Water from a Watershed Perspective

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INTRODUCTION

A Need for Environmental Awareness

From the first time I took my class to spend the week at Camp Cullen on Lake Livingston to the present, I have had a growing admiration for the beauty and serenity of the rivers and lakes of Texas. But over the years I have seen these natural resources coming under increasing stress related to growth and development. The continued existence of these unique places may well hinge on the concepts that we are teaching our students. These children, tomorrow's voters and leaders, will not be effective advocates for natural resources about which they have little knowledge or personal interest. So it is critically important that we instill both a "sense of place" and a commitment to stewardship for the natural resources of Texas. It is the purpose of this unit to create that "sense of place" and to provide a foundation for understanding the environmental issues facing the citizens of Texas.

Someone once stated, "to love something you must first know it, to protect something you must first love it." If I can connect my students with the uniqueness that is Texas, then everyone benefits. Students come away with a better understanding of the land and the dynamics that have shaped it and hopefully a greater appreciation for things they take for granted. The land and the citizens of Texas benefit because future environmental decision-makers will be better educated and informed.

I believe we have lost much of our wisdom and intimacy with nature. A typical urban dweller spends about 85 percent of his time indoors in artificial environments with controlled light, humidity, and temperature. We have forgotten that we are utterly dependent upon nature for so many of our fundamental needs. Most of us are far removed from the land and have disconnected with nature (it is hard to hear nature through the blare of television sets). So it is my hope that these enlightened students, committed to place, will have something to say about its future.

Thinking Critically about the Environment

Water issues in the state are complex and solutions to water related problems will require more than simple identification and description, they will require an examination of our values and decisions based on good science. We must choose what we want the environment to be. We must look at the options and as Aldo Leopold stated, choose the option that tends to preserve the integrity, stability, and beauty of the biotic community.

The Lower Neches Valley Authority may feel a proposed dam project on the Neches River to boost water supplies is necessary. In opposition, the Sierra Club may feel the dam will flood thousands of acres of bottomland hardwood forests and disrupt an already hard-pressed ecosystem. The solution to such an eco-problem has as much to do with our system of values as it does with the science underlying an informed decision.

Thinking, reasoning, analyzing, and problem solving are skills that are necessary when dealing with the stresses placed on Texas' watersheds. These are the very same skills we try and weave through our daily lessons. Focusing on the water issues and Texas' watersheds allows me to teach across subject areas and relate learning in the classroom to the needs and issues of the state.

WATER

The Nature of Water

We start at the beginning, understanding what we are composed of, and where it came from. Water, H_2O, the only chemical formula everyone learns. Two atoms of hydrogen welded to one of oxygen. Their union is a molecule, a cluster of atoms, the basic unit of water. Water is the combination of the universe's most popular reactive elements. This molecule is the product of two cosmic events: the Big Bang, which started it all and gave us a cosmos made mostly of hydrogen, and stellar evolution, which reformulated hydrogen into oxygen and all the other elements that make up our planet. The planet cooled, heavy elements sunk to the core, lighter elements formed the rocky crust at the surface. Among this rocky crust were volatile compounds (hydrogen, nitrogen, hydrogen sulfide, carbon oxides, and water). As the Earth cooled and solidified, vapors were released. In a process called degassing, an atmosphere of carbon dioxide, nitrogen, and water vapor was formed. At some point in Earth's history the temperature fell enough for water to condense, clouds formed, and it rained.

This drop of water (a **polar molecule**) falling through the atmosphere dissolves atmospheric gases and affects all it touches: the land, lakes, and rivers. It is the universal solvent (due to its asymmetrical distribution of charge allowing water to separate polar solute molecules). This property allows for the transfer of nutrients vital to animals and plants.

Water molecules tend to bind to other substances. Water is "sticky" and elastic, and tends to clump together in drops rather than spread out into a thin film. Surface tension is responsible for capillary action, which allows water and dissolved materials to move through the roots of plants and the tiny blood vessels in our bodies.

Water absorbs or releases more heat than many substances for each degree of temperature increase or decrease. This property (a high specific heat index) helps to regulate the rate at which air changes temperature and explains why the temperature change between seasons is gradual rather than sudden. Large bodies of water are the world's great heat reservoirs and heat exchangers.

Water is unique in that it is the only natural substance that is found in all three states at the temperatures normally found on Earth. Water in its solid form is less dense than in its liquid form; without this unusual property, lakes and rivers would freeze from the bottom up killing aquatic life.

Critical Water Issues

Water is an absolute necessity for human survival; we are 70 percent water. Every life-sustaining process is directly or indirectly affected by water. It is an essential nutrient; you can live without food for a month, but less than a week without water (the average person needs about two liters of water a day). Water is life and all human beings on the face of the planet are dependent on less than 1 percent fresh water, of which most is groundwater (97.2 percent in the oceans, 2.15 percent in polar ice, and 0.65 percent fresh water).

Water is in constant movement through oceans, air, soil, rivers, and lakes in the hydrological cycle. The sun evaporates water in the oceans; the wind moves part of the vapor as clouds over land, where the water is released as rain and snow. The precipitated water then either evaporates again, flows back to the sea through rivers and lakes, or finds its way into the groundwater. It is this distribution of precipitation that creates a problem, not all citizens of this planet have equal access to water resources (East Texas receives on average 56 inches per year as compared to eight inches per year in West Texas). Couple this with a growing population, and this equates to fewer water resources for each person. In the past 100 years, the world population tripled but water use for human purposes multiplied six times. Today, half of all available freshwater is being used for human ends, twice what it was only 35 years ago.

Unless we find ways to use water more efficiently, this imbalance between supply and consumption will reduce freshwater ecosystem services, increase the number of aquatic species facing extinction, and further fragment wetlands, rivers, deltas, and estuaries. The following conclusions can be drawn, based on current scientific evidence: (1) over half of accessible freshwater runoff globally is already appropriated for human use; (2) more than a billion people currently lack access to clean drinking water (three to four million people die of waterborne diseases annually, including more than two million children) and almost three billion lack basic sanitation services; (3) because the human population will grow faster than increases in the amount of accessible fresh water, per capita availability of fresh water will decrease in the coming century; (4) climate change will have a major impact on the earth's hydrological cycle; (5) at least 90 percent of total water discharge from U.S. rivers is strongly affected by channel fragmentation from dams, reservoirs, and irrigation; and (6) globally, 20 percent of freshwater fish species are threatened or extinct and freshwater species make up 47 percent of all federally listed endangered animals in the United States.

Where does this leave us? Water has become imperiled, not through the deliberate actions of evil men, but through the small doings of many ordinary people, doing things the way they have always done them. Business as usual will only bring increased stress on an already overtaxed resource. Whether the water crisis deepens and intensifies or whether key trends can be steered toward sustainable management of water resources depends on certain key factors.

One factor is limiting the expansion of irrigated land along with improving irrigation management practices. This is the most important determinant of water stress, at least stress related to water quantity. In Texas, 63 percent of all water use is from irrigation. A second factor is changing the way we manage water, making water more productive. The goal would be to use the same amount of water to produce more by using improved technology and using higher-yielding crop varieties. Pricing water at full cost, increasing the awareness of water issues, finding ways to develop additional water supplies, and educating the public would also help people realize the importance of this vital resource. Finally, it must be understood that many of the practices used to manage water for human needs will also benefit ecosystems. Water is essential to life, development, and the environment, and the three must be managed together, not sequentially. Understanding this relationship calls on awareness and an understanding of the watershed (the appropriate scale of management), which leads to the sustainability of aquatic resources.

Sustainability, meeting the needs of the present generation without degrading the various components of the hydrologic cycle or the ecological systems that depend on it is the overarching objective. Setting ecological sustainability as a key goal acknowledges that ecosystems provide many outputs that humans require to sustain themselves as living, biological organisms. Human health and the integrity of ecological systems are inseparable objectives. Humans are "a part of" not "apart from" their environment.

To conclude, it is this understanding of water issues facing all citizens, along with developing knowledge about the unique characteristics of water, and finally the geological and environmental importance of water that sets this project in motion. Using the watershed as a reference point and realizing that the water needs of the state are varied and complex, students will begin to piece together a picture of the water issues facing various watersheds in the state.

TEXAS WATER

Water Distribution in Texas

Texas receives about 366 million acre-feet (1 acre-foot = 325,000 gallons, an area about the size of a football field covered with one foot of water) of rain in an average year.

Precipitation averages 56 inches per year in the eastern portions of the state and only eight inches in West Texas. This rainfall feeds 15 major river basins, eight coastal basins, and 6,700 inland reservoirs, and eight million acres of wetlands. (Texas has only one natural lake – Caddo Lake in East Texas. The other 6,700 lakes are reservoirs that are man-made.). About 97 percent of the surface water consumed by Texans is drawn from 191 reservoirs that each holds more than 5,000 acre-feet of water. At present, the state uses only about 65 percent of its surface water. Texas also has nine major aquifers (the Gulf Coast aquifer lies beneath Houston) and 20 minor aquifers; these are underground natural rock formations that hold groundwater.

Just about two-thirds (63.3%) of all water used in Texas is for irrigation, with 21.3% used for municipal purposes, and 15% for industrial use. Most water supply and demand projections show that Texas has enough water in the state as a whole, but each region in the state has different water resources, different needs, and faces different problems.

Texas Water - Management

Managing water resources in Texas is a difficult task. Consider the following factors. Texas has considerable geographic variation, so water supplies vary across the state, from shortages in West Texas to abundant supplies in the eastern portion of the state. Couple that with Texas' growing population demanding more water from basically a static supply, serious limitation on groundwater due to over-pumping and pollution, and a convoluted set of statutes and legal decisions involving water, and you have a management nightmare.

To sort out the complex water issues in the state, two agencies, the Texas Natural Resource Conservation Commission (TNRCC) and the Texas Water Development Board (TWDB), are involved in water use planning. The TWDB is charged with developing a state water plan to ensure that "sufficient water will be available at a reasonable cost to further the economic development of the entire state". The TNRCC issues water rights permits, wastewater discharge permits, and attempts to balance economic and environmental needs (it does this using total maximum daily loads, TMDLs, which is an estimate of the maximum amount of pollution a body of water can receive and still meet water quality standards). The TNRCC also oversees drinking water quality, and measures the water quality of all state rivers, streams, reservoirs, and bays to determine if they meet their designated use. Texas Parks and Wildlife (TPW) participates in the water rights permit process to protect aquatic habitat and wildlife along with aquatic ecosystems. If the TPW's concern is not met, it may request that the TNRCC hold public hearings on the water rights application.

In 1997 the Texas legislature, in part reacting to the drought of 1996, passed Senate Bill 1, more popularly known as the "Water Bill". Among other features, this changes the way the state conducts water planning. SB1 shifts the emphasis from water development to better management of existing water resources through conservation. It also shifted water planning from the state to the regional level by dividing the state into 16 regional planning areas (Houston is in region H), each of which is required to submit a regional plan (see www.texaswatermatters.org/region_h.htm). Both the TNRCC and the TPWB will review the plans, which will be updated within five years. The National Wildlife Foundation asked that region water planning groups give careful consideration to the following four principles: (1) sufficient water must be available to support fish and wildlife; (2) aggressive efforts are necessary to conserve water and minimize the demand for new water supplies; (3) new water projects must avoid the destruction and degradation of wildlife habitats; (4) both surface and groundwater supplies should be developed and managed in a sustainable manner.

Texas Water - Ongoing Concerns

Perhaps the single biggest policy issue related to the use of water is the question of the appropriate amount of fresh water needed to maintain the state's bays and estuaries (where a river meets the sea and fresh and saltwater mix). As rivers wind their way down to the gulf and water is used and reused for industry, irrigation, and municipalities, both the quality and quantity of the water are altered, affecting both bays and estuaries. These areas and their adjacent wetlands serve as important spawning grounds for many species of marine life and depend greatly upon the inflows of fresh water from rivers and streams. These aquatic habitats contribute around $2.9 billion annually to the state's economy. In addition, preserving these habitats helps ensure water quality, since they act as a natural filtering system for many pollutants.

The TPW, TNRCC, and the TWDB will determine how much flow must be allowed to pass through any new reservoir or diversion. Inflows are also necessary to protect aquatic flora and fauna. Diminished flows cause losses in habitat diversity, along with a decrease in stream productivity, and a degradation of water quality.

Surface Water Quality

The Clean Water Act of 1972 forms the basis today for water quality protection for surface water in streams, rivers, and lakes as well as for groundwater. It sets the water quality standards for major rivers and lakes and required discharge permits for both public and private facilities. It also protects wetlands by requiring the U.S. Army Corps of Engineers to issue permits, known as Section 404 permits, for all dredging and filling projects. Under the Clean Water Act, Texas must define how water bodies will be used and must develop and enforce a comprehensive set of water quality standards. Texas must monitor the water bodies to determine whether they meet the standards and produce a water quality inventory. This inventory is also the basis of the Clean Water Act 303(d) list, which identifies all "impaired" water bodies that do not meet their designated uses. The state is then required to implement watershed action plans to restore these impaired water bodies. The basis for these action plans is the development of the total maximum daily loads (TMDLs).

To protect surface water quality at the state level, the Texas legislature adopted the Clean Rivers Act, which directed the river authorities to conduct a regional assessment of water quality for each major river basin. The Clean River Act takes a river basin or watershed approach to water pollution management. Today, the TNRCC is the primary agency responsible for water quality management.

Pollution

Sources of pollution typically fall into one of two categories: point source pollution and nonpoint source pollution. Point source refers to pollutants discharged from one discrete location or point, such as a wastewater treatment plant. Pollutants discharged in this way could include fecal coliform bacteria and nutrients from sewage, heavy metals, or synthetic organic compounds. Nonpoint refers to pollutants that cannot be identified as coming from one discrete location or point. Examples would be oil and grease that enter the water with runoff from streets and nitrogen from fertilizers and pesticides. Since the passage of the Clean Water Act, most water pollution control efforts have focused on point source pollution, which generally comes from the millions of gallons of wastewater discharged from industrial facilities and sewage treatment plants. Nonpoint source pollution is difficult to control through regulation, because it results from our everyday activities, like fertilizing our lawns or maintaining our cars. For 1996, the major sources of pollution in reservoirs and bays were nonpoint, while city wastewater discharges were the major sources of pollution for streams and rivers.

The most common cause of pollution in surface water is elevated levels of nutrients and fecal coliform bacteria. High fecal coliform levels were identified in all coastal and river basins. Toxics, such as pesticides, metals, and PCBs, are also causing great concern. If soluble, they pose a threat if the water is used for drinking or swimming; if not soluble they may become attached to sediments and be consumed by aquatic wildlife, thereby entering the food chain. This puts humans at risk as the toxic compounds are magnified as they make their way up the food chain.

Other water quality concerns such as low oxygen levels, high nutrient levels (usually phosphorus, nitrogen, and ammonia), destruction of aquatic habitats through erosion, development, and dredging all reflect the degradation of surface water quality in the state.

Groundwater, like surface water is vulnerable to contamination from a variety of sources, but unlike surface water, groundwater does not benefit from the same protection. For example, there are no groundwater quality standards. In addition it is difficult to determine how much groundwater contamination results from human activities and how much contamination is due to natural causes (for example, saline intrusion). But in Texas, all nine major aquifers and 20 minor aquifers have experienced some from of contamination. These contamination problems stem partly from land-based development and over-pumping.

Coastal Resources

Coastal waters – estuaries, wetland, and bays – are critical to the economy and ecology of Texas. Almost three-fourths of the fish harvested in the Gulf of Mexico depend on estuaries and bays for mating and spawning. These wetlands are home to more than 80 species of plants and animals. Species that either live in or depend upon the estuaries include shrimp, oysters, blue crabs, and finfish. About 30,000 commercial fishermen catch almost 100 million pounds of coastal fish and shellfish worth an estimated $200 million. The total economic contribution from all coastal activity is $3 billion per year.

As more people move into the coastal area, fragile habitat is lost. More than one-third of the state's population is located within 100 miles of the coast and twenty percent of the state's population lives in the four counties surrounding Galveston Bay, Galveston, Chambers, Brazoria, and Harris. Along with population growth comes increased development and demands for water.

Estuaries and bays are threatened by a variety of pollution sources and are among Texas' most endangered waters. Most of these water quality problems are related to high levels of fecal coliform bacteria, but other problems exist, including the lack of freshwater flow, causing pollutants to concentrate in the estuaries.

Coastal wetlands are another part of Texas' endangered waters. Wetlands are defined in state law as areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support vegetation adapted for life in saturated soils. Coastal wetlands include salt and brackish marshes, tidal inlands, and forest scrub. Coastal wetlands act as a natural filter for various contaminants, they help control excessive runoff to the bays, they act as a buffer between land and water, and they are essential for many species of wildlife. Like the rest of coastal Texas, they are subject to a variety of threats. Subsidence, soil erosion, and conversion of wetlands for urban or agricultural development are the major threats to these areas. In 1991, wetlands were recognized for the first time as "waters of the state" under Texas Water Quality Standards and a policy of no-net-loss of state owned wetlands was adopted by the state legislature.

THE WATERSHED - A FOCAL POINT

Texas has a rich and diverse collection of rivers, with the Pineywoods bayous and moss-draped cypress lined streams of East Texas to the spring-fed, limestone-bedded rivers of the Edwards Plateau, and on to the arroyos of the Trans-Pecos Mountains, each with its unique set of circumstances. The watershed provides a framework, which integrates ecological, geographical, geological, and cultural aspects of the land. The term watershed in this context is the entire area drained by a stream and its tributaries. The highest land surrounds the river basin, forming its outside boundary as well as dividing it from adjacent basins. From this boundary, or divide, all water falling into the basin flows downhill to a pour point. From this point the outlet could be a stream, lake, playa, estuary, aquifer, or ocean. A watershed can be as large or as small as you want to define it.

The 13 major river basins of Texas vary greatly in size, shape, and stream patterns. Although the river basins share many common features, each is unique. River basins reflect the climate, geology, topography, and vegetation of an area.

Five Texas river basins originate outside Texas. Two begin in Colorado: the Rio Grande in the San Juan Mountains at about 14,000 feet and the Canadian River in Raton Pass at nearly 8,500 feet. Three rivers commence in New Mexico: the Red River as Blanca Creek at 4,640 feet, the Brazos River in Running Water Draw at about the same elevation and the Colorado River in Sulfur Draw at about 4,000 feet. The eight other Texas river basins originate within Texas.

The Canadian and the Red Rivers have their outlets, or pour points, beyond Texas. Our remaining 11 river basins spill into the Gulf of Mexico. Only the Rio Grande and the Brazos River discharge directly into the Gulf of Mexico, where they built substantial deltas in the recent past. The remains of their deltas make the shoreline bulge into the Gulf of Mexico.

The remaining river basins spill into estuaries and bays along the coast. The Sabine and Nueces Rivers flow into Sabine Lake and where they join as one river basin. Similarly, the Trinity and San Jacinto Rivers drain into the connected Galveston and Trinity Bays. The Colorado River, which formerly combined with the Brazos River in delta building, now flows into Matagorda Bay. The Lavaca River empties into Lavaca Bay, the Guadalupe and San Antonio together build a delta into San Antonio Bay, and the Nueces River discharges into Corpus Christi Bay.

In Texas, watersheds come in all sizes and shapes. No matter where you live, you are in a watershed. The Rio Grande is the longest, 1,250 miles in Texas, covering 48,259 square miles, the San Jacinto River basin, only 70 miles, the smallest.

Climate, especially rainfall and evaporation, strongly controls the flows of rivers and streams in Texas. In the Sabine River basin, mean annual rainfall is nearly 60 inches and annual evaporation is less than 70 inches, whereas in the Rio Grande basin, mean annual rainfall ranges from 8 to 20 inches and annual evaporation is as much as 105 inches. This pattern creates year around stream flows in East Texas streams and rivers, but only intermittent flows in most West Texas streams.

The river basin is also strongly defined by its geology. In wetter East Texas, where uncemented sand and mud dominate the landscape, river valleys are wider and contain meandering streams carrying great loads of suspended sediments. In contrast, West Texas streams cut deep river channels into the hard limestone and sandstone canyon walls. These streams usually flow clear.

Using the watershed as a focal point is logical considering that all surface water within the basin that is not consumed, contained, or evaporated eventually reaches the river basin. Consequently, all human and natural activities along the basin have the potential to affect water quality. Industrial, municipal, agricultural, and other activities are interrelated with the quality of surface water within the watershed. By looking at the entire watershed, and the total impact on the water quality of that system, a clear picture of the supply and demand issues, ecological impacts, and other problems faced by the system is highlighted.

Texas rivers serve the citizens of this state well. They quench our thirst, provide magnificent scenery and recreation, create habitats for our wildlife, and supply water for agriculture and industry. It is sad to note that no Texas river basin is in a natural state; all have been impacted by humans in some manner.

GENERAL TEACHING STRATEGY

Overview

This unit is geared toward a sixth grade class with limited experience in the area of environmental science. To make the unit more meaningful it will be necessary to cover certain fundamental science topics. Water chemistry and the physical properties of water will be covered. Specific activities on pH, evaporation and condensation, non-point source pollution, and other topics will be discussed. There will be a collection of articles from National Wildlife, Texas Parks and Wildlife, Audubon, and other magazines featuring articles focused on water issues and related topic for students to read.

Once this is completed, students will be placed into groups of two and assigned a particular watershed at random. Over the course of the project, students will be given specific tasks related to their watershed. They will be required to keep a journal of their findings and at the end of their journey, students will be required to make a class presentation on their particular watershed. This will be done using display boards on which they will have illustrated various components of the project. I anticipate the project lasting one nine-week semester (depending on the class and interest, time will be adjusted accordingly). Arrangements will be made with the Trinity River Authority to view Lake Livingston, the dam, and various components of their system (whether this is done before the unit or after is yet to be determined). Various speakers will be invited to come and discuss issues and plan activities dealing with water in the state of Texas.

The first task will be to describe the geography of the watershed. Does geography play a role in the problems that the watershed is facing? For example, the Upper Panhandle relies almost exclusively on the Ogallala Aquifer; however the aquifer is a rapidly depleting resource. Surface water (from the Canadian and Red Rivers) is limited. How does the geography of the land help or hinder the regions water planning?

Students will be supplied with the addresses of various agencies in order to write and ask for information related to their watershed. Websites such as www.epa.gov/surf/ allow the student to link his watershed to an environmental profile. Along with this profile is a listing of the counties and metropolitan areas located in the watershed.

Texas Parks and Wildlife's website, www.tpwd.state.tx.us/texaswater/rivers/index.htm, provides addresses for students to write their watershed's governing body or river authority. River authority sites have the area's history, the purpose of the water authority, and other useful information. The *Texas Environmental Almanac* also includes information on each specific regional water planning area and its current needs and status.

A discussion of the flora and fauna of the watershed along with any endangered species can be found at www.tpwd.state.tx.8us/nature/nature.htm. Students will investigate the relationship between water issues and wildlife issues. How are they related and what is being done to protect the wildlife of the state. Specific activities and worksheets will be generated for the students. Writing the TNRCC, the TPW, and other agencies will be required for each group.

The following activities are a very small sample of the almost infinite amount of activities and lessons related to water science found either on the web or in books such as *Project Wild*. If you search the web you will find information specific to your needs. I have listed some of the more inclusive sites in the bibliography.

LESSON PLANS

Plan Number One

Question

What is a topographical map and how can it tell us where water flows? Understanding where water flows as it makes its way into streams, ponds, and rivers can give insight into the biological, physical, and chemical characteristics one may see in these bodies of water. A topographic map represents the elevation change over a particular landscape using contour lines to show elevation. Different elevations are marked by different contour lines creating a series of loops and circles. Reading the lines is key to understanding how water flows over the land and its watershed.

Topographic maps can give us clues about the type of stream we have in our area, even if we have never seen it in person. The steepness of the land and land use such as housing developments, farming, or urban areas can all have potential effects on the quality and characteristics of a local stream. Human use of water resources such as channelization (straightening of a stream to deter meandering along the flood plain) and dams creating reservoirs can also be seen on topographical maps. The reasons for creating these types of alterations to a stream or river can lead to insightful discussions with students regarding where their water comes from.

Objectives

Students will identify characteristics of topographical maps and learn to use and create them to describe water flow.

Materials

Sample topographic maps
Cardboard cut into five shapes
Graph paper
Ruler
Map pencils

Procedure

1. Give each student a topographic map. Review some of the basic characteristics of the map such as contour lines, scale, and key.
2. To illustrate what the contour lines represent, have students make a map of a mountain using the cardboard shapes. Starting with the largest piece, have them place it on their graphing paper and trace around the edge. Continue tracing the cardboard pieces inside the traces they just made until an outline of the smallest piece has been done. The resulting map will be a topographical map of their mountain.

Plan Number Two

Background

Every molecule of water that was present when the earth's oceans were formed is still present today in one of water's three forms – as a gas, a liquid, or solid ice. Most of the freshwater in the world is frozen in the polar ice caps. The largest part of what remains is groundwater, underground water that moves between layers beneath the earth's surface. We increase our population but we still have the same amount of water. Some places in the world will have access to less water unless we conserve. The major purpose of the activity is for students to become aware of the amount of water they use and waste each day at school and to make recommendations for ways to conserve the water both at school and at home.

Objectives

Students will: (1) record and interpret how much water they use in a day at school; and (2) make recommendations as to how they can save a significant percentage of that water.

Method

Students estimate and calculate water use in school and then design and try ways to conserve water.

Materials

Paper
Pencil
A variety of liquid measurement containers

Procedure

1. Ask the students to estimate how much water each student uses each day at school. Have containers of different volumes for students to use as a reference. Write down their estimates and have students make a graph using this information.
2. Ask students to monitor their use of water for a day. They will time their drinks of water and record the data in a notebook. They will also do the same for washing their hands, using the restroom, etc.
3. Have each student come up with an individual number of gallons used per day. (Use three gallons per flush.)
4. Compare the estimates to the actual water used.
5. Find the class average, the range, mode, and median. Why are certain students above or below the average?
6. Ask the students if it would be possible to reduce the amount of water used and if so, how? For example, cups could be used at the drinking fountain to reduce the amount of water going down the drain.
7. After a day or two, ask if the conservation practices changed their behavior or attitudes.

Plan Number Three

Background

An ecosystem is a community of different species interacting with each other and with the chemical and physical factors making up its nonliving environment. In a local environment, physical factors such as sunlight, moisture, temperature, and wind influence the stability of an area and determine the kinds of plants and animals that live there.

Objectives

Students will: (1) investigate and measure components in three different ecosystems; (2) describe similarities and differences they observe among three ecosystems; and (3) identify ways that the abiotic components of an ecosystem affect the biotic components.

Method

In this activity, students will examine three different environments as they focus on sunlight, soil moisture, temperature, wind, plants, and animals in each environment. By comparing different environments, students will begin to consider how nonliving elements influence living elements in an ecosystem.

Materials

Butcher paper
Marking pens
Paper for recording observations
A trowel
Light meter
Thermometer
Small strips of paper
Compass

Procedure

1. Find three sites that are somewhat different from each other in terms of sunlight, air temperature, soil moisture, wind, and number and types of plants and animals living there.
2. If possible, select one site that is open, like a field or lawn; one that has trees; and one that contains water. Plan to visit the sites on the same day at about the same time.
3. Use the butcher paper and marking pens to record each team's data.
4. Help students to see that any place has both living and nonliving parts that work together to make an ecosystem. Explain that they will investigate ecosystems at three different study sites to find out how living and nonliving elements affect each other.
5. Divide your class into six teams. Explain that each team will investigate and record observations of a different component of three different study sites.
   Team One – *Soil*: Ask this team to determine the soil moisture at the three sites. Students should determine the moisture (wet, moist, dry), and they should look for other characteristics such as texture, color, and smell. They should also notice if the soil has plant material or organisms and record this data.
   Team Two – *Sunlight*: Ask this team to determine how much sunlight penetrates the ground at each study site. This can be determined by using either a light meter or photosensitive paper.
   Team Three – *Wind*: Ask students to determine wind movement and the direction of the wind for each site.
   Team Four – *Temperature*: Ask the team to measure each site's temperature at ground level, one inch deep into the soil, and at one yard off the ground.

Team Five – *Plant Life*: Ask this team to observe the various kinds of plants at each site (large or small trees, shrubs, plants, grasses). Also record the most common types of plants found in each location and where each grows relative to the others.
Team Six – *Animal Life*: Ask this team to note the various kinds of animals at each site (insects, reptiles, fish, and frogs). Students should also look for any kind of evidence of animals such as scat or tracks.

6. After teams have had sufficient time to investigate each location, have them come together and present their findings to the group.
7. Prepare a large class chart and discuss differences and similarities between the sites.
8. Questions:
    a. Which site had the greatest number of plants? Animals? Which has the least of each? How can you explain this difference?
    b. How are plants and animals the same at different sites? How are they different?
    c. Which site had the highest air temperature? The lowest? The most wind? The least?
    d. Which had the wettest soil? The driest?
    e. Do plants seem to affect the light intensity, air temperature, and soil temperature in an area?
    f. How does water seem to influence the soil temperature, air temperature, and soil moisture?
    g. What relationship does light seem to have with air temperature? With soil moisture? With plants?
    h. Which of the six elements that we studied seems most important for determining the character of the environment at each site? What makes you say so?
9. Visit each site again at different times throughout the year and notice if things have changed. How have humans affected each site? Have the effects been harmful or positive?

ANNOTATED BIBLIOGRAPHY

Teacher Resources

Austin AIM High Office and the Texas Natural Resource Conservation Commission. *WET Instruction Handbook*. GI-26. Austin, Tex.: Austin AIM High Office and the Texas Natural Resource Conservation Commission, September 1990.

Ball, Philip. *Life's Matrix: A Biography of Water*. Berkeley, Calif.: University of California Press, 2001.
Philip Ball, a writer for Nature magazines, describes every aspect of water. From its origins to NASA's search for water in the farthest reaches of the solar system, Ball covers it all.

Huser, Verne. *Rivers of Texas*. College Station, Tex.: Texas A&M University Press, 2000.
Wonderful book on the rivers of Texas based on the author's experiences. Huser explains how everything in Texas affects or is affected by its rivers.

Slattery, B.E. *WOW! The Wonders of Wetlands*. Michaels, Md.: Environmental Concern Inc., 1995.
Full of information and activities for all ages concerning wetlands, activities are correlated with the National Science Education Standards.

Texas Center for Policy Studies. *Texas Environmental Almanac*. Austin, Tex.: University of Texas Press, 2000.
An environmental road map of the state, drawn from a wide array of sources. A useful reference book when needing facts and figures on environmental issues in the state.

Texas Natural Resource Conservation Commission. *Conducting a Watershed Survey*. 2001. GI-232.

Internet Resources

www.adopt-a-watershed.org/about.htm
Uses a local watershed as a living laboratory to make the activities dealing with watersheds come alive. Includes a K-12 curriculum and plenty of activities.

www.texas.sierraclub.org/water/
Sierra Club's Lone Star Chapter water resource pages.
Includes a position paper, principles for an environmentally sound regional water plan, comments on Region H's water plan, and other information on Texas water issues.

www.tpwd.state.tx.us/nature/nature.htm
Texas Parks and Wildlife site
Site covering Texas rivers; river authorities, flow rates, and a great deal more.

www.bickerstaff.com/articles/waternut.htm
Excellent website covering the fundamentals of Texas water law.

www.texaswater.org/water/conservation/default.htm
A listed of websites dealing with efficient use of the state's water.

www.epa.gov/owow/watershed/index2.html
Environmental Protection Agency
EPA's strategy for protecting and restoring aquatic ecosystems.

www.epa.gov/surf/
Environmental Protection Agency
Allows you to find a great deal of information on your favorite watershed.

Student Sources

www.epa.gov/water/kids/waterforkids.html
Water for Kids
Websites devoted to explaining water issues in kid terms. A variety of sites geared toward middle school students.

www.epa.gov/safewater/kids/exper.html
Hands-on activities and investigations, fact sheets, reference materials, and a glossary for K-12.

http://ga.water.usgs.gov/edu/
USGS's Water Science for Schools website.
A wealth of information.