise, anthropogenic impacts like cutting trees along a stream bank, farming to the edge of a stream, sediment runoff from farms and construction sites, excess nutrients from agriculture or lawns, and outright dumping of hazardous materials can all cause long-term if not permanent changes to aquatic ecosystems.

13. **Describe the natural aging process of lakes and ponds.**

    All lakes and ponds go through a natural aging process known as eutrophication. Even in a natural system with no anthropogenic inputs a lake will slowly fill with sediment from the surrounding land as well as with plant detritus from the lake itself or from the land. As the lake gradually fills in there will be less room for fish and other organisms that live in it. More importantly, the temperature will usually increase over time, causing reductions in the amount of dissolved oxygen the water can hold. This in turn makes it harder for fish and other animals that get their oxygen from the water to survive. Excess nutrients in the water from decaying plants may cause yet more plant growth, further choking the system and increasing the amount of detritus filling the lake. Over time what was once a relatively deep lake or pond will gradually change to a swampy areas with wetland plants and eventually trees. As the former lake continues to fill in, the land surface gradually rises until more terrestrial (land living) plants and trees take over. This process can be seen in the many oxbow lakes around Louisiana. Lake Providence, Lake St. Joseph, Raccourci Lake, Marengo Bend, False River and many others along the Mississippi River are just a few examples.

14. Diagram an aquatic food web and describe the flow of energy within it.

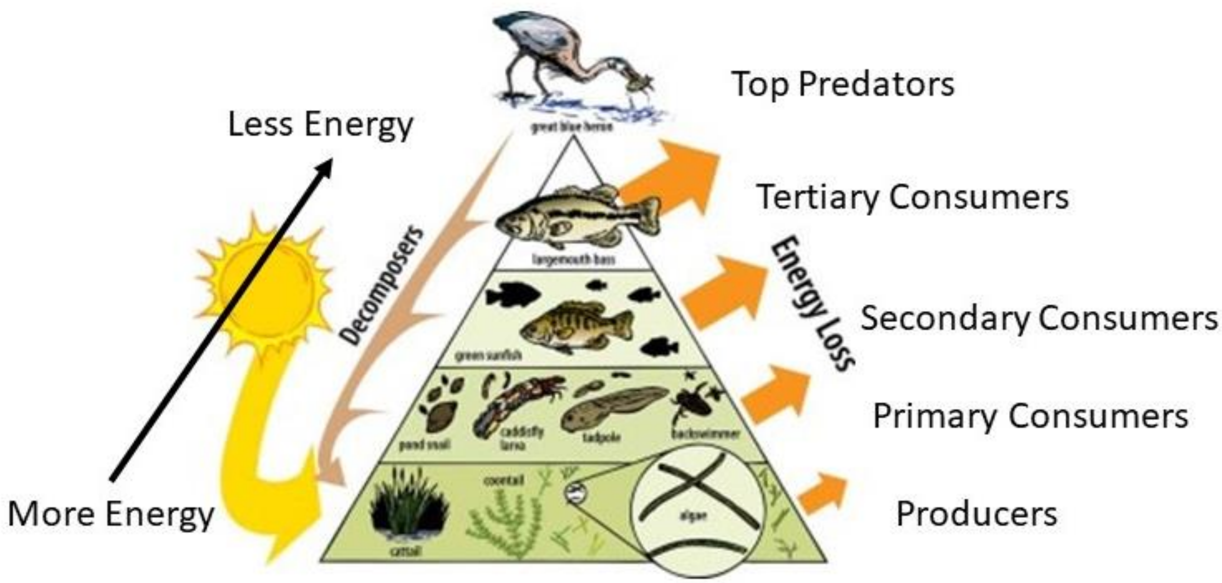
The following diagram shows a simplified food web for a small pond. As with all food webs, energy comes from the sun and starts with photosynthesis of plants and algae in or near the water. This is point with the highest energy level in the system. As animals eat or are eaten by other things the energy level declines with each increase in the trophic level from primary producers (plants), to primary consumers (small animals), to secondary consumers (larger animals) and so on. Eventually, nothing is left but the decaying detritus of formerly living things, which is deposited in the bottom of the pond or washed downstream. Of course, since the system is not closed, energy is constantly fed into the pond by the sun, so the overall energy level of the system remains more or less the same.



https://www.biologyonline.com/dictionary/biotic-factor

15. Relate the energy pyramid to different trophic levels and the total amount of energy available to consumers.

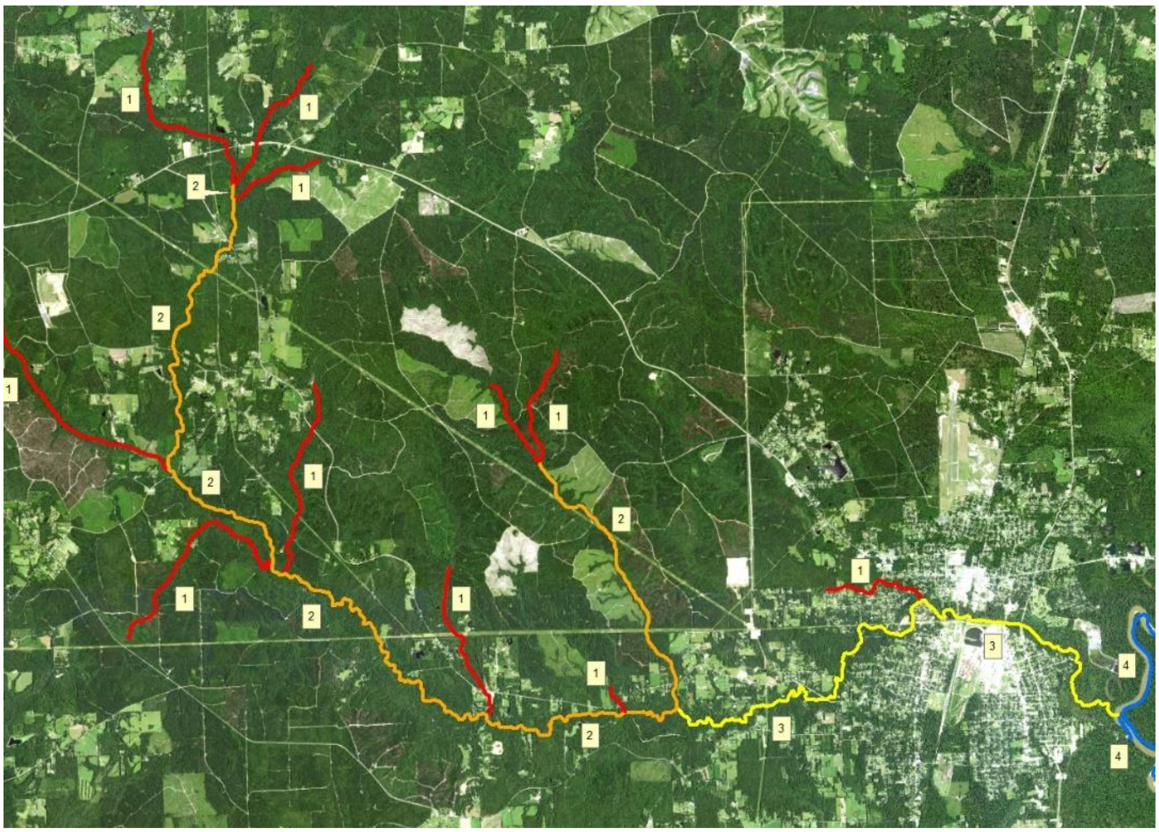
As discussed with the food web above, the amount of available energy in the energy pyramid is greatest at the base where energy is provided by the sun, and decreases up each level of the pyramid. This is because a lot of the original energy from the sun is lost as body heat, motion of the animal, reproduction, and eventually death and decay. That last one, death and decay, does return some of the original energy back to the lower levels of the pyramid as food energy provided to whatever level of organism consumes it.



https://texasaquaticscience.org/habitats-aquatic-science-texas/

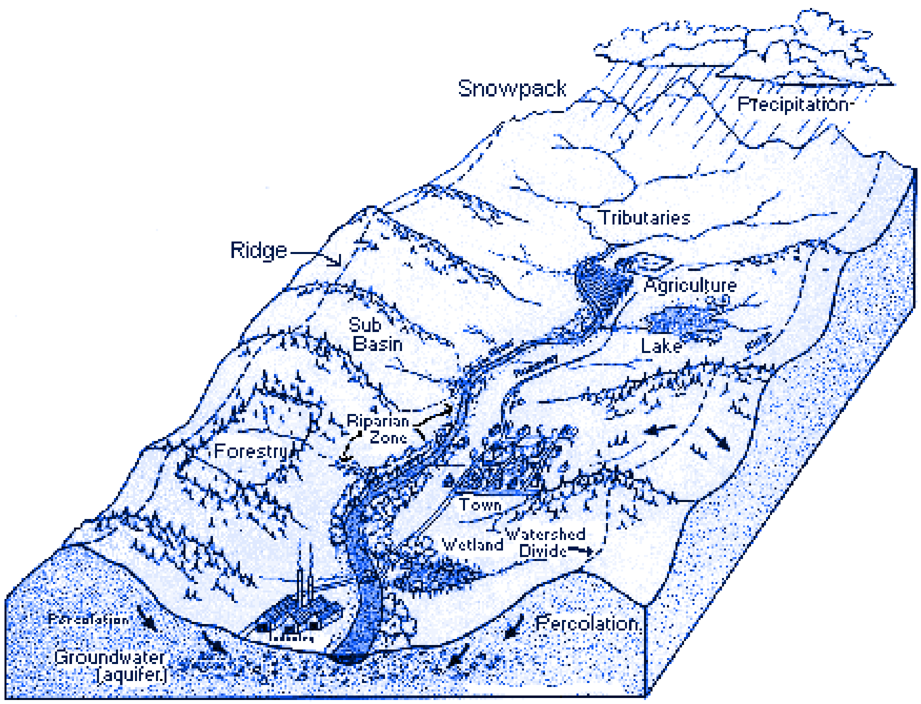
16. Determine the order of a stream and describe what the order indicates.

Stream order is the ranking of a watersheds tributary streams from its most upstream *perennial* tributary to its farthest downstream reach within the area of interest. A reach is simply a section of a stream and can be however long you want to consider it. There are different types of stream order. The map below shows the most common method, the Strahler stream ordering system. In this system, two *same order* streams combine to create a higher order stream. For example, a 1st order stream and another 1st order stream results in a 2nd order stream reach. Combining *different reach orders* keeps the higher order. So 1st order plus 2nd order keeps the 2nd order ranking for the downstream reach. Combining two 2nd order reaches increases the downstream order to a 3rd order reach. The following simplified example is for Bogue Lusa Creek where it flows into Pearl River. In reality, there are many more small 1st order streams upstream from those shown below in red.



17. Describe the importance, functions, and characteristics of watersheds/catchment areas.

A watershed or catchment area is the area of land in which all water flows to the same point. A watershed can be as small as the area around your neighborhood that flows into a single stream or as large as the Mississippi River watershed, which comprises about 40% of the lower 48 states of the United States. It covers parts of 32 states and two Canadian provinces.



Produced by Lane Council of Governments

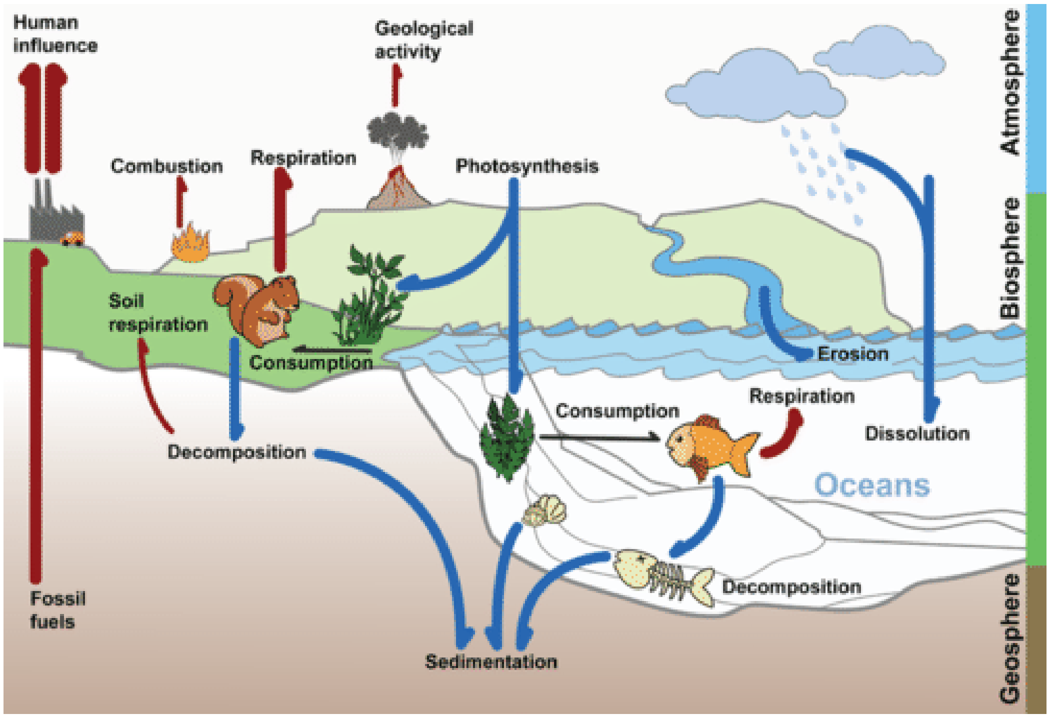
https://www.erosionpollution.com/watershed-protection.html

Watersheds are defined by the highest points of land, the ridge in the diagram above, surrounding a stream or lake. Water falling on one side of the ridge flows into the watershed's stream. Water falling on the other side flows into a different watershed. The Continental Divide along the Rocky Mountains is a major example of one such ridgeline, with water to the east flowing into the Gulf of Mexico and ultimately to the Atlantic, while water to the west flows to the Pacific Ocean.

18. Explain the role of aquatic ecosystems in biogeochemical cycles, such as the carbon, nitrogen, and phosphorus cycles.

All things in nature tend to cycle up, down, and around as things grow, die, decay and lead to new life. The same is true for the abiotic, biogeochemical parts of nature like the important elements of carbon, nitrogen and phosphorus. All forms of life contain and depend on all three of these elements, so it's no surprise they also cycle as they move through the environment. Here are examples of the carbon, nitrogen, and phosphorus cycles in aquatic ecosystems.

Carbon Cycle

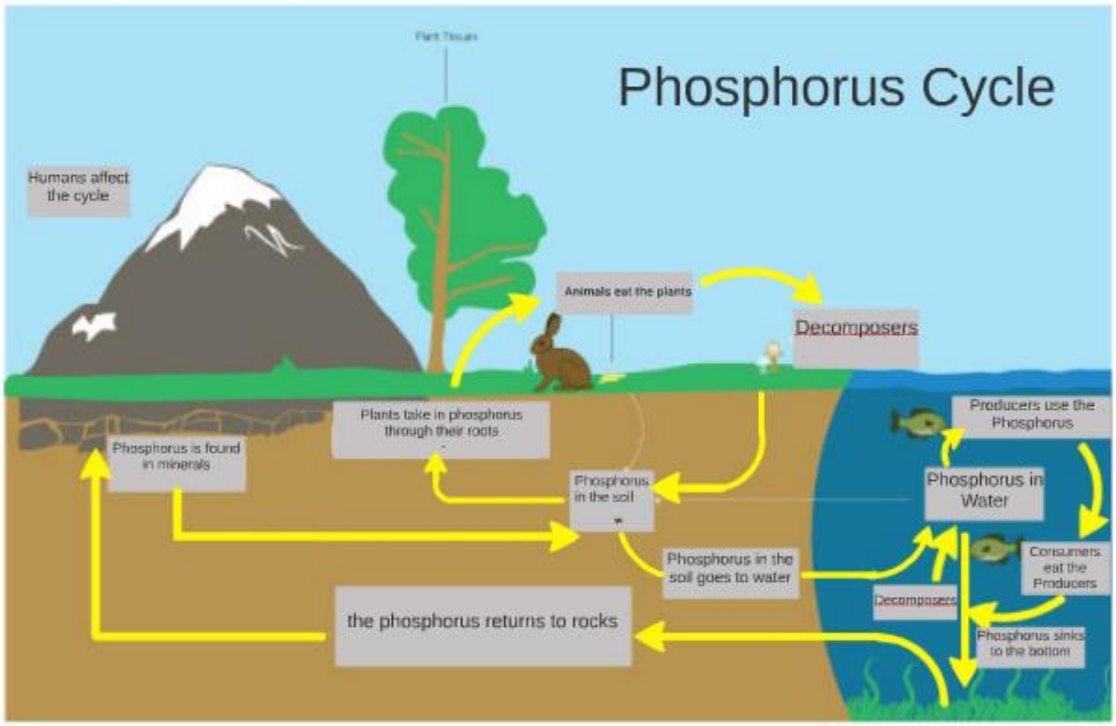


https://www.ck12.org/book/ck-12-biology-advanced-concepts/section/18.9/

Each arrow in the diagram represents movement of carbon through the ecosystem. It includes aquatic, terrestrial, and atmospheric aspects. Coal, natural gas, and oil in the form of fossil fuels actually form a part of the carbon cycle, albeit a part that last millions of years. Carbon dioxide, which is release by the burning of fossil fuels and by the respiration (breathing) of animals is an import link in the cycle and one of the major contributors to global warming.

Phosphorus Cycle

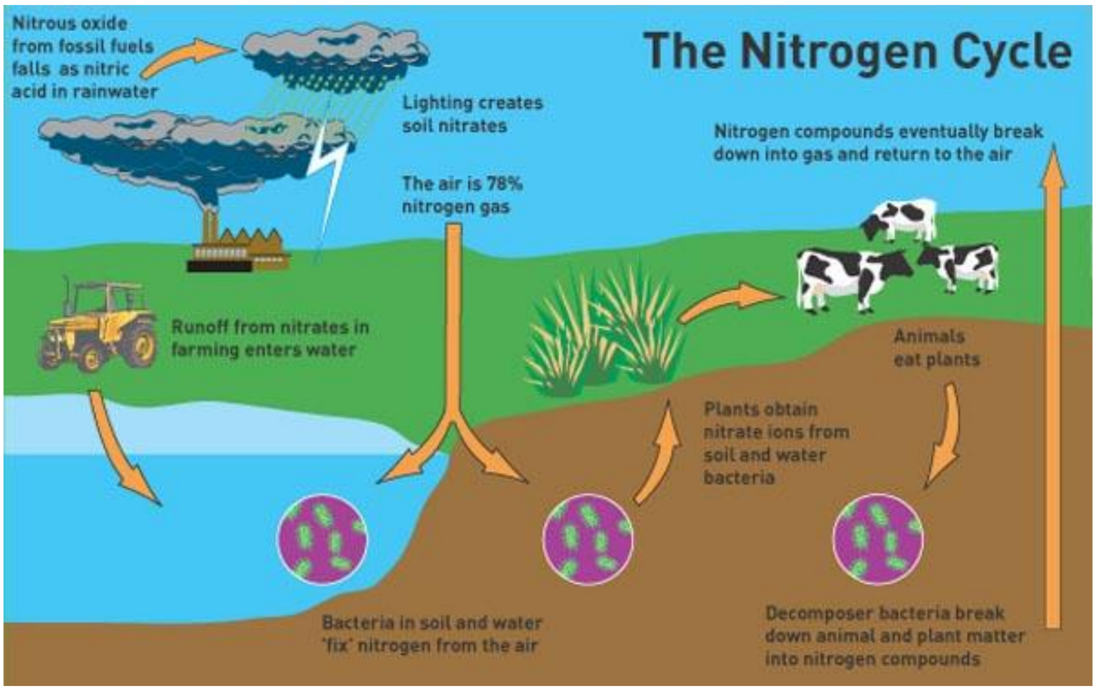
Like the carbon cycle, the phosphorus cycle moves through aquatic, terrestrial, and atmospheric phases. Also like carbon, parts of the phosphorus cycle can last millions of years as the phosphorus contained in plants and animals gets transferred to soil and sediment. It is then trapped in the ground and may be gradually converted into rock that is later uplifted to the surface of the earth and released back into the environment.



https://prezi.com/v9h8ox5fryh_/phosphorus-cycle/

Nitrogen Cycle

Like the carbon and phosphorus cycle, the nitrogen cycle has aquatic, terrestrial and atmospheric components. In the aquatic portion of the following diagram plants and animals in the water act the same as they do on land. Notice that bacteria in soil, water, and plants play an important role in the nitrogen cycle by "fixing" nitrogen from the air or water. This means the nitrogen is taken from the air or water and converted by the bacteria into a form that can be used by plants and animals. Bacteria also break down plant and animal waste, releasing the nitrogen back into the soil, water, and atmosphere.



https://ibiologia.com/nitrogen-cycle/

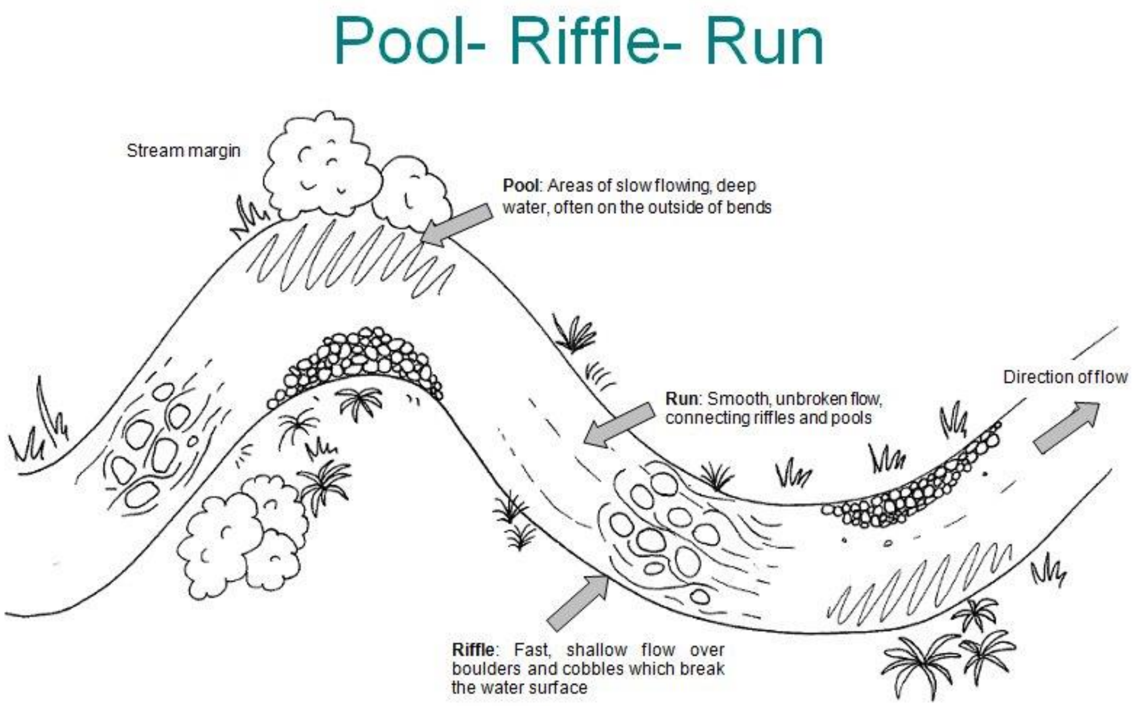
19. Describe the basics of hydrology:

a. Stream/River geomorphology (Catchment area/Drainage basin, Channel, Bank, Meander, Riffle, Water Table, Thalweg, Hyporheic Zone, et cetera):

Stream/river geomorphology, also known as "fluvial" geomorphology, is the study of how rivers and streams move around on and affect the landscape through which they flow. Once water starts to gather into a defined stream within its catchment area or drainage basin (discussed earlier) it starts to take on common characteristics. These characteristics depend on the slope of the ground and how much water is in the stream. The most common stream forms are meanders, riffles, pools, runs or glides, sandbars, and cut-banks.

Meanders are the curved bends streams naturally form as they move across the floodplain. They can be very tight and looping or more spread out depending on the width of the floodplain, the size of the stream and especially on the slope. Sometimes the loops can cut through the neck of the bend leaving behind an oxbow lake. The Mississippi River has many examples of these along its western side in Louisiana.

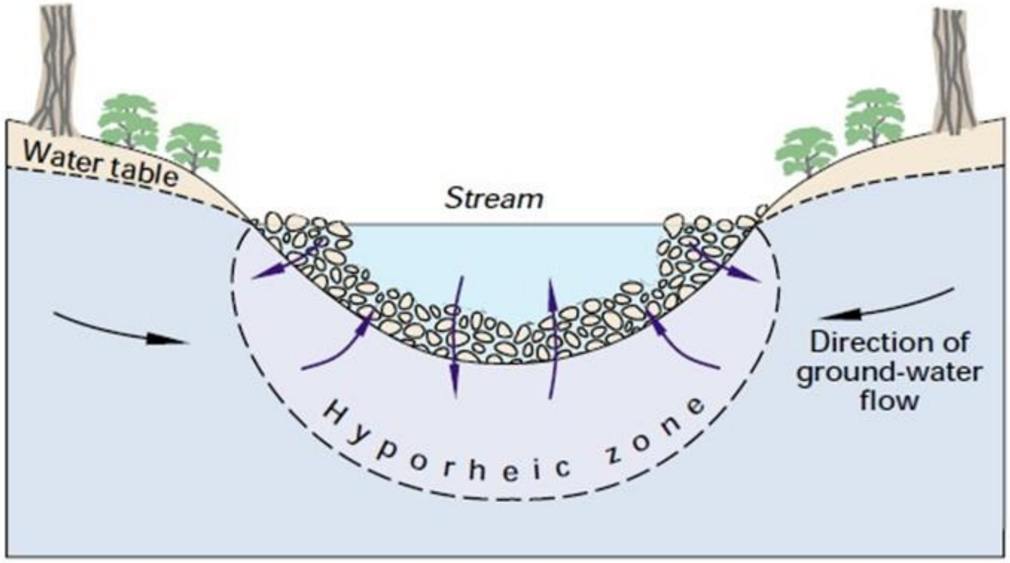
Riffles are areas of gravel and cobbles (larger gravel) where the water is shallower and flows over and through the rock. Pools are deeper water areas, usually on the outside of bends, that form where the water flows faster and cuts into the bank. Fish like to hang out in these pools. Sandbars often form on the inside of bends where the water moves more slowly and sand carried by the water drops out. They are often good places for camping and picnicking if you're canoeing down a stream. Runs are areas between pools and riffles where the water is deeper and flows in a more uniform, unbroken direction. What's known as the "thalweg" of a stream is not shown in the following diagram but it's easy to visualize. It a line more or less in the middle of a stream where the majority of water flows. In runs and riffles it's usually near the middle, but between sandbars and pools or cut-banks it tends to be a little closer to the pool side of the stream.



https://twitter.com/cc_nb/status/987013978134953984

b. Groundwater flow:
Two important characteristics of streams and lakes are groundwater flow and the hyporheic zone. Groundwater flow was also discussed in the section on aquifers. It is simply the underground movement of water through sand and gravel from higher elevations to lower elevations.

c. Interactions between surface water and groundwater:
When the water table reaches a stream or lake the groundwater frequently moves into the open water of the stream or lake through what's known as the hyporheic zone. During times of low rainfall or drought streams often maintain their flow through the influence of groundwater through the hyporheic zone.



https://slideplayer.com/slide/8569315/

d. Impact of landscape factors on water movement:

Things that happen on the landscape often impacts what happens to rivers and streams. This is especially the case with anthropogenic or man-made changes. Things like the development of new residential areas, shopping centers and offices all increase the amount of impervious surfaces. (Impervious simply means water can't run through it.) As a result, less water is able to soak into the ground and aquifers, while more water is routed more quickly toward gullies, and streams. This causes water to rise more quickly and higher in streams, vastly increasing the chance of flooding downstream from any new development. A better way to approach development is to avoid building in known floodplains. Along with that, it's good to plan the development to include pervious pavement, rain gardens, swales, retention ponds, and other features to reduce the amount of flow that eventually finds its way to natural streams.

Another significant anthropogenic impact on the aquatic environment is the channelization of streams. This is often done in an effort to reduce flooding by speeding up water flow. But the result is the destruction of natural stream habitat and an increase in flooding downstream where the water is routed. A better solution is to preserve the natural floodplain and sinuosity (meanders) of the stream by not building in the floodplain in the first place.

e. Stratification in freshwater and saltwater systems:

Saltwater is naturally more dense, or heavier, than freshwater. This is because the saltwater has minerals like sodium chloride, salt, dissolved in it. As a result, in estuaries where freshwater streams merge with saltwater systems like the Gulf of Mexico and the oceans, the freshwater often floats on top of the saltwater for longer or shorter periods of time depending on how turbulent the water is and how different the fresh/salt gradient is. For example, in the Mississippi River, especially when the river is very low, a wedge of saltwater from the Gulf of Mexico can work its way all the way up to New Orleans. This can be a problem in some areas where drinking water intakes may be located near the freshwater/saltwater border.

f. **Discharge and recharge for aquatic systems:**
Groundwater flow can often work the other way, with water from streams and lakes moving into underground aquifers where it can move from high areas like hills and mountains toward low areas like valleys and plains. This was discussed earlier in the section on aquifers. Springs are a good example of where groundwater reaches or discharges to the surface of the land, but springs can also be felt sometimes as cool water coming in from the bottom of warmer streams.

g. **Runoff:**
Rainwater runoff from things like roads, parking lots, farms, pastures, and commercial forests can often contain pollutants like gasoline, oil, metals from cars, nutrients from fertilizers, pesticides and herbicides from lawns and fields, or excess turbidity (mud and silt) from construction sites, forests, and fields. Taken together, this is known as nonpoint source pollution, which is actually the leading cause of water pollution in Louisiana and the nation. Control of nonpoint source pollution is an important thing to consider when trying to protect water quality. For more information on nonpoint source pollution refer to the Louisiana Department of Environmental Qualities Nonpoint Source Pollution Program.

Organisms:

20. Describe the roles of producers, consumers, and decomposers in various aquatic ecosystems and identify their trophic levels.
As seen in the section on food webs and energy webs, aquatic systems consist of three main trophic levels. These are producers, consumers and decomposers. Producers are at the base of the food web because they get their source of energy directly from the sun in the form of photosynthesis. This uses the sun's energy to convert carbon dioxide into carbon for sugars and other components necessary for the growth of the plant. Primary consumers then feed on the plants and microorganisms that also use photosynthesis. These are usually things like other small microorganism but there are a few fish that will directly eat plant material and primary producing microorganisms. Secondary consumers then eat the primary consumers, while tertiary consumers eat the secondary ones. This can continue for several levels up to what are known as top predators or consumers. Humans, along with some birds, reptiles and mammals can all be top consumers. Decomposers do exactly what they sound like. They decompose the dead organisms at all levels. This returns some of the nutrients and energy to lower levels in the food web where it can be recycled back into the system in the form of food for those organisms. See the food web and energy pyramid shown earlier.

21. Categorize different types of aquatic plants based on their adaptations.
Like terrestrial plants, aquatic plants are specially adapted to different areas of a stream or lake. These adaptations are generally based on water depth and how fast the water is flowing. Plants growing in a lake are generally very different from those living in a fast flowing, shallow stream. Marsh plants are often different from both lake and stream plants because they need to survive in areas that are wet part of the time and dry at other times. A list of common wetland plants can be found in Table 1. More information on aquatic plants, what they look like and where they live can be found at the following websites:

http://www.herbarium.lsu.edu/home.html
http://www.rnr.lsu.edu/plantid/listwetland.htm
https://www.wlf.louisiana.gov/species

Table 1: Common wetland plants of Louisiana.

Common Name	Scientific Name	Common Name	Scientific Name
duckweed	*Lemna minor*	cutgrass	*Zizaniopsis miliacea*
pondweed	*Potamogeton pusillus* (also other species)	cattail	*Typha latifolia; T. angustifolia; T. domingensis*
widgeon grass	*Ruppia maritime*	Rouseau cane	*Phragmites communis*
waxmyrtle	*Morella certifera*	duck potato	*Sagittaria platyphylla*
coontail	*Ceratophyllum demersum*	bulltongue	*Sagittaria lancifolia*
lotus	*Nelumbo lutea*	smartweed/knotweed	*Polygonum aviculare*
bulrush/three-square	*Scirpus californicus; S. maritimus; S. olneyi*	millet	*Echinochloa walteri*
panicum	*Panicum dichotomiflorum; P. hemitomom; P. repens; P. virgatum*	wiregrass/marsh grass	*Spartina patens*
palmetto	*Serenoa repens*	mangrove	*Avicennia germinans*
Baccharis	*Baccharis halimifolia*	bald cypress	*Taxodium distichum*
tupelo gum	*Nyssa aquatica*	black willow	*Salix nigra*
milfoil	*Myriophyllum myriophyllum*	red maple	*Acer rubrum*
fragrant flatsedge	*Cyperus odoratus* (also other species)	buttonbush	*Cephalanthus occidentalis*
fanwort	*Cabomba caroliniana*	dwarf spike-rush	*Eleocharus parvula* (also other species)
wild celery	*Vallisneria americana*		

22. Identify the major characteristics of fish, amphibians, and other aquatic animals.

Specific characteristics makes a fish a fish and an amphibian and amphibian. The same goes with all other aquatic animals. Fish of course usually have scales, get oxygen from the water through gills and mostly lay eggs either directly in the water column or on the bottom. Although like much in biology there are exceptions. Catfish have smooth skin and certain species bare live young because the eggs hatch inside the mother; or sometimes the father. Amphibians like salamanders, frogs, and toad don't have scales. The skin is usually smooth and needs to stay moist most of the time. Toads are a major exception in that there skin tends to be bumpy and drier than frogs. The common feature is they all need to return to the water to lay their eggs. Aquatic reptiles like snakes and alligators have scaly skin and lay their eggs on land. Finally aquatic mammals like otters, mink, muskrats and nutria are typical furry mammals that happen to live in and near the water. All aquatic animals are specially adapted to the particular needs required by an aquatic habitat.

23. **Analyze physical and behavioral adaptations to aquatic environments that are common among many types of organisms, such as streamlined body shape, eye placement, countershading, et cetera.**
Animals that live in aquatic environments, especially those that live in the water throughout their lives, have specialized adaptations for that environment. Bodies tend to be streamlined to allow for easy movement through the water. This is easy to see with fishes. Scales are helpful to protect fish from abrasion on rocks, guard against parasites, and to reduce friction in the water. Fish of course have fins for movement and gills for obtaining oxygen from the water. Most fish have a swim bladder, which allows for adjusting its buoyancy and where it stays in the water column. Eye placement for fish tends to be toward the sides to allow them to see potential predators from both sides of their bodies. In addition to ears, fish are able to sense sounds and vibrations in the water around them through a lateral line of sense organs along their sides. Many fish have what's known as countershading. This means that the upper part of their bodies tend to be darker while the lower parts tend to be lighter. In this way they are harder to see from above because the dark coloration blends in better with the bottom. By contrast, they are also harder to see from below because the light coloration blends in with the light coming from above the water.

    Aquatic macroinvertebrates are highly specialized in their body types. Those that live in fast moving streams tend to be more streamlined and designed to cling to rocks along the bottom. By contrast, those that live in still water or that burrow into the sand and mud can be chunkier.

    Aquatic mammals also tend to be streamlined and most importantly have thick, dense fur to protect them from colder water. Each has specialized feeding adaptations depending on its preferred habitat and food preferences.

    There are many more adaptations animals and plants use to live in the water. The following are a few resources to explore further:

    https://sciencing.com/plant-animal-adaptations-swamps-8397188.html
    https://u.osu.edu/worldunseen/mammal-adaptations-to-aquatic-ecosystems/
    https://texasaquaticscience.org/living-in-water-aquatic-science-texas/

24. **Describe the role of cyanobacteria in aquatic ecosystems and their role in harmful algal blooms.**
Cyanobacteria are a common type of bacteria found in both freshwater and saltwater. They are somewhat unique in that they are a bacteria that also contains the mechanisms for photosynthesis. As a result, cyanobacteria may look a lot like algae when found in dense quantities in the water. In fact, they are sometimes mistakenly named algae when referred to in connection to harmful algal blooms (HABs for short). Cyanobacteria come in dozens of different species, most of which are harmless, or at least are harmless most of the time. The problem occurs when the cyanobacteria "bloom" into dense accumulations either on the surface or throughout the water column. Such blooms can be bright green as you would expect, but can also be blue or red, depending on the most prevalent species. Under certain conditions that scientists still don't fully understand, cyanobacteria can produce very toxic substances that they release from their cells either directly or after they die and start to decompose. These toxins can make humans very sick and can kill dogs, cattle, horses and other animals that drink the water or even come in contact with it. It's important to remember that if you come across water that is unusually green, blue, or red, or if the surface of the water looks like it has had brightly colored paint spilled on its surface, then stay out of the water.

https://www.deq.louisiana.gov/page/harmful-algal-blooms-habs
https://www.epa.gov/cyanohabs/learn-about-cyanobacteria-and-cyanotoxins

25. Describe the unique life cycles of aquatic creatures, including adaptations such as anadromy, catadromy, metamorphosis, et cetera.

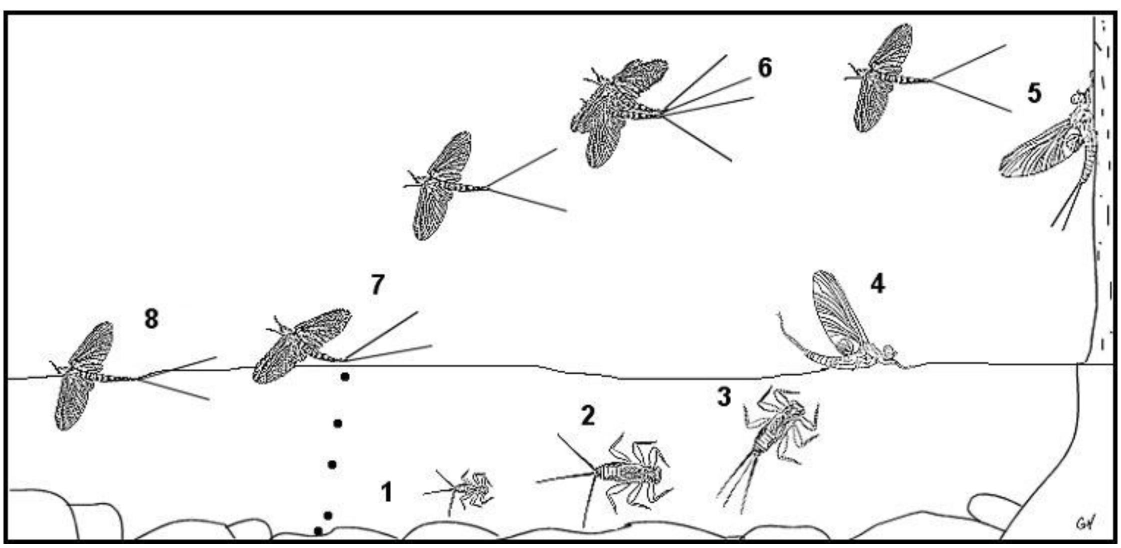
Anadromy refers to the ability and really the requirement that a fish or invertebrate requires both saltwater and freshwater in order to complete its life cycle. Salmon require freshwater streams to spawn and lay their eggs. After spawning the adults all die, providing nutrients to the water that help microscopic organism grow. These microorganisms will later feed the larval (baby) salmon. The larval fishes then swim downstream to the ocean where they live for many years before eventually returning to the freshwater stream where they first hatched.

Catadromy is the opposite of anadromy. In catadromous species, the animal lives most of its life in freshwater but must return to the ocean to spawn and lay their eggs. Although rarely seen in Louisiana, American eels are an example of a catadromous species.

Metamorphosis is commonly known for such insects as caterpillars turning into butterflies. In butterflies this is known as complete metamorphosis and includes a pupal stage between the larval caterpillar and the adult butterfly. What is less commonly known is that there are also many types of aquatic insects that go through what's known as incomplete metamorphosis. In incomplete metamorphosis for aquatic insects, the adult female lays her eggs in the water where they hatch into tiny six-legged nymphs that somewhat resemble the adult. There is no pupal stage with incomplete metamorphosis, because the nymph simply keeps shedding its exoskeleton until emerging at the final stage with a complete adult body including wings. At that point, the nymph leaves the water, either by climbing up a plant stem above the water surface just before emerging, then flying away when the wings dry. Species like dragon flies and damselflies emerge as adults in this way.

Other species such as mayflies come to the surface of the water and emerge there while floating, then they fly off in mass groups of thousands or even millions at one time. Most aquatic macroinvertebrates actually live most of their lifespans as aquatic nymphs, only surviving a few days as adults during which time they must find a mate and lay their eggs. Some species, like mayflies, don't even have mouthparts and only live as adults for a day or two at most before dying. The dead or dying become food for birds, fish, and numerous other animals.

https://www.michiganradio.org/news/2019-07-08/massive-mayfly-swarm-seen-leaving-lake-erie-on-weather-radar



http://www.delawareriverguide.net/insects/mayflycyc.html

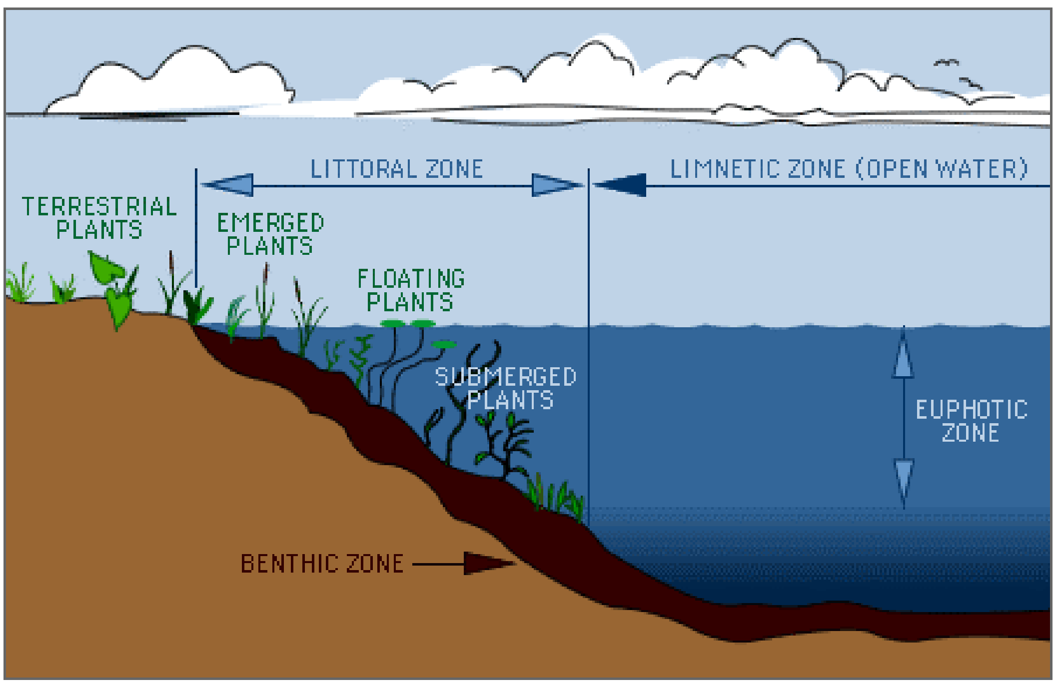
26. Identify the ecological niches of aquatic organisms.

An "ecological niche" has many aspects of biology captured in the phrase.

- The role an organism plays in its environment
- The specific habitat of the species
- When a species is active in the habitat
- The resources required by a species

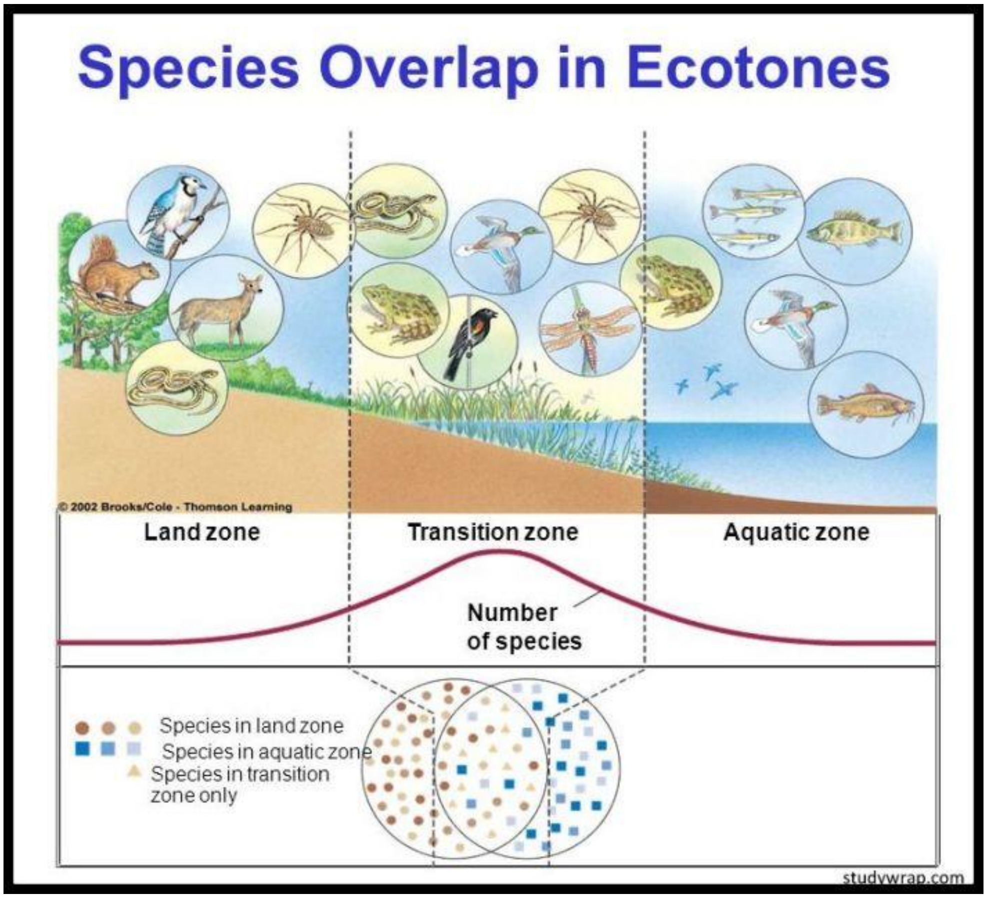
Niches help separate plants and animals so they don't directly compete as much with one another. For example, two species may live in the littoral zone of a stream or pond. One of the two feeds during the day while the other feeds at night. Because of the difference in feeding times, chances are they are eating different things. Likewise, one species may eat a particular plant or animal while the other eats something completely different. The same goes for the many possible combinations of species, habitats, times of day, and feeding habits.

In an aquatic ecosystem the primary large scale niches are terrestrial plants, the littoral zone and the limnetic zone. Within the littoral zone there are the emerged plants that are rooted on the bottom but extend above the water's surface, the floating plants that are rooted on the bottom and who's leaves float at the surface, and finally the submerged plants that are rooted on the bottom and stay below the surface. In the limnetic zone there is the euphotic zone where light extends and the benthic zone near the bottom where there is less light or even no light in deeper water. The euphotic zone is where most if not all plants grow under the water.



https://ireviewgear.com/cool-gear/how-to-catch-more-fish-trout-the-littoral-zone/

It's important to remember that aquatic niches, and especially food webs, also extend to some extent to terrestrial plants and animals. In nature the transition areas between niches and habitat types often have the most diversity of species because the necessary ecological characteristics for a wider variety are available to the organisms inhabiting the area. So the transition area between land and water will have both terrestrial and aquatic organisms interacting to the benefit of both.



https://studywrap.com/environment-ecosystem-ecotone-and-niche-importance-of-ecosystem-ecotones-importance-and-characteristic-of-ecotones/

27. Explain the distinctions between species designations (such as common, rare, endangered, threatened, endemic, extirpated, and extinct) and provide examples of each type.

Terms such as common, rare, threatened, endangered, endemic, extirpated, and extinct are often used to refer to animals from the smallest insects or plants to the largest whales. The terms are used to provide a rough assessment of the health of a population in the world or on a local level.

"Common" refers to species that are currently in no danger of becoming extinct. Larger animals in Louisiana such the eastern gray squirrel, eastern cottontail rabbit, white-tailed deer, eastern wild turkey, and American alligator are all examples of animals that are common and currently under no threat of extinction. Notice that this list was very specific to certain species of squirrels, rabbits, deer, turkey, and alligator. This is because other types of these animals in America or other parts of the world may be more at risk. In legal and wildlife management terms this distinction between species is very important. When discussing threats to populations of animals it's not always correct to simply say "rabbit" or "squirrel."

The term "rare" is not found in the Federal Endangered Species Act of 1973 (ESA). Its common definition is "something that is not found in large numbers and is consequently of interest or value." The term is frequently used in non-technical writing to describe rare animals but it has no specific definition in legal terms for the U.S Fish and Wildlife Service (USFWS) or the Louisiana

Department of Wildlife and Fisheries (LDWF). There are many rare animals in Louisiana that may or may not be officially considered threatened or endangered. Examples include the black pinesnake, eastern chipmunk, hispid pocket mouse, reddish egret, glossy ibis, Calcasieu painted crawfish, Ouachita fencing crawfish, six-banded longhorn beetle and the little dubiraphian riffle beetle. You can see from this brief list that there are far more species considered rare that have yet to be formally ranked as threatened or endangered. This isn't because they don't have critically low populations but rather because there are so many small, unnoticed species that biologists are unable to conduct the studies needed to locate and fully demonstrate their vulnerability. The public and biologists often focus on larger species in hopes that protecting their habitat will also protect the small things that live in the same area.

Threatened is defined in the ESA as "any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." The key part of this definition is that the animal is likely to be at the brink of extinction **in the near future**. Animals in this category are generally given protections from hunting or otherwise harming them and their habitat may also be protected. Threatened Louisiana species listed by the USFWS under the ESA include the following:

Gulf sturgeon	Loggerhead sea turtle	Gopher tortoise
Ringed map turtle	Eastern black rail (a bird)	Louisiana pinesnake
Inflated heelsplitter mussel	Rabbitsfoot mussel	Louisiana pearlshell (a mussel)
West Indian manatee	*Geocarpon minimum* (a plant)	Piping plover (a bird)
Northern long-eared bat		

Endangered is defined in the ESA as "any species that is in danger of extinction throughout all or a significant portion of its range." In simple terms the animals in this category are at the brink of extinction **now**. Animals in this category are given the highest level of protection under the ESA. Protection includes conservation of critical habitat for the animal as well as penalties for harming or killing them. Endangered Louisiana species under the ESA include the following:

Leatherback sea turtle	Hawksbill sea turtle	Fat pocketbook (a mussel)
American chaffseed (a plant)	Louisiana quillwort (a plant)	Pink mucket (a mussel)
Pallid sturgeon	Kemp's Ridley sea turtle	

For both the threatened and endangered category under the ESA there is no fixed limit on the number of animals required to be included in either category. The determination is made by wildlife biologists working for the USFWS, along with state agency personnel with the LDWF. There are many more species at risk in Louisiana but it takes specialized work by both the USFWS and the LDWF to identify the species and do the surveys needed to include them under the ESA. Sometimes a local population may have a high number of individuals but because it is the only known population the species may be considered threatened or endangered. This is because if the habitat for that one population is destroyed, then the at-risk species goes with it.

Endemic species are plants and animals found only in very specific locations and nowhere else. Examples include the Pearl River ring map turtle and the ringed map turtle which are found only in Louisiana and Mississippi.

Extirpated species are those which have been completed removed from a specific location but may still be found in other areas of the country. Species believed to be extirpated from Louisiana include the Texas horned lizard and the whooping crane.

Extinct species are gone forever. Examples in Louisiana include the ivory billed woodpecker. In the United States a famous extinct species is the passenger pigeon. Before it was hunted to extinction and its habitat degraded the passenger pigeon darkened the skies with massive flocks that reportedly stretched for miles. It only took a few years for market hunters and others to kill them off for sport and cheap food. The last passenger pigeon, named Martha, died at the Cincinnati Zoo in 1914.

https://www.wlf.louisiana.gov/page/wildlife-diversity
https://www.fws.gov/endangered/?ref=topbar

Aquatics and Society:

Native and Indigenous peoples have cultures and traditions that include close relationships with the environment. Native and Indigenous communities are unique, and each group has its own history, culture, Indigenous systems of science, traditional ecological knowledge, and conservation practices. The NCF-Envirothon encourages each state, province, and partner nation to consult with your local Native and Indigenous communities to highlight their unique environmental perspective in your Envirothon learning objectives, study materials, and competitions. The following Learning Objectives should be applied on a local, state/provincial, national and/or worldwide (international) scale as appropriate to each objective and the unique parameters under consideration.

Responses to the following four topics are combined following topic 31.

28. **Describe the basics of water quality and water quality improvement.**
29. **Explain the history of human impact on water quality and water resources.**
30. **Identify how major legislation protects water resources.**
31. **Identify key stakeholders, agencies, and organizations that oversee water resource protection and management (such as local conservation districts or water boards, state/provincial agencies, and national environmental and conservation agencies).**

Water Quality History and Legislation:

Just as clean water is vital to human and ecosystem health, polluted water is a major source of illness and habitat decline. The introduction of public waterworks to meet the increasing demands of the increasing human population in the early 19th century led to widespread water quality degradation problems beginning around 1870, as first untreated sewage and then industrial waste (beginning in the 1930s) were transported into nearby waterbodies that were also being used for drinking water and sanitation (bathing, cleaning, etc.). This led to widespread outbreaks of diseases including cholera and typhoid fever.

https://acwi.gov/monitoring/webinars/industrial_internet_11242015.pdf

The Federal Water Pollution Control Act of 1948 was the first major U.S. law to address water pollution. Increasing public awareness of and concern about water pollution led to comprehensive amendments to this Act in 1972, from which emerged the law that became known as the Clean Water Act (CWA). The 1972 CWA gave the federal Environmental Protection Agency (EPA) the power to implement pollution control programs, established the basic structure to regulate and require permits for pollutant discharges, set water quality standards, and recognized the need to address nonpoint source pollution. The objective of the CWA is "to restore and maintain the chemical, physical and biological integrity of the Nation's waters."

https://www.epa.gov/laws-regulations/history-clean-water-act

States and Tribes are partners with EPA in efforts to restore and protect the Nation's waters through the water quality standards program. The EPA has assigned state agencies and tribes with the majority of hands-on rulemaking, monitoring and management of water quality so long as state/tribal standards are either as strict as or stricter than federal requirements. EPA Regional Offices serve as the primary contact between states and tribes and federal water quality standards. Louisiana is located in EPA Region 6.

In Louisiana, the LDEQ describes the standards and criteria for regulating water quality in what is known as the Louisiana Environmental Regulatory Code (ERC). Louisiana's ERC regulations for water can be found in 09. Part IX Water Quality at:

https://www.deq.louisiana.gov/index.cfm/page/BFBC8E60-E92A-00DD-F602B65D8B37C397
https://www.deq.louisiana.gov/resources/category/regulations-lac-title-33

The same group that determines these criteria is also responsible for conducting assessments or tests to determine if these criteria are being met. Another group within LDEQ samples the water in approximately 130 locations around the state every month. In most cases the water is tested for about 20 different parameters or chemicals found in the water. Each of these parameters and locations has their own criteria that are used to determine if the water is meeting its designated uses, which were described previously. More information on water quality standards, monitoring and assessment can be found in Louisiana's biennial Water Quality Integrated Report:

https://www.deq.louisiana.gov/page/louisiana-water-quality-integrated-report

Part III of the Integrated Report provides an overview of Louisiana's water quality assessment process.

Responses to the following five topics are combined following topic 36.

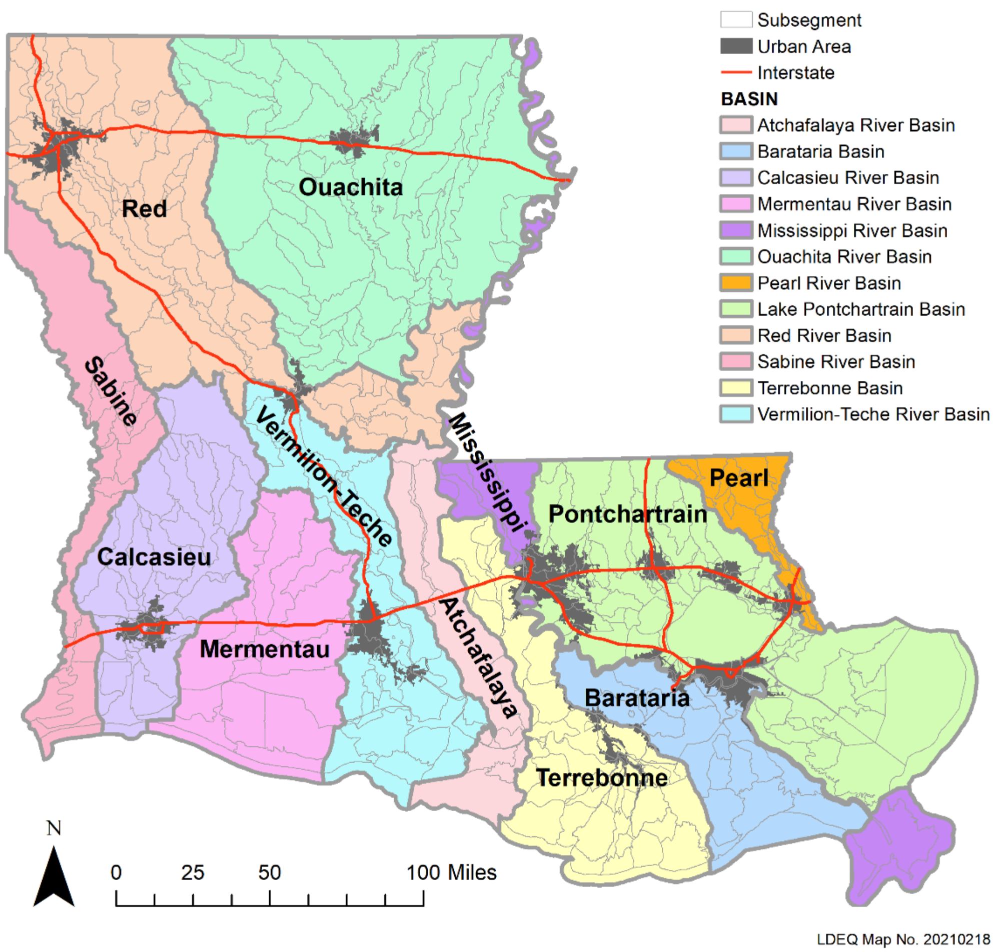
32. **Explain why it is important to take the entire watershed/catchment area into account when planning for water quality.**
33. **Identify state/provincial river basins.**
34. **Explain how human activities upstream impact downstream water quality, and why investing in conservation upstream is important.**
35. **Identify biotic and abiotic factors that impact water quality.**
36. **Identify ecological and human demands on the water supply and provide recommendations for balancing these demands.**

Watershed Management:

As previously discussed, a watershed is an area of land that drains to a river, bayou, lake, estuary, or wetland. Louisiana has 12 large watersheds, called basins, which are divided into 476 smaller watersheds called *subsegments*, as you can see in the map below.

Table of Louisiana Watershed Basins, from LAC 33:IX.1123.A.1:

Basin Name	Basin Number
Atchafalaya River Basin	01
Barataria Basin	02
Calcasieu River Basin	03
Lake Pontchartrain Basin	04
Mermentau River Basin	05
Vermilion-Teche River Basin	06
Mississippi River Basin	07
Ouachita River Basin	08
Pearl River Basin	09
Red River Basin	10
Sabine River Basin	11
Terrebonne Basin	12



LDEQ collects water quality data for each subsegment in the state. You can go to LDEQ's website and find out what the water quality is within your watershed at:

https://www.deq.louisiana.gov/faq/category/35

It is important to focus water quality management efforts on the watershed scale, as this will best ensure the collective impacts of point source and non-point source pollutants are addressed. One example of watershed scale management is the EPA's Healthy Watersheds Program (https://www.epa.gov/hwp), which is a systemic approach to watershed management, meaning it protects aquatic organisms and their habitat as well as the watershed features and processes that support them, including vegetative riparian corridors, the headwaters of streams, hydrology, geomorphology and natural disturbance (flow) regimes. The holistic protection approach provided by the Healthy Watersheds Program is essential for addressing the widespread threats to healthy watersheds, including habitat loss and fragmentation, alteration of flow and channel modification, invasive species, and climate change.

Healthy watersheds provide many ecosystem services, which can include: nutrient cycling, carbon storage, erosion and sedimentation control, increased biodiversity, soil formation, wildlife habitat and migration, water storage, water filtration, flood control, food, materials, and recreation. Healthy watersheds are all less vulnerable to threats, including from: invasive species, climate change, and natural disasters. Humans rely on these ecosystem services to support our way of life.

https://www.epa.gov/hwp/benefits-healthy-watersheds

Freshwater is essential to life and societal well-being, therefore as a society we have given preference to its utilization for consumption, irrigation, and transport over other goods and services provided by freshwater ecosystems. However, in recent decades there has been a shift toward recognizing the benefits of the wider goods and services provided by healthy freshwater systems. This is important, as in the short-term this ensures the continued provision of these goods and services, but in the long-term ensures the ability of these systems to adapt to a changing climate.

https://ecommons.cornell.edu/xmlui/bitstream/handle/1813/57244/MEETING_ECOLOGICAL_AND_SOCIETAL_NEEDS_FOR_FRESHWATER.pdf?sequence=1

37. Describe water conservation practices and in which situations they are most effectively used.

Water Conservation:

Population growth and the increasing occurrence of drought in regions across the country can strain national water supplies. Combined with the potential for increased climate variability related to climate change, it is expected that there will be increasing competition for water resources in the future. There are many other stresses on the water supply, including poor water quality, over-allocated groundwater (aquifer) resources, and the country's aging wastewater and sewage treatment systems. From a public water supply level, water conservation can mean being more water-conscious in your daily life and to use higher-efficiency appliances when possible. Another method is to reduce the use and maintenance of artificial landscapes (grassy lawns) and replace them with heartier, more drought-tolerant native landscaping. However, public supply only accounted for 12% of total freshwater withdrawals in 2015. The major users of freshwater in the country are agricultural irrigation, which accounted for 42% of total freshwater withdrawals in 2015, and the cooling systems for thermoelectric power generating facilities, which accounted for about 36% of freshwater withdrawals. Therefore, irrigation techniques and adoption of best available technology that increase the efficiency of water use and improves water quality are key to conserve water and energy without decreasing yields or increasing costs.

https://www.usgs.gov/special-topics/water-science-school/science/thermoelectric-power-water-use?qt-science_center_objects=0#qt-science_center_objects

https://www.ers.usda.gov/topics/farm-practices-management/irrigation-water-use/
https://pubs.usgs.gov/fs/2018/3035/fs20183035.pdf

38. Identify causes of hypoxia and anoxia in aquatic systems, how these conditions impact the functioning of the ecosystem, and best management practices for prevention and treatment.

Cultural Eutrophication and Hypoxia:

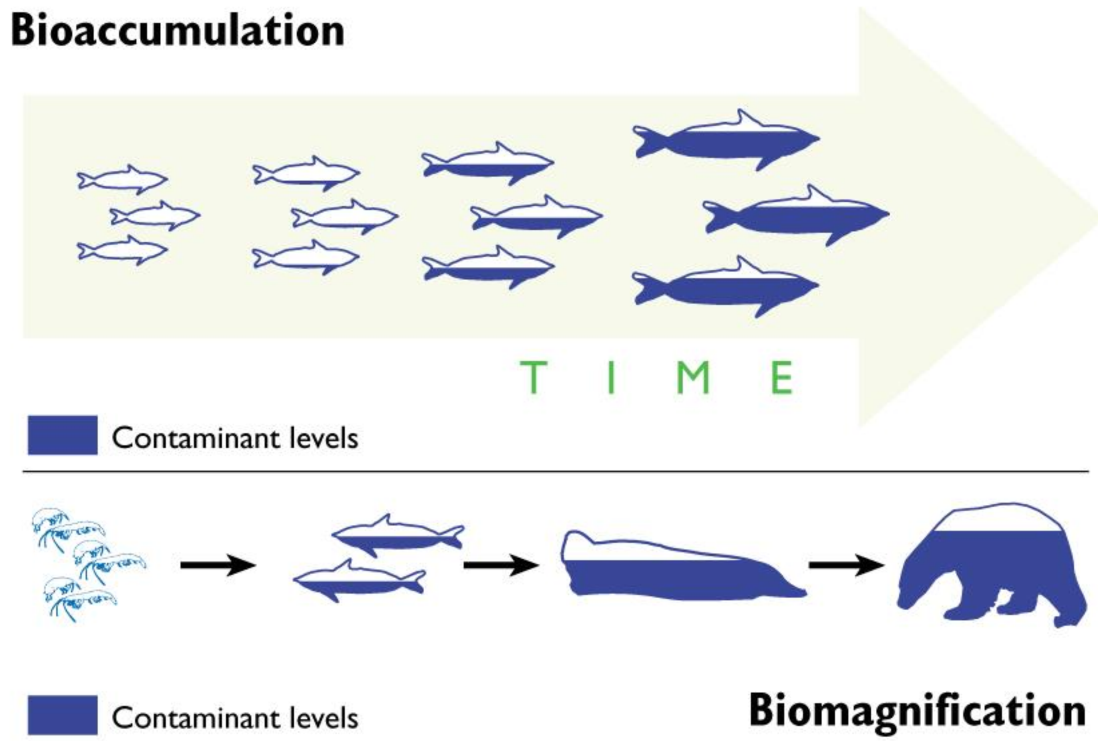
Nutrient pollution from human sources is a leading cause of cultural eutrophication. As previously discussed, eutrophication is the accumulation of excess nutrients, particularly N and P, in water bodies. As discussed previously, excessive levels of nutrients support excessive growth of algae and cyanobacteria, particularly in warm, slow-moving rivers, shallow lakes, and coastal waters. Algal blooms resulting from eutrophication affect aesthetic water quality (appearance, color, taste, and odor) and sometimes produce harmful toxins. As algae die and decompose, microorganisms utilize the organic-N and P that are released and, in doing so, consume oxygen. Hypoxia, or "low oxygen," occurs when dissolved oxygen (DO) levels in the water are depleted to a level that affects critical processes of species in that habitat. Hypoxia can lead to the death of less mobile animals like shellfish and young fish that are dependent upon oxygen for life and are unable to move into healthier waters. Reduction of non-point source pollution sediment and nutrients, such as through the employment of agricultural best management practices including wetland restoration, planting and maintaining riparian corridors, and using technology for smart application and timing of fertilizer where needed are all methods of addressing NPS; as is reducing phosphorous inputs from sewage treatment facilities.

39. Describe how a disturbance to one trophic level will impact organisms in other trophic levels.

Trophic Levels and Biomagnification:

The term trophic refers to the general position of an organism in the food web. There are four basic trophic levels in a simplified food web (autotrophs/producers; first-order consumers (herbivores - get food energy from ingesting autotrophs); second-order consumers ("carnivores" that get their food energy by ingesting first-order consumers); third-order consumers ("top carnivores" that get their food energy by ingesting second-order consumers). Trophic interactions are the feeding interactions between trophic levels. The interaction between algae and a minnow would be a trophic interaction between an autotroph and an herbivore. Pollutants can move from the environment to living organisms through trophic transfer up the food chain through processes called bioaccumulation and biomagnification.

Bioaccumulation refers to the build-up of a toxic chemical in the body of a single living organism (such as zooplankton ingesting toxins bound to sediment in the water column as they filter feed), while biomagnification is the increase in concentration of a toxic chemical when moving up a food chain (i.e., moving up trophic levels from zooplankton to fish, etc.). For biomagnification to occur, a pollutant must be biologically active, which means it must be fat-soluble (dissolved in fat and stored in tissue), mobile, not able to be broken down into smaller particles, and persistent (resist breaking down for long periods of time).



https://mercurypolicy.scripts.mit.edu/blog/wp-content/uploads/2013/01/bioaccumulation_graphic.jpg

40. Describe cultural eutrophication and how it affects lakes and ponds.

See 13 and 38 above.

41. Describe natural and human impacts on river and stream health, flow, structure, and velocity.

Mercury contamination of fish is currently a big issue in Louisiana and the nation. This contamination results from a number of sources, but the largest single anthropogenic (man-made) source is coal-fired power plants. Coal contains low levels of elemental mercury. When coal is burned the mercury is released into the atmosphere where it travels in the air until falling out in rain or dust. Once this mercury reaches a water body it may be methylated, which changes the form of mercury into one that can be accumulated by animals in their bodies. As larger animals eat smaller ones the mercury builds up in their bodies in a process known as bioaccumulation. As a result, fish such as largemouth bass, bowfin (choupique), king mackerel, and other predatory fish can develop somewhat hazardous concentrations of mercury in their flesh. These concentrations are generally not high enough to cause harm to humans. However, pregnant women and small children are more at risk because mercury can permanently affect developing brains.

The second most significant form of water pollution in Louisiana is sewage. In addition to causing dissolved oxygen problems as described above, sewage can cause health problems for humans swimming in the water. Sewage frequently contains high levels of what are known as fecal coliforms. These bacteria are naturally found in the intestines of warm blooded animals, where they contribute to the digestion of food. Since they are found in animal intestines they naturally end up in the waste product of those animals. While fecal coliforms are not normally harmful by themselves, the presence of fecal coliforms may indicate the possible presence of harmful bacteria, viruses, and parasites that may be coming along for the ride. It is these harmful organisms that can cause illnesses should someone accidentally swallow contaminated water while swimming.

Fortunately, sewage treatment plants in Louisiana are regulated by LDEQ under the terms of the CWA, which was discussed earlier. Unfortunately, many cities and towns cannot afford to properly build or maintain their sewage treatment plants in order to adequately treat the sewage before it is released to area streams. Also of concern are the thousands of homes and camps located in Louisiana that use septic tanks or nothing at all before releasing their waste to the environment. In many parts of the State, people feel it is okay to simply run a pipe to the nearest ditch or stream. Decades ago, when there were not as many people as there are now, this may have been acceptable. However, today there are so many people living along Louisiana's streams and lakes that many of them have become contaminated with sewage. Money often lies at the heart of the problem with both municipal sewage treatment systems and septic tanks. Everyone wants clean water for swimming and drinking but nobody wants to pay for it! More information on municipal sewage treatment and septic tanks can be found at:

http://home.howstuffworks.com/sewer.htm

Responses to the following three topics are combined following topic 44.

42. **Recommend best management practices for improving water quality and enhancing aquatic habitat, such as riparian buffers.**
43. **Identify threats to aquatic ecosystems, such as pollution, biomagnification of toxins, erosion, development, invasive species, excess nutrients, thermal shock, et cetera.**
44. **Distinguish between point and non-point source pollution and give examples and management strategies for each.**

Point Source Discharges:

Point source discharges are releases of wastewater from an identified location. Wastewater may originate from large industrial or petrochemical facilities. It may also be discharged from large municipal sewage treatment plants or small neighborhood or business wastewater facilities. In each case the discharger must have a permit from the LDEQ to ensure that the discharge will not harm or impair the water quality of the water body receiving the discharge. LDEQ administers and reviews the Louisiana Surface Water Quality Standards found in the Louisiana Environmental Regulatory Code, Title 33 Louisiana Administrative Code, Part IX, Chapter 11. LDEQ is also charged with the responsibility of maintaining and enhancing the waters of the State through the permit process. Permitting regulations and implementation plans establish procedures to effectively incorporate the water quality standards into wastewater discharge permits. Although all applications for permits to discharge wastewaters are considered on a case-by-case basis, LDEQ believes that a consistent approach to application reviews is important. Draft water quality permits are reviewed by the facility requesting the permit and subject to a public review period to ensure citizens in the area have a chance to comment on the facility. This public review period is a chance for local citizens to get involved with the permitting process, and thereby have some impact on what happens in their area.

https://www.epa.gov/npdes-permits/louisiana-npdes-permits

Nonpoint Source Pollution:

In addition to point sources of water pollution, a larger source of pollution is what's known as nonpoint source (NPS) pollution. Nonpoint source pollution is any pollutant that runs off the land from our yards, farms, forests, streets and parking lots throughout the watershed. Nonpoint source pollution enters our bayous, rivers, and lakes when it rains and includes sediment (mud), fertilizers, pesticides, oil, metals, litter, and bacteria (from animal waste). What the land is used for determines the possible pollutants the water picks up as it moves into streams and lakes. Agricultural land frequently causes high levels of pesticides, fertilizers, and soil or sediment to be picked up by stormwater. When these pollutants get into streams or lakes they can cause problems for fish, other organisms, or people who use those water bodies. Runoff from urban areas like roads and parking lots often have high levels of oil, gasoline, metals, and other chemicals from the cars and truck using them. Runoff from suburban lawns and agricultural areas often contains herbicides and insecticides, fertilizers, and sediments. Oil, grease and toxic chemicals from urban runoff and energy production. Sediment from improperly managed construction sites, crop and forestlands, and eroding streambanks. Salt from irrigation practices and acid drainage from abandoned mines. Bacteria and nutrients from livestock, pet wastes and faulty septic systems. Taken together, NPS pollution now accounts for over half of the water pollution in Louisiana and the nation. More information on NPS, the different sources and forms of NPS pollution, and ways to prevent it can be found at:

https://www.epa.gov/nps

Reduction of non-point source pollution sediment and nutrients, such as through the employment of agricultural best management practices includes wetland restoration, riparian barriers, and the utilization of technology in the application and timing of fertilizer are all methods of addressing NPS; and through reducing phosphorous inputs from sewage treatment facilities.
The CWA initially focused on cleaning up discharges of pollutants to water bodies by requiring industry of all sizes, cities, and towns to reduce or eliminate the amount of harmful chemicals in their wastewater. Yes, cities and towns contribute significant amounts of water pollution through their sewage treatment facilities. Largely as a result of the CWA, water quality in the United States is much better than it was 30 years ago. But there is still much work to be done. Nonpoint source pollution, which was described earlier, is now the largest single source of water pollution in the United States. This is largely because nonpoint source water pollution can occur anywhere and anytime it rains.

http://www.epa.gov/lawsregs/laws/cwa.html

45. Describe the impact of changes in climate on water quality and water resources.

Temperature increases and shifts in precipitation patterns resulting from climate change will increase the frequency and intensity of flooding and droughts around the globe, depending on location. This means some areas will become wetter, and others dryer. According to the EPA, Louisiana is likely to become warmer and the droughts and floods we experience are likely to become more severe over time. "Our changing climate is likely to increase damages from floods, reduce crop yields and harm fisheries, increase the number of unpleasantly hot days, and increase the risk of heat stroke and other heat-related illnesses."

https://19january2017snapshot.epa.gov/sites/production/files/2016-09/documents/climate-change-la.pdf

46. Describe action that can be taken to mitigate adverse human impacts on aquatic systems.

The CWA initially focused on cleaning up discharges of pollutants to water bodies by requiring industry of all sizes, cities, and towns to reduce or eliminate the amount of harmful chemicals in their wastewater. Cities and towns contribute significant amounts of water pollution through their sewage treatment facilities. Largely as a result of the CWA, water quality in the United States is much better than it was 30 years ago, but there is still much work to be done. Nonpoint source pollution, which was described earlier, is now the largest single source of water pollution in the United States. This is largely because nonpoint source water pollution can occur anywhere following a precipitation event (rain, snow).

http://www.epa.gov/lawsregs/laws/cwa.html

47. Explain the process of ocean acidification and describe its effect on marine ecosystems.

Ocean Acidification:

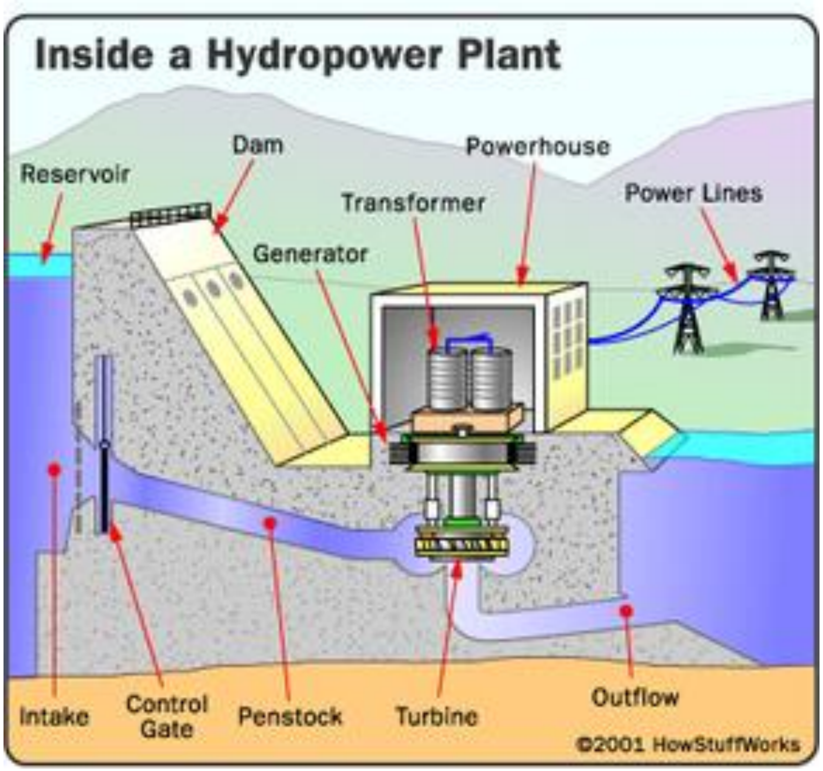
The burning of fossil fuels (coal, gas, and oil) in thermoelectric power plants results in the release of carbon dioxide (CO2) into the atmosphere. Since the industrial revolution, when we greatly expanded fossil fuel combustion for the production of goods and generation of electricity, the concentration of CO2 in the atmosphere has greatly increased. The ocean is one of the greatest carbon sinks on the planet, about 25% of CO2 emissions each year are absorbed into the ocean. However, the addition of CO2 to seawater produces bicarbonate ($HCO3^-$) and carbonate (CO_3^{2-}) ions, which make the ocean more acidic and lower its pH, in a process called ocean acidification. Since the industrial revolution, the ocean's pH has dropped from 8.21 to 8.10, which is equivalent to ten times greater acidity. Acid wears on and weakens calcium structures like the shells of crustaceans, including commercially harvested crabs, and makes it harder for them to thrive. Ocean acidification is similarly harmful to coral reef ecosystems, as the lower pH makes it harder for them to build their skeletal structures, which are made of calcium carbonate.

https://www.climate.gov/news-features/understanding-climate/climate-change-atmospheric-carbon-dioxide
https://oceanservice.noaa.gov/facts/acidification.html
https://www.whoi.edu/press-room/news-release/scientists-identify-how-ocean-acidification-weakens-coral-skeletons/
https://nmssanctuaries.blob.core.windows.net/sanctuaries-prod/media/archive/education/pdfs/dungeness_crab_oa_fact_sheet.pdf

48. Describe how water can be used as a source of renewable energy.

Hydropower:

Hydropower, or hydroelectric power, is the use of flowing water to generate electricity. It is considered a renewable resource as it uses the natural flow of a river or stream, or an ocean current, and water is not generally consumed in the process. Hydropower accounts for about 37% of total U.S. renewable electricity generation, and about 7% of total U.S. electricity generation. Many of us think of large dams like the Hoover Dam when we think of hydropower, but hydropower facilities come in all sizes, including "damless" diversions on run-of-river facilities in which a portion of a stream channel is diverted and flows through a hydropower generating facility before rejoining the stream channel.



https://www.energy.gov/eere/water/hydropower-basics
https://science.howstuffworks.com/environmental/energy/hydropower-plant1.htm

49. Explain the economic, societal, and cultural impacts of water quality and quantity resource issues (such as water scarcity, damming projects, pollution disasters, et cetera).

As described earlier, as the human population has grown and dispersed across the planet, we have placed new and increasing demands on water resources. Industrial agriculture practices for the production of crops and livestock require large quantities of freshwater to be diverted from rivers and streams, the quality of which may be degraded downstream due to runoff from the application of fertilizers, herbicides, and pesticides (nonpoint source pollution). Industry similarly requires the use of large quantities of freshwater for manufacturing and processing of materials. Permits specify the allowable levels of pollutants present in industrial wastewater discharge. Damming projects have been implemented worldwide to provide water for a multitude of uses, including drinking water supply, recreational use, transportation, and hydropower. Channels and other river control structures protect urban areas and facilitate transportation, but alter historic flow regimes. Technological advances and science-based regulatory standards have led to improvements in water quality and stream restoration efforts that better represent historical stream flow where possible, as described in state water quality standards and regulations.

https://www.usgs.gov/mission-areas/water-resources/science/streamflow-alteration?qt-science_center_objects=0#qt-science_center_objects

50. Describe the roles of key leaders in water quality and conservation, both historical and present (such as Marjory Stoneman Douglas, Jacques Cousteau, Amariyanna Copeny, Vanessa Nakate, et cetera).

Water Conservation Leaders:

- **Marjory Stoneman Douglas** - Dedicated her life to preserving and restoring the Florida Everglades. Douglas authored the 1947 bestseller *The Everglades: River of Grass*, which raised national awareness of the importance of the Everglades as a valuable natural resource in need of protection, and led to the creation of 1.5 million acre Everglades National Park.

  https://www.womenofthehall.org/inductee/marjory-stoneman-douglas/

- **Jacques Cousteau** – A leader in the environmental movement, and co-creator of SCUBA (the self-contained underwater breathing apparatus) in 1943. Cousteau explored the world's oceans and rivers aboard the diving and scientific research vessel the *Calypso* for four decades beginning in 1950. He played a key role in raising awareness of the human impact on degradation of oceans and rivers through pollution, over-exploitation of resources, and coastal development.

  https://www.cousteau.org/about-us/

- **Amariyanna Copeny** – A youth role model and environmental activist, Copeny is best known for her work raising awareness of the Flint water crisis when she was eight years old through a letter she sent to President Obama and for successful fundraising efforts that support access to clean water and health resources for the youth of Flint, Michigan.

  https://cypp.rutgers.edu/office/amariyana-copeny/

- **Vanessa Nakate** – A young climate action leader from Uganda, and founder of the Rise Up Climate Movement. Nakate was a speaker at COP25 in Spain, which called on the World Economic Forum to stop subsidizing fossil fuels. Nakate is also a leader in a campaign to save Congo's rainforest, which is facing massive deforestation, and on projects to install solar and institutional stoves in schools.

  https://www.un.org/youthenvoy/vanessa-nakate/

Field Skills:

51. Identify common aquatic animal species including fish, reptiles, amphibians, and mammals.

There are too many common animal species in Louisiana to include in this brief study guide. Students are encouraged to check the LDWF website at, https://www.wlf.louisiana.gov/species for photos and detailed descriptions of Louisiana plants and animals.

52. Identify common aquatic macroinvertebrates and their pollution tolerances.

The macroinvertebrates living in a water body can be used to determine if the stream or lake is healthy enough to support a good aquatic community. Macroinvertebrates are organisms that are large enough to see with the naked eye (macro) and do not contain a vertebral column (invertebrate). Most macroinvertebrates used for this process are the aquatic larval stages of flies. Other macroinvertebrates that can be used include crayfish, clams, snails, leaches, and worms. Different types of macroinvertebrates have different tolerances toward water pollution. An easy to follow guide to aquatic insects and their tolerance to pollution can be found on the LDEQ website at:

https://www.deq.louisiana.gov/assets/docs/Envirothon/Aquaticmacroinvertebratedocuments.pdf

More information on aquatic macroinvertebrates can be found at:

https://extension.usu.edu/waterquality/learnaboutsurfacewater/propertiesofwater/aquaticmacros

Be prepared to view and identify actual examples of the macroinvertebrates during the test. A copy of the "bug sheet" and survey form will be provided with the test.

53. Calculate a biotic index and determine water quality for freshwater systems.

The Louisiana Macroinvertebrate Stream Survey Form on the LDEQ website can be found at: https://www.deq.louisiana.gov/assets/docs/Envirothon/Aquaticmacroinvertebratedocuments.pdf. Using this "bug sheet" and survey form a careful stream surveyor can collect a sample of aquatic macroinvertebrates from most any stream and get a good idea of the water and habitat quality for the stream. Be prepared to view and identify actual examples of the macroinvertebrates during the test. A copy of the "bug sheet" and survey form will be provided with the test.

Additional information can be found at:

https://extension.usu.edu/waterquality/learnaboutsurfacewater/propertiesofwater/aquaticmacros

54. Identify common aquatic plants and their growth zones.

Bullet 21 and Table 1, above, provide website references to aquatic plants that can be found in Louisiana. Students are encouraged to review the tables and website for detailed information. Be prepared to view and identify actual examples of the plants during the test.

55. Identify invasive aquatic species.

A less recognized form of water quality impairment comes from invasive aquatic species. These are organisms, frequently plants but also mussels, mammals, and fishes that have been accidentally or deliberately introduced to Louisiana's environment. Water hyacinth, salvinia, hydrilla, zebra mussels, and nutria are all aquatic invasive species that are now causing extensive damage to Louisiana's water bodies and aquatic ecosystems. Invasive species generally grow at such a rapid pace that they tend to choke out native plants and animals that should be living in or around the water. In the case of nutria, they can quickly destroy marshes and trees or burrow into levees causing failures of these important structures. The State of Louisiana has developed an Aquatic Invasive Species Council to try and deal with this problem. The Council is composed of representatives of a number of State and Federal Agencies, along with industry and citizen groups who are charged with coming up with a strategy to address this problem. While many of these harmful species are here to stay, the Council is working to prevent more species from entering Louisiana, while trying to reduce the impact of the existing species. More information on aquatic invasive species, including photos of the most common plant and animal invasives in Louisiana, can be found at:

http://is.cbr.tulane.edu/
http://www.anstaskforce.gov/

56. Utilize common water monitoring tools to determine local water quality (such as a Secchi disk, Ekman dredge, dip net, pH meter, aquatic sensors, et cetera).

LDEQ primarily uses water quality sampling and field or laboratory analysis to determine the quality of Louisiana waters. This testing is done with a variety of sampling equipment including electronic water meters, water sampling devices, sediment sampling devices, flow meters, and other more specialized equipment. (All equipment pictures were originally taken from the Rickly.com website, which is now Performance Results Plus online catalog. (https://prph2o.com/)

Electronic sampling devices are widely used to measure parameters such as dissolved oxygen, pH, salinity, conductivity, and temperature. There are several companies that make different versions but they all work in the same basic fashion. These devices work by lowering an electronic probe or group of probes into the water. The probes are attached to a small box-like device that allows the user to read the results for the various parameters. These devices must be carefully maintained and calibrated in order to ensure accurate measurements are obtained.

YSI electronic water meter

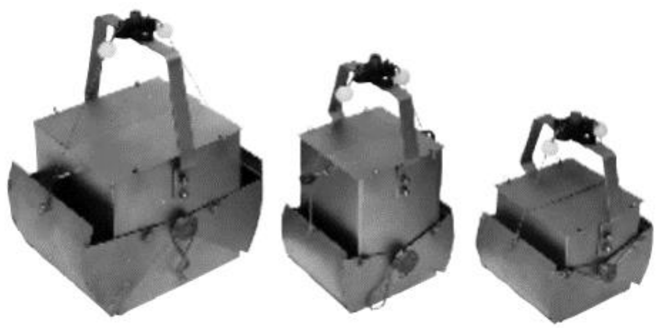
Hydrolab electronic water meter

Water sampling devices usually consist of bucket or tube-like devices used to obtain water from either the surface or deeper underwater. However, it is important to make sure the bucket or tube device is not made of or contaminated with chemicals that may result in false detections of chemicals in the water. Laboratory analysis has become so accurate, with detection levels in the very low parts per million, parts per billion, even parts per trillion and parts per quadrillion, that proper sampling techniques are more important than ever.

Kemmerer water grab sample bottle

Van Dorn horizontal water grab sample bottle

Sediment sampling devices consist of various implements designed to grab sediment from the bottom of a water body. Some consist of long poles with a “clamshell” device on the end that closes and grabs the sediment. Others are weighted clamshells that are lowered into the water on ropes. Once the clamshell hits bottom, tugging on the rope causes the device to close and grab the sediment. Sediment samples are then sent to laboratories to determine if harmful chemicals are present in sufficient concentrations to cause harm to fish, macroinvertebrates, or humans.



Ekman bottom grab samplers

Ponar bottom grab sampler

Van Veen bottom grab sampler

Flow or current meters are used to measure the speed of water flowing in a stream. This measurement along with measurements of the stream width and depth profile can be used to estimate not only the speed of the water but also the quantity of water moving past a given point on a stream. Flow measurements are usually given in cubic feet per second or CFS, and are known as a stream's "discharge". A sluggish bayou may have a discharge of 0.1 or even 0 CFS if there has been no rain in recent days. By contrast, the Mississippi River's discharge ranges from about 200,000 CFS to 1,000,000 CFS. Discharge or CFS is important when estimating the quantity of various chemicals found in the water. This in turn is used by LDEQ to determine the amount of different pollutants that can be safely released into the water without harming aquatic life or humans. This determination is done using a mathematical model known as a Total Maximum Daily Load or TMDL. TMDLs are used to develop water discharge permits and to make recommendations regarding the prevention of nonpoint source water pollution. Taken together, these actions are designed to protect and improve the uses of water bodies in Louisiana.

Be prepared to identify various pieces of water sampling equipment and know what they are used for.

Pygmy flow meter

Wading rod flow meter

Columbus weight mounted flow meter

https://www.fondriest.com/usgs-top-setting-wading-rods.htm
http://envcoglobal.com/catalog/water/liquid-flow/current-meters-and-discharge-monitoring/river-gauging-equipment/hydro

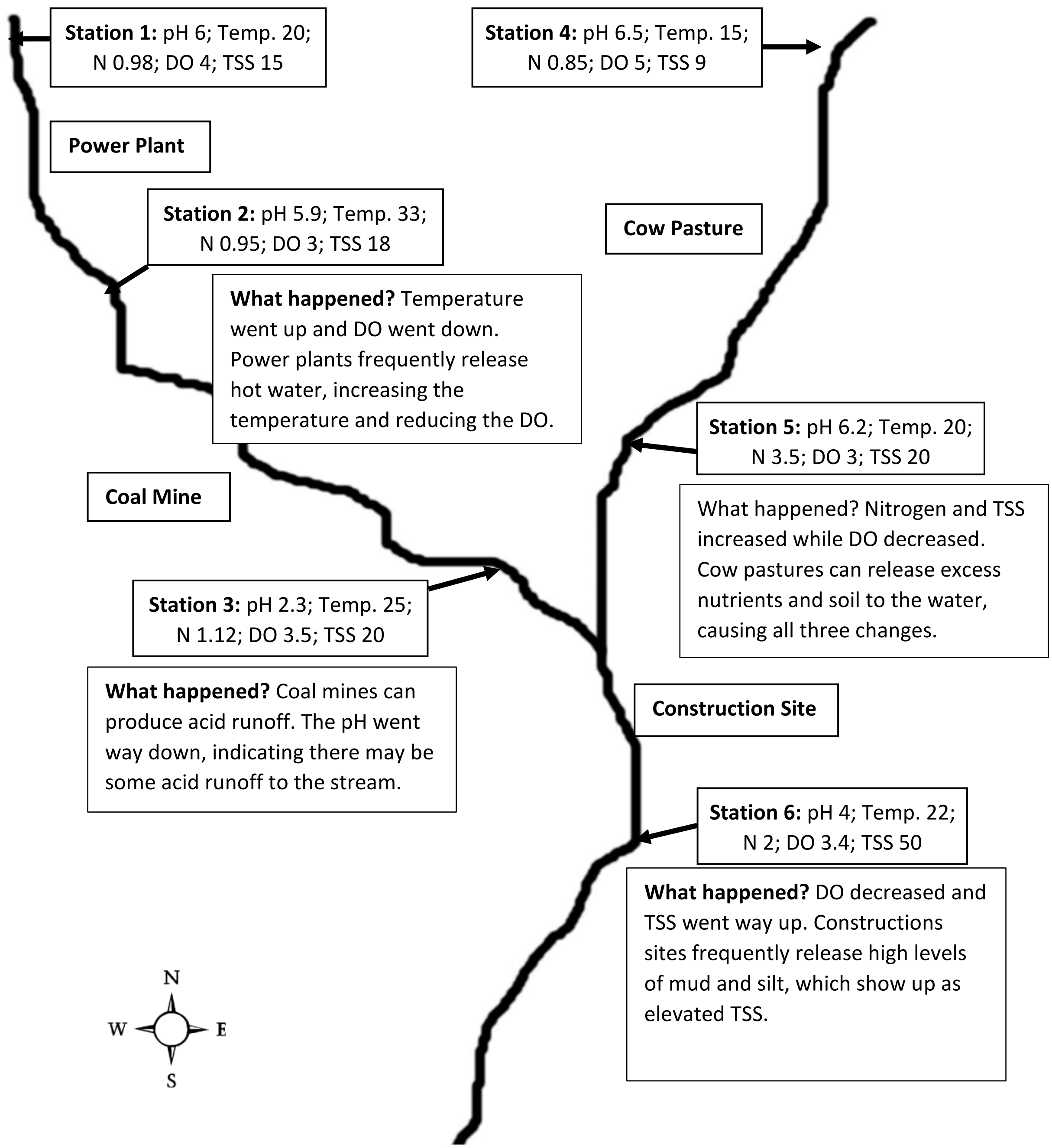
57. Interpret results of water quality monitoring measures (such as dissolved oxygen, turbidity, E. coli counts, pH, nutrient levels, et cetera) and provide recommendations for best management practices.

Using the water chemistry parameters described in bullet 9.b., above, be prepared to interpret a set of data, determining if and where water quality problems are found in a fictitious watershed. The following is an example of how to interpret the data. To interpret the data it may be helpful to write the data results on the map near each site number. This makes it easier to view how the water chemistry changed as you go downstream.

10-year average water quality measurements on the Rancid River

	pH	Temperature (°C)	Nitrogen (mg/L)	Dissolved Oxygen (mg/L)	Total Suspended Sediment (mg/L)
Station 1	6	20	0.98	4	15
Station 2	5.9	33	0.95	3	18
Station 3	2.3	25	1.12	3.5	20
Station 4	6.5	15	0.85	5	9
Station 5	6.2	20	3.5	3	20
Station 6	4	22	2	3.4	50

Power Plant	**Construction Site**	**Cow Pasture**	**Coal Mine**

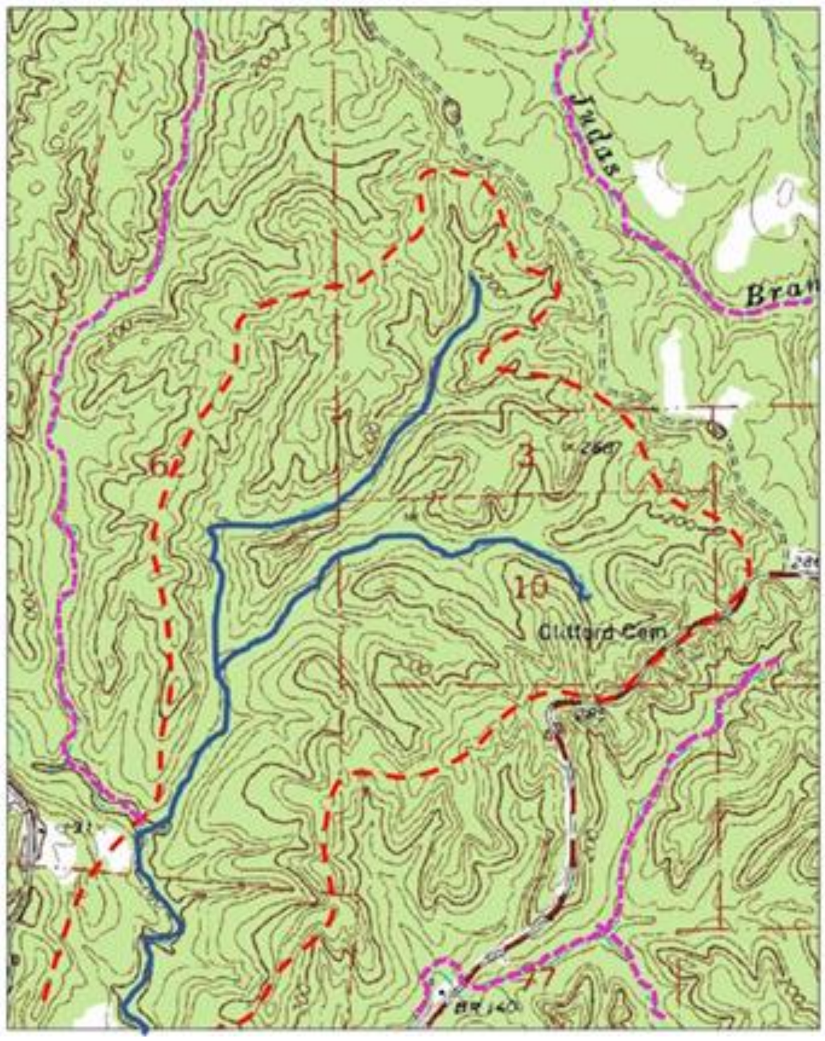


58. Utilize common technologies in water resource management (such as GPS, GIS, aquatic sensors, et cetera).

This is a complex topic that will not be covered on the Louisiana test.

59. Delineate a watershed using a topographic map.

On the following topographic map, the blue lines are two streams in a small watershed. The red dashed line outlines the approximate watershed boundary as it runs along the highest ridge between neighboring watersheds. The purple dashed lines are streams in those adjoining watersheds. Calculate relevant hydrological measures such as base flow, water volume, runoff, water balance, et cetera.

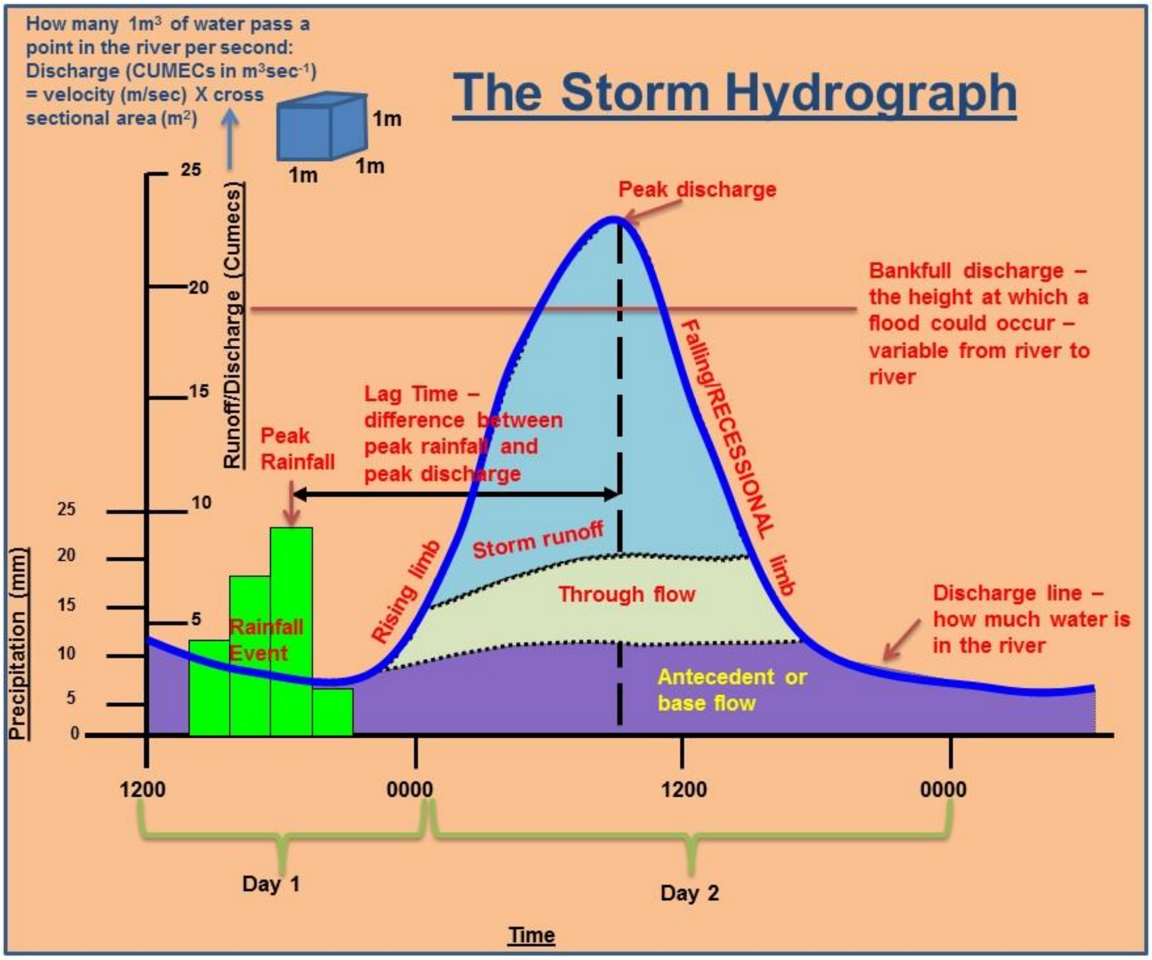


60. Calculate a water budget, including precipitation, evapotranspiration, storage, stream flow, discharge, and recharge.

This is a complex topic that will not be covered on the Louisiana test.

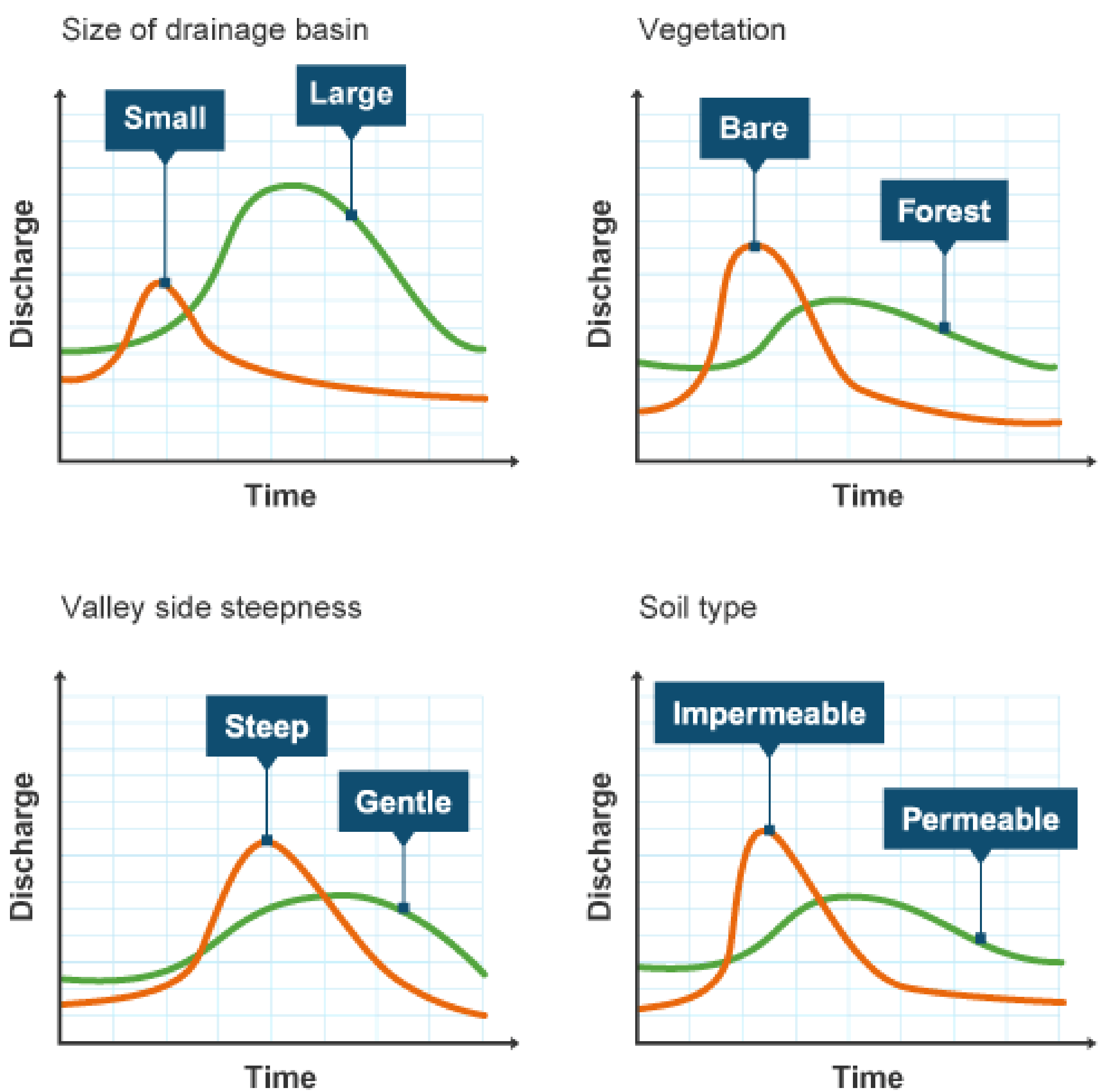
61. Interpret a hydrograph.

A hydrograph is a visual graph showing streamflow, hydrology, over time. Hence the name, hydrograph. Hydrographs are very useful in determining how rainfall, land use, and watershed size affects the flow of a stream. In the following graph, day 1 shows a large rainfall event in the evening with the green bars. This is followed the next morning with a sharp rise in the discharge or flow of water. Discharge in this case is measured in cubic meters per second but in the U.S. discharge is usually measured in cubic feet per second.



https://www.coolgeography.co.uk/A-level/AQA/Year%2012/Rivers_Floods/Hydrographs/Hydrographs.htm

The following four graphs show the effect of drainage basin size, vegetation, valley side steepness, and soil types on flow in the river following a large rain event. An increase in impermeable surfaces in a city in the form of parking lots, roads, and buildings has the same effect on discharge as what's shown in soil type hydrograph. This causes increased downstream flooding because the water is unable to slowly soak into the ground and runs off much faster than it would from a field or forest. Unfortunately, more and more construction in and around cities and towns often leads to increased flooding in those areas. Be prepared to interpret a hydrograph in terms of what may be causing increases and decreases in the discharge.



https://alevelrivers.weebly.com/storm-hydrographs.html

Broad Scale Curriculum Guidelines (These are the broad topics covered in the previous sections.)

Abiotic Factors:

Know the processes and phases for each part of the water cycle and understand the water cycle's role in soil nutrient erosion, salinization of agricultural lands, and climatic influences.

Understand the concept and components of a watershed and be able to identify stream orders and watershed boundaries. Know the features of a healthy watershed and an unhealthy watershed.

Know how to perform and interpret chemical water quality tests and understand why aquatic organisms and water quality is affected by the physical, chemical and biological conditions of the water.

Biotic Factors:

Understand the dependence of all organisms on one another and how energy and matter flow within an aquatic ecosystem.

Understand the concept of carrying capacity for a given aquatic ecosystem, and be able to discuss how competing water usage may affect the ability of the system to sustain wildlife, forestry and anthropogenic needs.

Identify common, rare, threatened and endangered aquatic species as well as Aquatic Nuisance Species (ANS) through the use of a key.

Know how to perform biological water quality monitoring tests and understand why these tests are used to assess and manage aquatic environments.

Aquatic Environments:

Identify aquatic and wetland environments based on their physical, chemical and biological characteristics.

Know characteristics of different types of aquifers, and understand historical trends and threats to groundwater quantity and quality

Understand societal benefits and ecological functions of wetlands.

Understand the functions and values of riparian zones and be able to identify riparian zone areas.

Water Protection and Conservation:

Understand how education programs and enforcement agencies are working together to protect aquatic habitats and preventing those who use our waterways from inadvertently transporting Aquatic Nuisance Species ANS from one river to another.

Interpret major provincial and/or federal laws and methods used to protect water quality (i.e. surface and ground water). Utilize this information to propose management decisions that would improve the quality of water in a given situation.

Be familiar with the Federal, Provincial and state agencies that provide oversight of water resource, and understand that Geographic Information Systems (GIS) is a useful and important tool in the management of water resources.

Identify global and local sources of point and nonpoint source pollution and be able to discuss methods to reduce point and nonpoint source pollution.

Understand the interaction of competing uses of water for water supply, hydropower, navigation, wildlife, recreation, waste assimilation, irrigation, and industry.

Know the meaning of water conservation, and understand why it is important every time you turn on a faucet.