Texas A&M AgriLife Extension

EXPLORE

Water Projects

Exploring Water

texas4-h.tamu.edu

EXPLORE

TEXAS 4-H WATER PROJECT

Description
The Texas 4-H Explore series allows 4-H volunteers, educators, members, and youth who may be interested in learning more about 4-H to try some fun and hands-on learning experiences in a particular project or activity area. Each guide features information about important aspects of the 4-H program, and its goal of teaching young people life skills through hands-on experiences. Additionally, each guide contains at least six learning experiences, which can be used as a project guide, or as activities for six different 4-H meetings.

Purpose
Texas 4-H is designed to develop the youth of our state into productive adult citizens. The 4-H Program uses a non-formal educational process of engaging youth in a "learning by doing" process. This includes hands-on opportunities, participation in workshops and clinics conducted by volunteer leaders or professionals, as well as competitive experiences which allow 4-H members to demonstrate the knowledge they have gained. Through this entire process, the youth are learning key life skills such as working with others, teamwork, cooperation, and goal setting. Through all experiences, youth get to interact with adult volunteers and county Extension agents.

What is 4-H?
4-H members across the nation are responding to challenges every day in their communities and their world.

As the youth development program of the Cooperative Extension System of land-grant universities, 4-H is the nation's largest youth development organization, empowering six million young people throughout the United States. Cooperative Extension of 1862 and 1890 land-grant universities provide leadership to engage young people in 4-H in all 3,007 counties of the United States. The impact of the Cooperative Extension partnership is profound, bringing together National Institute of Food and Agriculture of USDA, land grant universities and county government to resource learning opportunities for youth.

Through America's 110 land-grant universities and its Cooperative Extension System, 4-H reaches every corner of our nation—from urban neighborhoods to suburban schoolyards to rural farming communities.

With a network of more than 6 million youth, 600,000 volunteers, 3,500 professionals, and more than 25 million alumni, 4-H helps shape youth to move our country and the world forward in ways that no other youth organization can.

Texas 4-H
Texas 4-H is like a club for kids and teens ages 5-18, and it's BIG! It's the largest youth development program in Texas with more than 550,000 youth involved each year. No matter where you live or what you like to do, Texas 4-H has something that lets you be a better you!

You may think 4-H is only for your friends with animals, but it's so much more! You can do activities like shooting sports, food science, healthy living, robotics, fashion, and photography.

Look for 4-H clubs at your school, an after-school program, a community center, or even on a military base or through the reserves for military families.

Texas 4-H is part of the Texas A&M AgriLife Extension Service and the Texas A&M System. Founded in 1908, 4-H is the largest youth development program in Texas, reaching more than 550,000 youth each year.

The 4-H Motto and Pledge
"To Make the Best Better!"

I pledge: My HEAD to clearer thinking, My HEART to greater loyalty, My HANDS to larger service and My HEALTH to better living, For my Club, my Community, my Country, and my world.

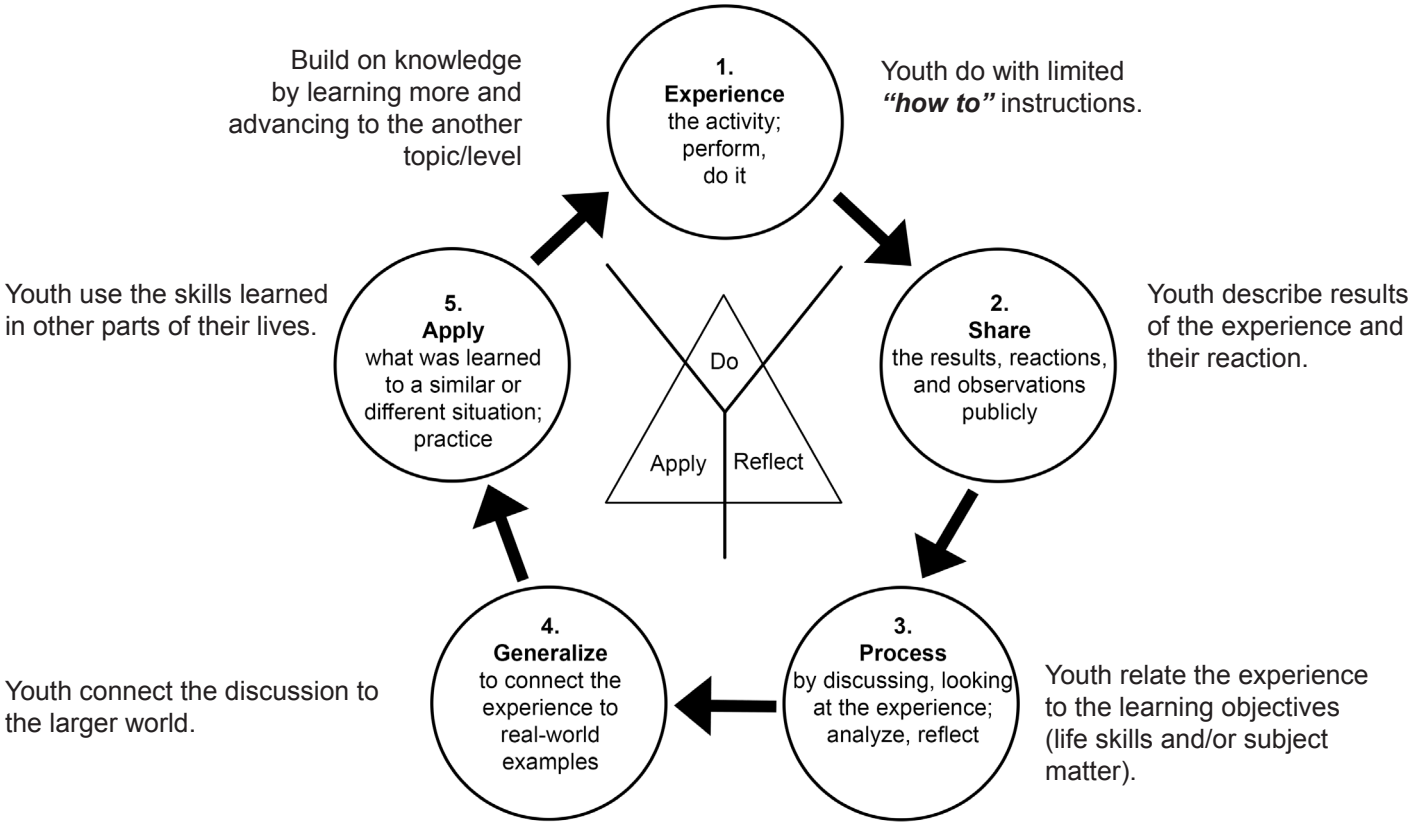
Participating in 4-H
4-H is a great program because it provides options for young people to participate. From a 4-H club located in your community, a SPIN club that focuses on one particular project area, or participating in 4-H through your classroom at school, 4-H allows youth to learn in many different environments. If you are interested in joining 4-H, contact your County Extension Office and ask for a list of the 4-H clubs in your area. If you are a school teacher/educator and would like to use 4-H curriculum or these project guides in your classroom, contact your Extension Office as well for assistance.

4-H "Learning by Doing" Learning Approach

The Do, Reflect, Apply learning approach allows youth to experience the learning process with minimal guidance from adults. This allows for discovery by youth that may not take place with exact instructions.

EXPLORE THE CONTENT

Introduction of the topic, overview and exploration of content, and review of objectives



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Developed by:
David Smith

EXPLORE Water Project

Its Value to Me, My Community, and My World

TIME:
30-45 minutes

MATERIALS NEEDED:
- Pencils
- Territorial map (1 map per team of 2 youth)

OBJECTIVES:
The 4-H member will:
- Understand the many ways our society depends upon water.
- Discover the challenges we face in providing a safe and reliable source of water to meet the many demands of our community and world.

EXPLORE THE CONTENT:
The importance of water cannot be overstated or overvalued. Though we often take it for granted, access to abundant, clean, safe, and affordable water affects our health, drives our economy, and adds to our quality of life. Unfortunately, millions of people around the world live in places where water is so limited or in such poor quality that much of their day is spent finding water to meet bare necessities. Water in these regions is essential for survival, but ironically much of this water is contaminated and is a major source of sickness and disease.

Water is important to practically every aspect of our life, and in ways we often do not recognize or appreciate. Water is essential to food production, transportation, sanitation and health, energy production, recreation, and even politics.

The most prosperous civilizations have always enjoyed access to fresh water, and the lack of water has been the downfall of others. Throughout history, people have wanted to live near rivers, lakes, and oceans. Even today, the U.S. the population density of counties located along coastal shorelines is more than 6 times greater than inland counties. In fact, these coastal counties account for 39% of the total U.S. population.

Since the dawn of civilization, irrigation has been used to grow food and fiber. As early as 6000 BC the Egyptians and Mesopotamians diverted water from the flooding Nile and Tigris rivers to agricultural fields. In 2000 BC the Romans built cement pipes to carry water. Even today, irrigation is extremely important for states like Texas, where more than 58% of total water use is for irrigation.

Water plays an essential role in transportation. Compared to rail, truck, and air carriers our major rivers and oceans offer a relatively inexpensive means to transport food and other commodities from inland locations to ports where ships and barges distribute cargo across the globe. In fact, water is the leading mode of transportation for U.S. trade of goods to foreign countries in terms of both amount and value.

In our communities, we rely upon water for drinking and sanitation. In the U.S. alone, there are more than 1.2 million miles of underground water pipe mains that distribute water from water sources to our homes and businesses. Water from septic systems is routed to treatment facilities where it is cleaned and released back into streams and rivers. Some treated water is even re-used

for landscape irrigation.

Water is also important for energy production. Hydropower is the most widely-used renewable source of energy. China is the largest producer of hydropower, followed by Canada, Brazil, and the United States. The largest use of water in the U.S. is for generating electric power. Power plants take 49% of the water used each day, mostly for cooling. Hydraulic fracturing (a process used to extract oil and natural gas) can use up to 5 million gallons of water on a single oil or gas well.

Water recreation provides an escape from the hustle and bustle of everyday activities. A trip to the lake for a day of boating or fishing, a canoe ride along a river, or a trip to the local water park adds fun and relaxation to our busy lives. Water tourism and recreation is also good for our economy. In fact, a recent report showed that outdoor recreation in Texas generated $28.7 billion in consumer spending, created 277,000 jobs, and $1.9 billion in state and local tax revenue.

Some water bodies, such as rivers, serve as the boundaries between counties, states, and even countries. For example, the Rio Grande River is the boundary between Texas and Mexico. Where rivers serve as borders between two different governments, conflict over water is common especially between countries whose economies depend upon a reliable and secure source of water (such as for growing crops). In these cases, treaties are often written to keep the peace.

DO:

Stake your claim!

1. Read the scenario as follows: Travel back in time to the year 1750. A new, uninhabited continent has been discovered and you along with two others from the Kingdom of Blowing Sand have been selected as governors of the three territories shown on the map. As winner of rock, paper, scissors, you have first choice of the three territories from which to build a new community. As a time traveler from the future, you understand very well the importance of water and its value to you, your community, and the world. It just so happens that the latitude of the new continent is similar to that of present day United States and Mexico. You can therefore assume that the climate, temperature and precipitation variations, and seasons are similar to that we experience today.
2. Group youth in pairs and provide them with a map of the new continent.
3. Identify topographical features such as rivers, mountains, lakes, coastlines, and oceans.
4. Have each pair select and name their new territory.
5. Discuss the selections and what factors influenced their decision. How important was water in their choice of territory?

REFLECT:

- What assumptions did you make about water when making your decision? (Possible answers ... “it’s clean”, “it’s abundant”, “groundwater is accessible”, etc.)
- What are the challenges in providing a consistent, clean, and safe supply of water to your territory?
- Whose is responsible to make sure water is available to everyone in the territory?
- How might a claim by someone else in an adjoining territory affect your claim?

APPLY:

- How has this activity helped bring to mind the value of water in your community and world?
- How might a significant drought, flood, or other natural disaster affect water supply in your community?
- What can we do to help others appreciate the value of water?

REFERENCES:

- National Geographic (2014). 13 Things You Probably Don't Know About the U.S. Water System (But Should). Retrieved on November 2, 2016 from: http://voices.nationalgeographic.com/2014/08/12/13-things-you-probably-dont-know-about-the-u-s-water-system-but-should/
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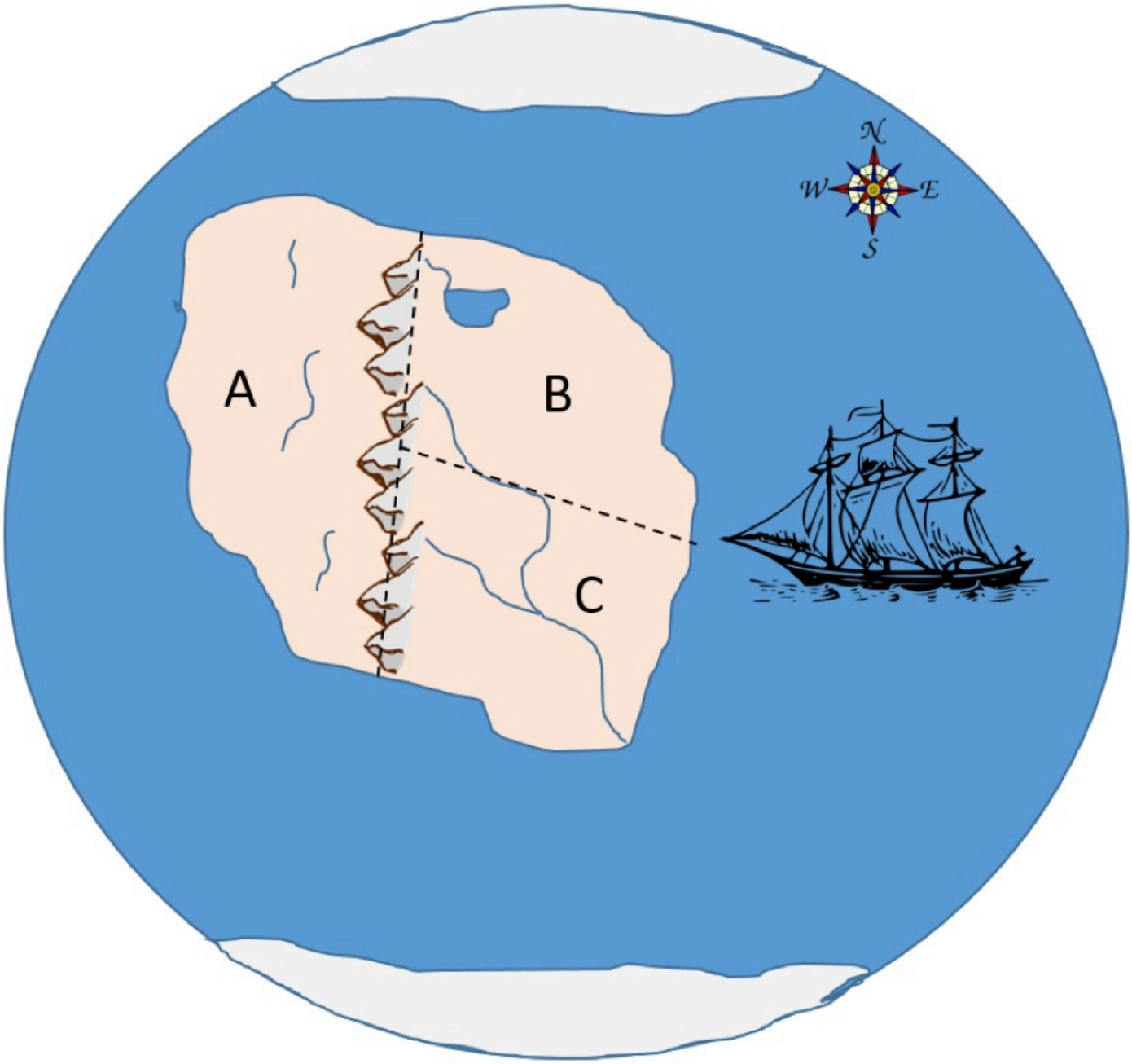
ACTIVITY: Stake Your Claim Handout



Navigating the Water Cycle

TIME:
30 -45 minutes

MATERIALS NEEDED:
- Pencils
- Water cycle graphic
- Lesson 2 – Worksheet (1 per pair of youth)

OBJECTIVES:
The 4-H member will be able to:
- Learn the key components and processes that drive earth's water cycle.
- Identify the natural factors and human activities that affect the water cycle.
- Recognize that even small scale changes to the water cycle can have broad societal impact.

EXPLORE THE CONTENT:
The water cycle, sometimes referred to as the 'hydrologic cycle' describes the state and movement of water on, in, and above earth. In 1756, Russian scientist Mikhail performed experiments and discovered the Law of Conservation of Mass which states that for any closed system, mass can neither be created nor destroyed, although it can be rearranged in space or changed in form. As we examine the water cycle and its many moving parts, we can see the application of this principle. We already have all of the water we will ever have. Some of it is found deep within earth's magma and through volcanic activity adds new water to the terrestrial balance. However, on earth as a whole, the total volume of water only changes form and location and also distributes energy (heat) around the planet making life as we know it sustainable.

There are many things that occur naturally that impact the water cycle and its many parts – on a large and small scale. For example, it is known that the buildup and movement of heat in the oceans affects precipitation and temperature patterns for many parts of the globe. On a smaller scale, excessive groundwater pumping and changes in land use can impact streamflow and evaporation. The following activity will help identify natural factors and human activities that influence the water cycle and its many components over a small region.

DO:
1. Group youth in pairs and provide them a copy of the water cycle depiction and accompanying worksheet.
2. Have students complete the worksheet.
3. Discuss responses as a group.
4. As a pair, draw emoji's to illustrate each of the terms in the water cycle and share them among the group.

REFLECT:
- What components of the water cycle are most likely to be impacted by human activity?
- What human activities have the greatest overall effect on the water cycle?
- Think about your county or community. How might human activity in one location impact the water cycle in a neighboring county or community?

APPLY:

- How has this lesson brought to mind your role in the water cycle?
- What part of the water cycle do you find most interesting? Difficult to understand? Why?

REFERENCES:

- United States Geological Survey (2016). Summary of the Water Cycle. Retrieved November 2, 2016 from: http://water.usgs.gov/edu/watercyclesummary.html

ACTIVITY: Water Cycle Activity

In school you have likely covered the water cycle and its important components. To refresh your memory, read through the following explanation of the water cycle as written by the United States Geological Survey (USGS) with certain key words left blank. Choose the word or phrase from the answer bank to complete the description of the water cycle.

ANSWER BANK – USE EACH TERM ONLY ONCE

sublimation	infiltrates	evaporation	aquifers
evapo-transpiration	ocean	springs	sun
glaciers	condense	precipitation	ice caps

The water cycle really has no real starting point, but let's begin where most of Earth's water exists – the _____. The _____ is the primary driver of the water cycle. As it heats the water in the ocean, some water is changed from a liquid to a gas (or vapor) through a process called _____. On land, soil and plants also take up and release water into the atmosphere. This process is called _____. In extremely cold climates, _____ changes snow and ice directly from a solid state directly to a gas without going through the liquid phase. Rising air currents then move this water vapor high into the atmosphere where the cooler temperature causes it to _____ and form clouds.

As air currents move clouds around the globe, cloud particles collide, grow, and fall out of the sky as _____ such as rain, snow, ice, or hail. In cold regions and high elevations, snow and ice can accumulate for thousands of years forming _____ _____ and _____. In warm climates snowmelt and rainfall will percolate into underground _____ or run off into lakes, rivers, and streams. When groundwater is near the surface, it can appear as _____ which often contribute to the base flow of a river or stream. Some water that _____ (or soaks into the ground) is used by trees, grass, shrubs, and other plants. Groundwater and surface water that is not absorbed, used by plants, evaporated, or consumed by humans and animals, eventually finds its way back to the ocean where the water cycle "ends" ... oops - I mean, where it "begins."

ACTIVITY: Water Cycle Activity - ANSWER KEY

In school you have likely covered the water cycle and its important components. To refresh your memory, read through the following explanation of the water cycle as written by the United States Geological Survey (USGS) with certain key words left blank. Choose the word or phrase from the answer bank to complete the description of the water cycle.

ANSWER BANK – USE EACH TERM ONLY ONCE

sublimation	infiltrates	evaporation	aquifers
evapo-transpiration	ocean	springs	sun
glaciers	condense	precipitation	ice caps

The water cycle really has no real starting point, but let's begin where most of Earth's water exists – the **ocean**. The **sun** is the primary driver of the water cycle. As it heats the water in the ocean, some water is changed from a liquid to a gas (or vapor) through a process called **evaporation**. On land, soil and plants also take up and release water into the atmosphere. This process is called **evapo-transpiration**. In extremely cold climates, **sublimation** changes snow and ice directly from a solid state directly to a gas without going through the liquid phase. Rising air currents then move this water vapor high into the atmosphere where the cooler temperature causes it to **condense**, forming clouds.

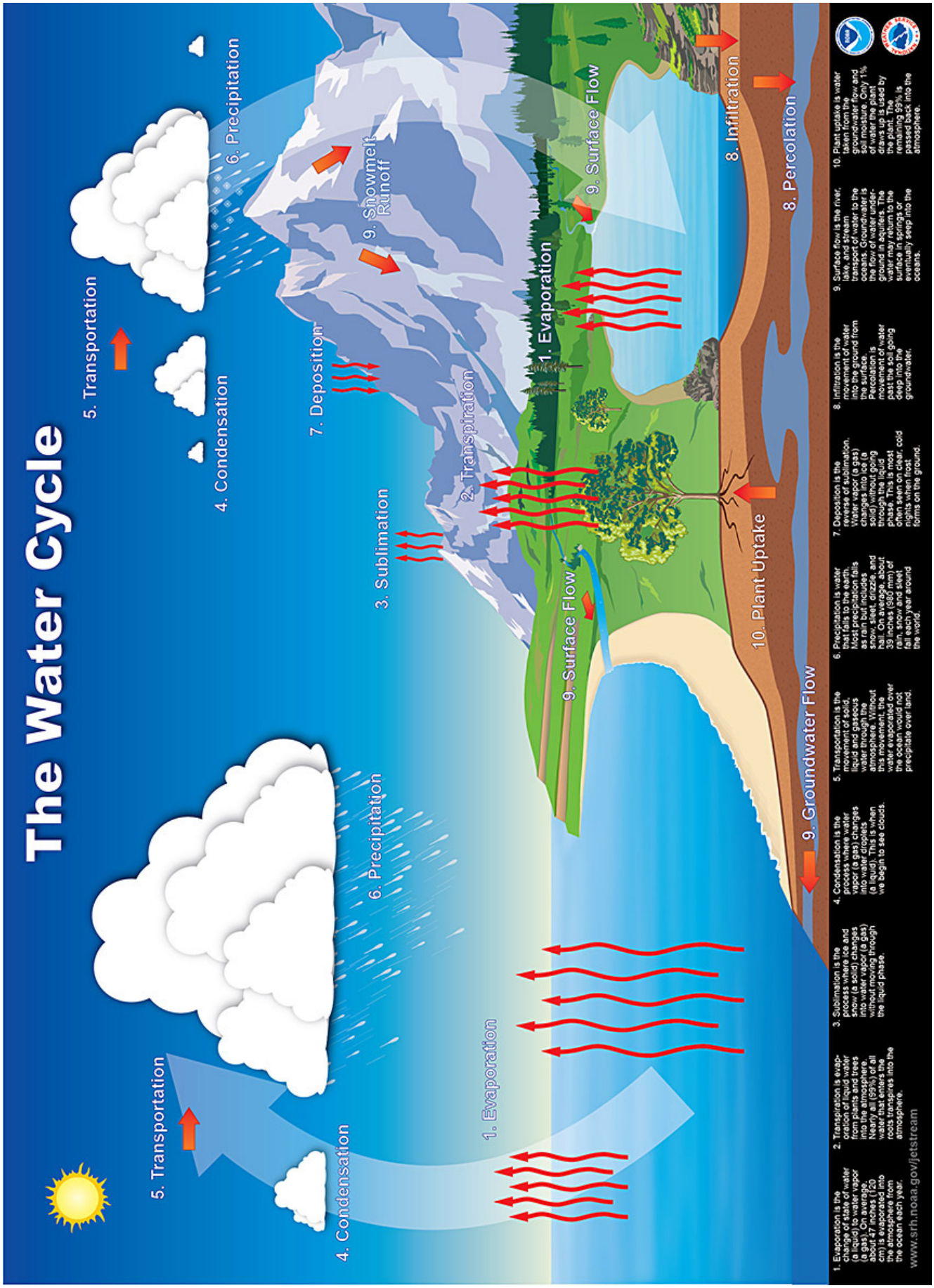
As air currents move clouds around the globe, cloud particles collide, grow, and fall out of the sky as **precipitation** such as rain, snow, ice, or hail. In cold regions and high elevations, snow and ice can accumulate for thousands of years forming **ice caps** and **glaciers**. In warm climates snowmelt and rainfall will percolate into underground **aquifers** or run off into lakes, rivers, and streams. When groundwater is near the surface, it can appear as **springs** which often contribute to the base flow of a river or stream. Some water that **infiltrates** (or soaks into the ground) is used by trees, grass, shrubs, and other plants. Groundwater and surface water that is not absorbed, used by plants, evaporated, or consumed by humans and animals, eventually finds its way back to the ocean where the water cycle "ends" ... oops - I mean, where it "begins."

ACTIVITY: Lesson 2 Worksheet

Water Cycle Component	What natural factors could change this part of the water cycle?	What are possible consequences?	What human activities could change this part of the water cycle?	What are possible consequences?
Water stored in the ocean				
Evaporation				
Precipitation				
Water stored as snow pack, ice and glaciers				
Stream flow				
Water stored in aquifers				
Spring flow				
Water stored in lakes and streams				
Infiltration				

ACTIVITY: Lesson 2 The Water Cycle

Source: http://www.noaa.gov/resource-collections/water-cycle



A Bird's Eye View of Community Water Planning

TIME:
30 - 45 minutes

MATERIALS NEEDED:
- Pencils, markers, tape or glue for each pair of youth
- Cut-out sheet for each pair of youth
- Contour map for each pair of youth

OBJECTIVES:
The 4-H member will:
- Understand the two major sources of water available for communities
- Learn about the essential components of a community water supply system
- Discuss natural factors and human activity can impact water availability

EXPLORE THE CONTENT:

In the US, water for human consumption, irrigation, and energy production comes primarily from two sources: surface water and groundwater. Though a substantial amount of water for irrigation is pumped directly from rivers and streams, municipalities depending upon surface water pump it from large reservoirs built along river systems. In Texas, more than half of the available surface water comes from reservoirs (lakes). Texas has 188 major reservoirs used for water supply and more than 20 others that serve no water supply purpose. Initially constructed for flood control, reservoirs are critical for storing water during times of drought when the rivers run shallow.

Groundwater supplies about half of the drinking water needs for the U.S and about 64% is used for irrigation. In Texas there are 9 major and 20 minor aquifers, underground layer of rock, gravel, sand, and silt that stores water and allows it to flow slowly beneath our feet. Water wells are dug into the aquifer and water is pumped to the surface for use. Many cities, farms and homes located away from rivers and reservoirs rely upon groundwater exclusively to meet their water needs.

Whether a community gets its water from reservoirs or from aquifers, it must be safe. Water treatment facilities clean and disinfect 'raw' water to a high quality suitable for public consumption. The most common water treatment processes include:

- Chlorination to control algae and stop biological growth
- Aeration to remove minerals such as iron and manganese
- Sedimentation to separate out solids
- Filtration to remove small particles
- Disinfection to kill bacteria, viruses, and other pathogens

Water treatment facilities are an essential part of any community water supply system. They are located in secure areas away from flood zones and protected from contamination.

From water treatment facilities, water is pumped into elevated water towers. Water towers serve two main purposes: 1) store large amounts of water to meet community needs, and 2) provide water pressure that pushes water over long distances. Depending on the size of the community and total water needs, there may be one or more water towers located throughout the city or town. Water pressure is generated when water is elevated. This is due to gravity. For example, a water tower 100 foot tall will produce

about 45 psi (pounds per square inch). Where the landscape is very flat, water towers are often very tall and installed at the highest point in the area. Where the topography is hilly or mountainous, you will find shorter water towers but they are usually located on the side or atop a hill. When properly located, water towers reduce the need for expensive pumps to generate water pressure.

In a community, much of the water previously used for cleaning and sanitation is routed through a wastewater treatment facility where it is either returned to the environment or reused for other purposes. Many residences have septic systems which separate solids from liquid and allow water to drain into underground pipes and into the surrounding soil. Other residences and business are connected to community wastewater treatment facilities that collect, clean, and release water back into streams. Often this water is "reclaimed" for other uses such as landscape irrigation. The level of wastewater treatment depends upon local water quality and environmental regulations. In regions where water is scarce, wastewater reuse is a common practice. This reduces the total demand on potable water sources.

Planning a water supply source for a new or growing community is challenging. There are many advantages and disadvantages to using surface water and groundwater. Surface water supply depends upon precipitation and stream flow. Groundwater is not only dependent on precipitation, but how much water is available will depend on where a well is located. Care must be taken to make sure that the amount of water being pumped out of the aquifer does not exceed the amount being replaced by recharge. Other complications to consider are distance to the community, water storage capacity, treatment requirements, and cost. Planning for population growth and environmental protection are also important considerations.

DO:

1. Read the following scenario and instructions: Congratulations on your new job as Community Planner of Blank Slate, USA! As the name implies, the community is not yet developed. Your first job is to design a water supply and treatment system for homes and businesses, a power plant, and a farm. The area has already been surveyed and even has a river flowing through it. As you think about where to locate the different components of your water supply system, consider which way the river is flowing, the changes in elevation, and the floodplain shown on the map.
2. Group youth in pairs and provide them with the contour map and cut-outs.
3. Which direction is the river flowing?
4. Instruct youth to reflect upon the information in the 'Explore the Content' about the different components of a water supply and treatment system.
5. Direct youth to discuss the best location for each of the components. Have youth glue or tape each cut-out onto the map.
6. Discuss their final design and the different factors that influenced their decision.

REFLECT:

- Why is it so important to know the land elevation when designing a water supply system?
- Think about your own city or town. Where is the water tower located? Why?
- What are some things that could change the community's water supply system in the future?

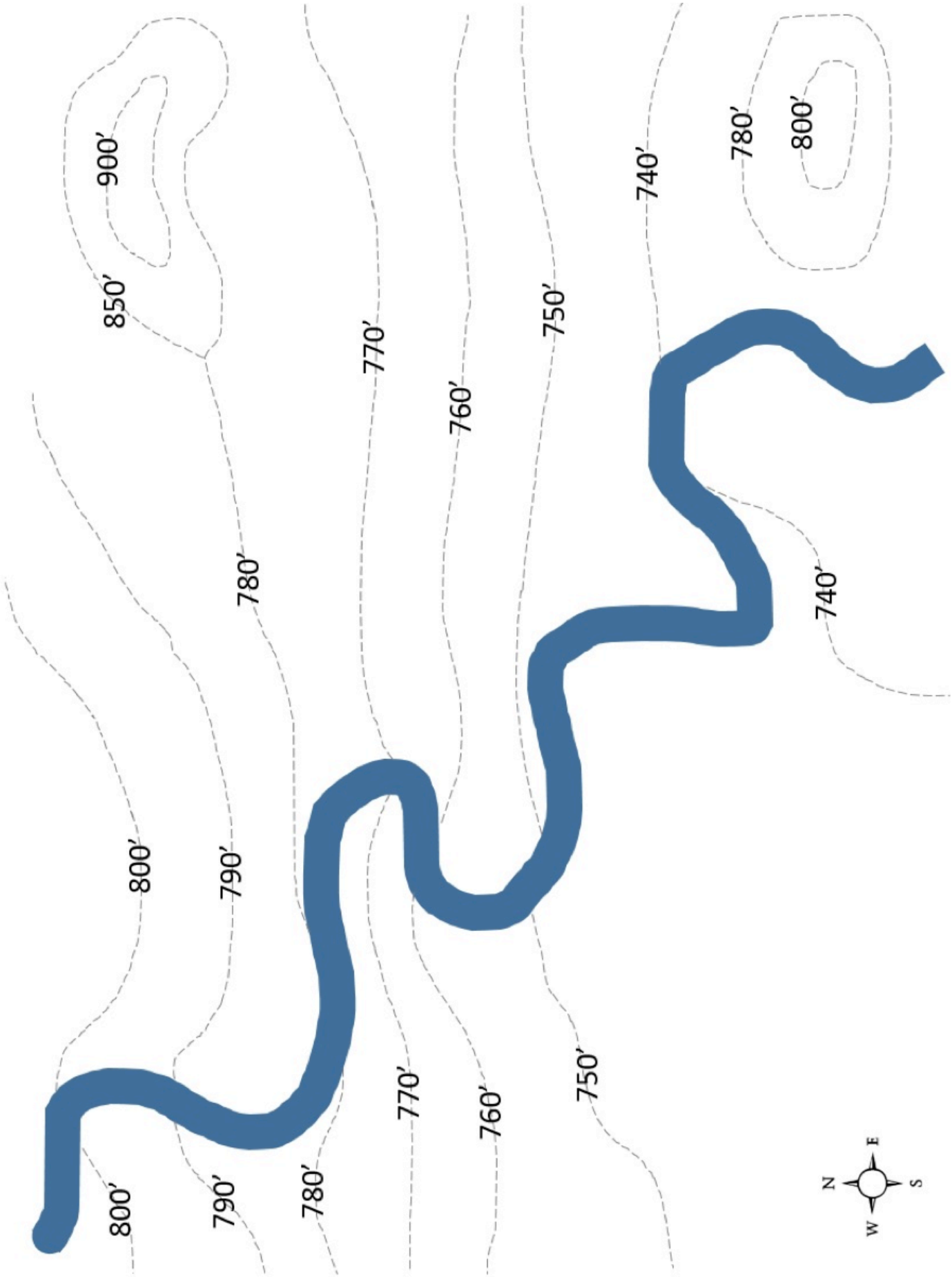
APPLY:

- How did this activity help you learn more about planning a water supply system?
- What would be the pros and cons of using groundwater instead of building a reservoir?
- What other things should planners consider when designing a water supply system for a new community?

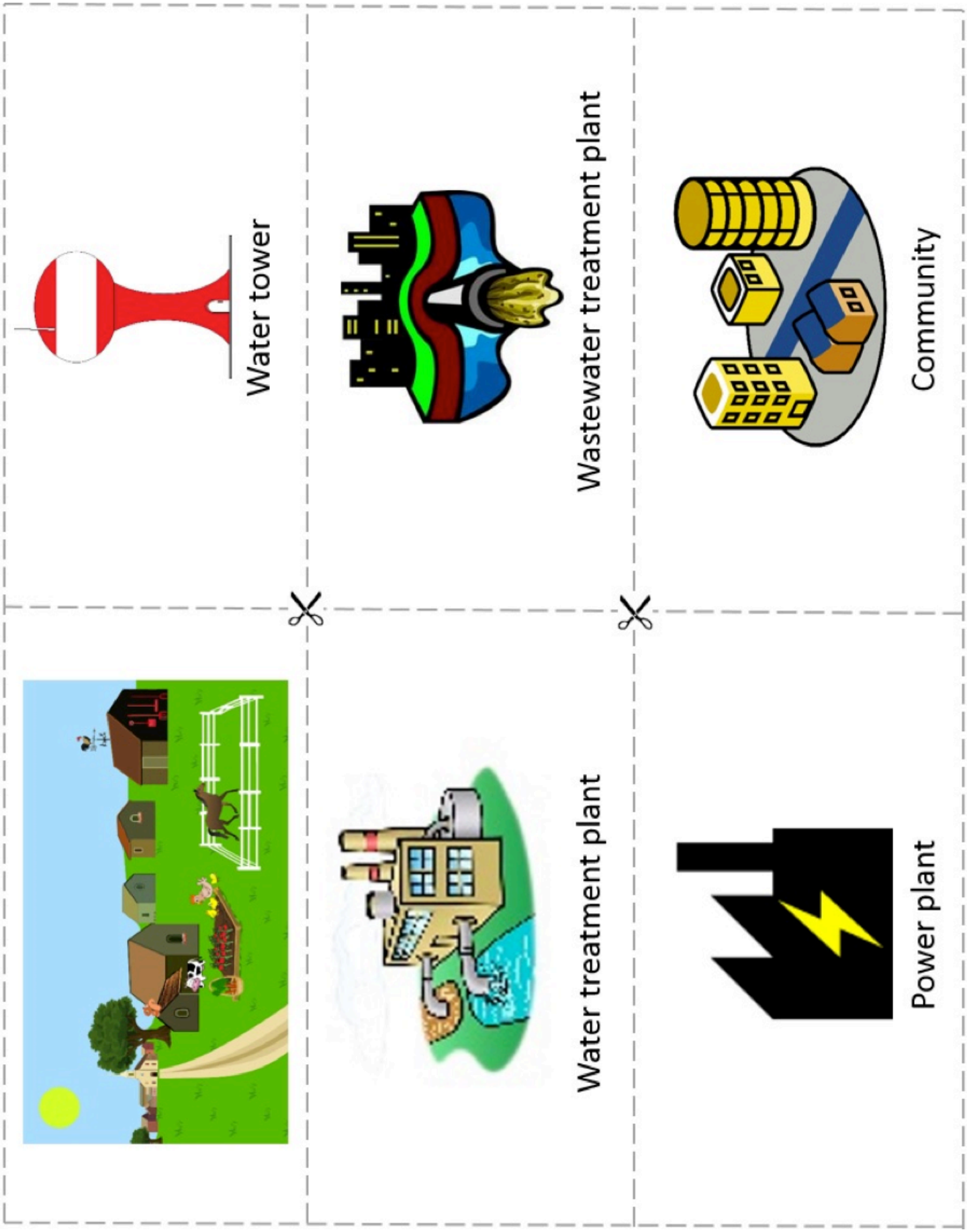
REFERENCES:

- https://www.twdb.texas.gov/surfacewater/rivers/index.asp

ACTIVITY: Community Planner Activity - Contour Map



ACTIVITY: Community Planner Activity - Cut Out's



Watershed Protection - A Shared Responsibility

TIME:
30 - 45 minutes

MATERIALS NEEDED:
- Pencils or markers for groups of 3-5 members
- Paper or flip charts for each group of 3-5 members

OBJECTIVES:
The 4-H member will:
- Learn the common sources of water contamination in watershed
- Discover best practices to protect our watersheds and improve water quality
- Discuss what messages are effective to encourage watershed stewardship

EXPLORE THE CONTENT:
Wherever you live, you are in a watershed. A "watershed" is an area of land that drains water to a common outlet such as a river, stream, reservoir, or a bay. Other common names for a watershed are basin or catchment. The size and shape of a watershed is determined by the surrounding topography. It can be large or small depending on the outlet point. For example, a small watershed may drain to a shallow creek, while the watershed for the Mississippi River includes parts of many states. Large watersheds usually contain many smaller watersheds.

The quality of water in our rivers, streams, reservoirs and oceans is affected by activities we do within the watershed. Because farming generally takes up large areas of land, farming practices such as plowing soil, fertilizing crops, and applying pesticides increases the risk that soil sediment, nutrients, and chemicals may be transported during heavy rain. Besides farming, there are many other potential sources of contaminants or pollutants within a watershed. In urban areas, cars and trucks leak oil, fuel, and lubricants onto roads and asphalt surfaces that are carried during rainstorms. Litter, animal waste, and other spilled material often wash into storm drains and creeks. At homes and businesses, lawn fertilizer and other landscape chemicals are sometimes carried away with irrigation runoff or during heavy rainfall. Failed or improperly designed wastewater treatment systems can also be a source of contamination, carrying bacteria, pathogens, viruses, and even medicinal drugs into creeks and streams. These are just a few examples of things humans do to impact water quality within a watershed. Other activities include mining operations, landfills, animal feeding operations, dairies, building construction, and industry.

Not all water quality problems can be blamed on human activity. Some sources of water pollution are natural and are difficult to control. Decomposing plants or excessive organic matter in water can lead to low dissolved oxygen affecting fish and other aquatic life. Flocking birds such as duck and geese put manure directly into water causing pollution. Extreme flooding can move large amounts of sediment into water bodies. Wildlife such as deer, wild pigs, raccoons, and coyotes defecate near streams and rivers which raises the fecal matter content and disease-causing organisms. A major threat to water quality in Texas is feral hogs. It is estimate that there are 4 million feral hogs roaming our watersheds causing millions of dollars in agricultural and environmental damage each year. Because they tend to live and

travel along waterways, feral hogs cause high fecal coliform levels in streams, harm aquatic life, and impair streams and rivers to the point where human contact is discouraged.

Protecting our watershed from contaminants and pollution is a shared responsibility. Whether we live on a farm or in a city, there are things we can do to keep our water clean. Farmers often build berms and practice contour plowing to slow down water runoff and help prevent erosion. They can also apply fertilizer and pesticides more precisely and at times when the risk of heavy rain and water runoff is less likely. In cities and towns, homeowners can limit lawn fertilization and manage sprinkler systems to prevent over-irrigation. Everyone can pick up trash, preventing it from washing into storm drains. Drivers can maintain vehicles in good condition, keeping oil, fuel, and lubricants from dripping onto roadways and parking lots. Finally, we can take hazardous material such as light bulbs, electronics, paint, chemicals, old tires and unused medicine to designated drop off centers instead of disposing them in landfills.

DO:

1. Divide group into groups of 3 to 5 members.
2. Have students discuss some of the major sources of watershed pollution in their community.
3. Instruct each group to work as a team to identify one water quality issue that they would like to address. Write this issue at the top of their paper or flip chart.
4. Have each group brainstorm possible solutions to address the problem, and identify one solution that they believe would best serve the community. Write this solution on the paper or flip chart.
5. Direct each group to decide the best strategy to achieve their solution. Write this on the paper or flip chart.
6. Have a spokesperson from each group share with other groups.

REFLECT:

- What organizations can promote watershed protection in your community?
- What are some strategies they can use?
- How can you be involved in watershed protection?

APPLY:

- Think about how your group interaction as you worked together to prioritize the issue and identify a solution. What are the pros and cons of working together as a team?

REFERENCES:

- Texas Parks & Wildlife (2016. Texas Waters – Exploring Water and Watersheds. https://tpwd.texas.gov/education/water-education/texaswatersprogram

ACTIVITY: Watershed Protection - A Shared Responsibility

ISSUE
SOLUTION
STRATEGY

Whose Water Is It Anyway?

Focus on Texas Surface Water Law

TIME:
30 - 45 Minutes

MATERIALS NEEDED:
- Pencils
- Worksheets and map for each pair of youth
- Calculator (optional) to share among groups

OBJECTIVES:
The 4-H member will:
- Learn the basic of Texas surface water law
- Understand how surface water rights are granted among water users
- Apply the Texas surface water law to a hypothetical scenario

EXPLORE THE CONTENT:
The State of Texas has many laws that govern the use and protection of water resources. The challenge for our growing state is to have a legal system that recognizes property rights while at the same time meets the essential needs of its citizenry. The two major sources of water in Texas are surface water and groundwater. In Texas, the water source determines which law to apply. Each source has different laws governing its 'ownership' and use. This lesson will focus on Texas surface water law.

According to the Texas Water Code, surface water is defined as "the water of the ordinary flow, underflow, and tides of every flowing river, natural stream and lake, and of every bay or arm of the Gulf of Mexico, and the storm water, floodwater and rainwater of every river, natural stream, canyon, ravine, depression and watershed" and "is the property of the state".

Water law in Texas has changed over time since the Spanish explorers and missionaries first arrived in the 1600s. Back then, the state was sparsely populated and water was mainly used for personal needs and for irrigation. Spanish rules of community irrigation ditches and government control over use of land and water continued under the Republic of Mexico. In the early 1800's American settlers into the region introduced English common law, also known as riparian law. Under riparian law, water rights were given to property owners whose land bordered a river or stream. Even after Texas won its independence from Mexico in 1836, Texas continued to follow riparian law. But, in the western part of Texas, irrigation expanded and this system of water rights proved impractical, especially during drought. Following the lead of other western U.S. states, Texas adopted a different system of surface water law called the 'Prior Appropriation Doctrine'. In 1967, the Texas Legislature merged the riparian water rights system and the Prior Appropriation system when it passed the Water Rights Adjudication Act. Existing riparian water rights holders were issued certificates protecting their existing right to use water. Others who wished to use surface water, but had no existing rights, had to apply to the State for water right permit. Permits were only granted for a specific amount of water, for a specific purpose, and only if water was available.

The Prior Appropriation water law system is commonly called 'first in time, first in right'. This means that water right holders who received their permits first have priority over those who

received their permits last. The originality date of the water rights permit is very important, especially in times when rainfall is in short supply and when available surface water is limited. In a drought, for example, there may not be enough water available for all water rights holders to get their allotted amount. Those with 'senior' or older origination dates get water first. As an example, Farmer Jones who has a water right dated 1900 would get his total water allotment before Farmer Smith with a water right dated 1910.

Today, the state agency responsible for issuing water right permits is the Texas Commission for Environmental Quality, or TCEQ for short. The TCEQ has issued more than 10,000 water rights which accounts for nearly all existing surface water. Very little surface water is available for new industry, business, farmers, and individuals. In addition, Texas has taken steps to ensure that not all water in a river is taken, but that a certain amount of water is left to support the needs of fish and wildlife. This water is called 'environmental flow'. Could you imagine what would happen to our bays, estuaries, and wetlands if all the water was taken upstream?

Water quantity (or volume) is usually described in units of gallons. However, a water right grants use of a specific amount of water in units of 'acre-feet'. As the term implies, one-acre foot is the volume of water that would cover one acre of land (about the size of a football field) with water one foot deep. One acre of land is 42,560 square feet.

1 acre-foot = 325,900 gallons

DO:

1. Group youth in pairs and provide them with worksheets and the map.
2. Read the following introduction while referring to the map: **A river flows from north to south as shown on the map. In a normal rainfall year, 20,000 acre-feet of water flows in the river. 10,000 acre-feet must stay in the river to meet environmental flow requirements to support fish and wildlife needs, but the remaining 10,000 acre-feet is available to farmers, industry, and municipal water right holders. Remember that in Texas surface water rights are governed by the Prior Appropriate Doctrine (also referred to as 'first in time, first in right'). Under this system, water right holders have rights to water based on the original date of the water right, with older water right dates taking precedent. Table 1 shows the current water right holder, their quantity of water right, and the original date of the water right.**
3. Have each group complete Activity 1, 2, and 3. Discuss the answers to the following questions:
   - Activity 1: What is the total water rights allocation for all users (in acre-feet)?
   - Activity 2: In a normal year, will all surface water right holders receive their allotted amount of water? If so, is there any water remaining that is available for future water rights holders? How much?
   - Activity 3: In a drought year, will all surface water right holders receive their allotted amount of water? If not, who will not receive water and what would be some alternatives?

REFLECT:

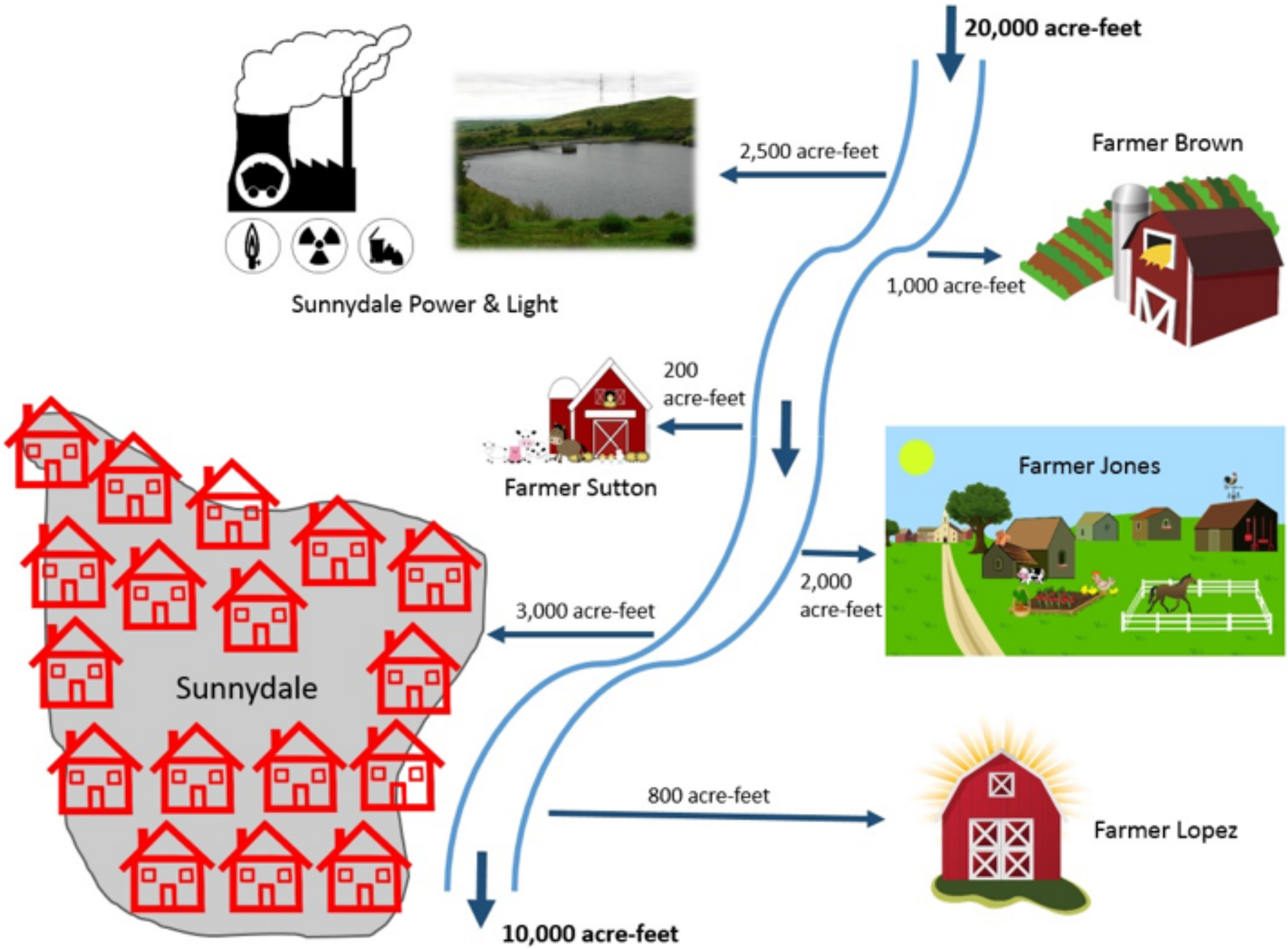
- Practically all surface water in Texas is already allocated to existing water rights holders. What challenges does this present for new businesses and growing cities?
- What other options do you think we have to meet future water needs?

APPLY:

- Do you believe Texas' Prior Appropriation Doctrine is the best way for allocating limited water resources?
- Should a new system of water rights be established? How would it work?

REFERENCES:

- Kaiser, Ronald A. (2016). Handbook of Texas Water Law: Problems and Needs. Published by Texas Water Resources Institute. Retrieved November 30, 2016 from: https://texaswater.tamu.edu/resources/2002-037_waterlaw.pdf
- Texas Agriculture Law Blog (2013). Texas Water: Basics of Surface Water Law. Retrieved on November 30, 2016 from: http://agrilife.org/texasaglaw/2013/09/30/texas-water-basics-of-surface-water-law/.
- Texas Water Development Board (2016). A Texan's Guide to Water and Water Rights Marketing. Retrieved November 30, 2016 from: http://www.twdb.texas.gov/publications/reports/infosheets/doc/WaterRightsMarketingBrochure.pdf.


20,000 acre-feet
Sunnydale Power & Light
2,500 acre-feet
Farmer Brown
1,000 acre-feet
200
acre-feet
Farmer Sutton
Farmer Jones
2,000
acre-feet
3,000 acre-feet
Sunnydale
800 acre-feet
Farmer Lopez
10,000 acre-feet

ACTIVITY 1: What is the total water rights allocation for all users (in acre-feet)?

Instructions: Using the information in Table 1, re-arrange the water right holders by priority date (oldest to youngest). Once arranged, calculate the total water rights allocatation for all users (in acre-feet).

TABLE 1

WATER RIGHT HOLDER	QUANTITY (acre-feet per year)	ORIGINAL DATES OF WATER RIGHT
Sunnydale Power & Light	2,500	1964
Farmer Brown	1,000	1975
Farmer Sutton	200	1907
Farmer Jones	2,000	1908
Town of Sunnydale	3,000	1951
Farmer Lopez	800	1947

WATER RIGHT HOLDER	QUANTITY (acre-feet per year)	ORIGINAL DATE OF WATER RIGHT
TOTAL WATER ALLOCATION		

ACTIVITY 2: Receiving Water Allotments in a Normal Year

In an 'average' year 20,000 acre-feet of water is available to be distributed among surface water right holders. 10,000 acre-feet of water must be left in the river to meet environmental flow requirements (see map).

In a normal year, will all surface water right holders receive their allotted amount of water? If so, is there any water remaining that is available for future water rights holders? How much?

Water Available	20,000	acre-feet
Water Taken by Right Holders	_____	acre-feet
Water Remaining in River:	_____	acre-feet

Remember – 10,000 acre-feet must be left in the river to meet environmental flow requirements.

ACTIVITY 3: Receiving Water Allotments in a Drought Year

In a 'drought' year 15,000 acre-feet of water is available to be distributed among surface water right holders. 10,000 acre-feet of water must be left in the river to meet environmental flow requirements (see map).

In a drought year, will all surface water right holders receive their allotted amount of water? If not, who will not receive water and what would be some alternatives?

Water Available	15,000	acre-feet
Water Taken by Right Holders	_____	acre-feet
Water Remaining in River:	_____	acre-feet

Remember – 10,000 acre-feet must be left in the river to meet environmental flow requirements.

Whose Water Is It Anyway

Focus on Texas Groundwater Law

TIME:
30-45 minutes

MATERIALS NEEDED:
- Pencils
- Maps of Texas Major & Minor Aquifers for each individual or pair of youth
- Map of Texas Groundwater Conservation Districts for each individual or pair of youth
- Groundwater scenario activity sheet – per group

OBJECTIVES:
The 4-H member will:
- Learn the basics of Texas groundwater law
- Compare Texas groundwater and surface water law
- Apply Texas groundwater law to hypothetical scenarios

EXPLORE THE CONTENT:
In lesson 5 you learned that all surface water found in Texas lakes, rivers, and streams is owned by the State. The State then grants water right permits to users based on water availability and for specific uses. In this lesson you will learn that ownership of groundwater is quite different.

Groundwater is the water beneath the land that fills small pores between particles of sand, silt, clay, and rock. These are called aquifers. In Texas there are 9 major and 20 minor aquifers underlying the state (see maps). Groundwater is an important source of water, especially in arid regions which get very little rainfall and have limited or no surface water available. About 80% of all groundwater is pumped to the surface and used to irrigate crops. Groundwater is also important for municipal uses (drinking and sanitation), landscape irrigation, manufacturing, and for livestock production.

Although surface water in Texas is considered state property, groundwater is private property. This means that groundwater is the property of the landowner directly above it. Groundwater law is governed by the Rule of Capture, first adopted by the Texas Supreme Court in 1904. The Rule of Capture says that landowners have a legal right to pump as much groundwater beneath their land as they can capture and put to beneficial use. Ownership legally occurs when the water is brought to the surface.

The Rule of Capture has been widely criticized because it provides little protection against over-pumping and depletion of aquifers. According the Rule, as long as the water brought to the surface is put to beneficial use, the landowner can pump as much as he/she wants. It is because of this that the Rule of Capture is commonly referred to as "the law of the biggest pump".

Texas courts have placed a few limitations on the amount of water a landowner can pump. For example, courts have said that a landowner cannot pump an unlimited amount of water when it is done to purposefully harm a neighbor, when water is used in a wasteful manner, or for the purpose of causing the land to subside or settle. The Texas Legislature has also recognized that current groundwater law can lead to over-pumping and harm to neighboring properties. The Legislature has encouraged that groundwater conservation districts be established throughout the state with the authority to manage groundwater pumping. To date, there are nearly 100 groundwater conservation districts in

Texas (see map). The Texas Water Code (Chapter 36) gives groundwater conservation districts authority to register and provide permits for water wells, regulate the spacing between wells, collect fees for pumping, and engage in projects to conserve and protect aquifers.

As our population grows, so too may be our dependence on groundwater to meet our basic needs and to support our economy. Many have suggested that the current groundwater law is no longer adequate to protect against the depletion of aquifers. Others prefer to maintain the private property aspect of groundwater, but give even more authority to groundwater conservation districts to place reasonable restrictions on groundwater pumping. What do you think?

DO:

1. Youth may work individually or in pairs for this activity.
2. Hand out the Groundwater Scenario Activity sheet.
3. Have each individual or group read through and consider their response to each case.
4. Discuss the responses to the following questions:
    - Case 1: What likely happened to cause make Mrs. Smith' water well go dry? Under the Rule of Capture, did Mr. Brown do anything illegal?
    - Case 2: Under the Rule of Capture, is Farmer Ted allowed to sell water he pumps from underneath his property and sell it to others?
    - Case 3: Mr. Power's suspects that what Mr. Burns has done violates the Rule of Capture. How would he support this argument?

REFLECT:

- Why is it important to protect our aquifers from over-pumping?
- Should groundwater conservation districts take a stronger role to restrict groundwater pumping? Why or why not?

APPLY:

- What are the main differences between Texas surface water law and groundwater law?

REFERENCES:

- Kaiser, Ronald A. (2016). Handbook of Texas Water Law: Problems and Needs. Published by Texas Water Resources Institute. Retrieved November 30, 2016 from: https://texaswater.tamu.edu/resources/2002-037_waterlaw.pdf.
- Texas Parks and Wildlife (July 2005). Who Owns the Water? A Primer on Texas Groundwater Law and Spring Flow. Retrieved December 20, 2016 from: http://tpwmagazine.com/archive/2005/jul/ed_2/.
- Texas Water Development Board (2016). TWDB Maps. Retrieved December 20, 2106 from: http://www.twdb.texas.gov/mapping/maps.asp

ACTIVITY 1: Groundwater Scenario Activity

CASE 1:
Mr. Brown and Mrs. Smith have been neighbors for the past 30 years and have been friends throughout. Because they live in a rural area and do not have access to the nearby city water service, they both have water wells to supply their water needs. Recently Mr. Brown decided to build a small fish farm and dug a deep water well to supply three fish ponds. A couple of months after operating his well, Mrs. Smith began seeing a little sand in her faucet water. Soon after, her well went dry and she had no water coming out of her well.

Question: What likely happened to cause make Mrs. Smith' water well go dry? Under the Rule of Capture, did Mr. Brown do anything illegal?

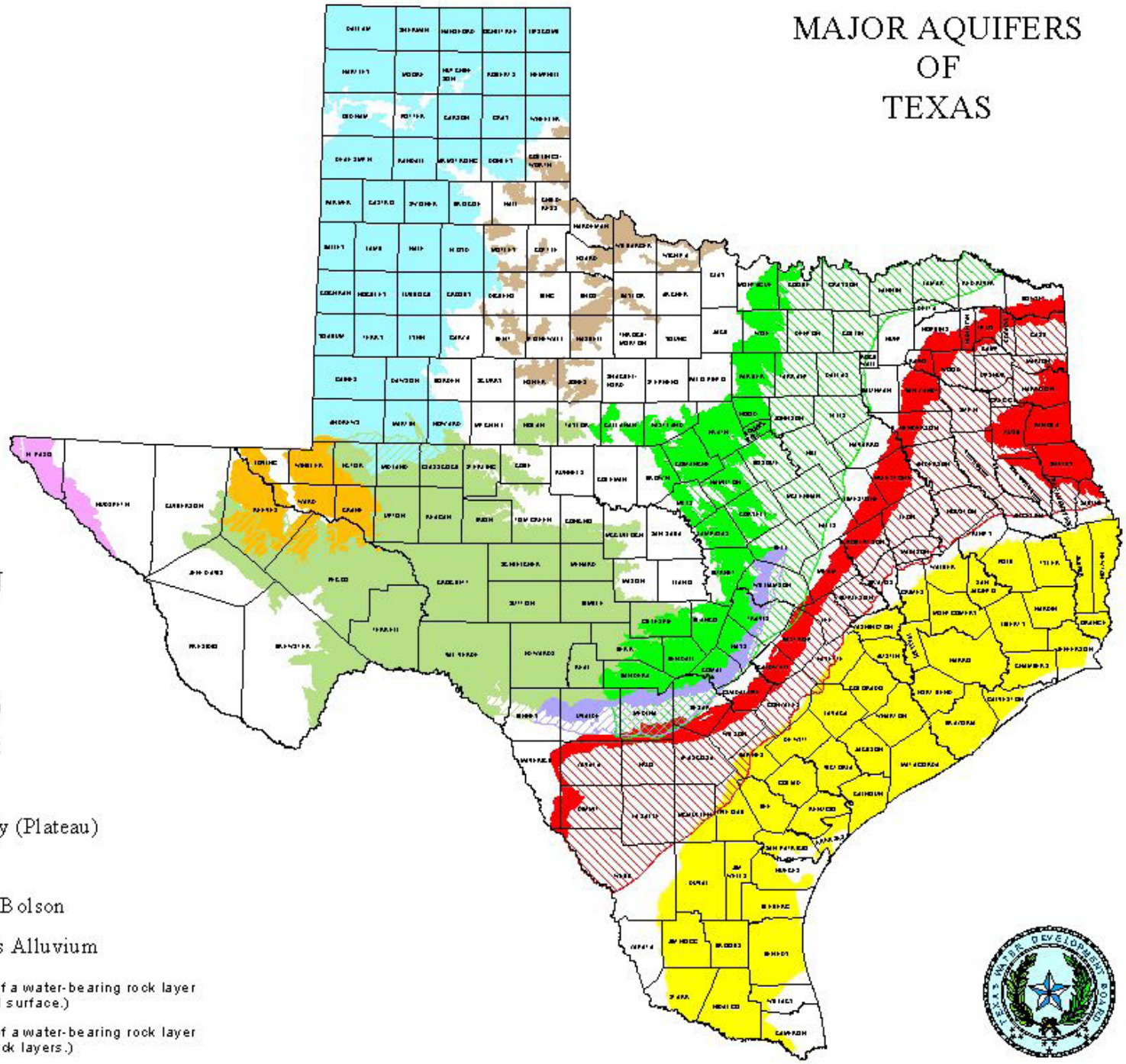
CASE 2:
Farmer Ted has several large water wells used to irrigate his 1,000-acre corn and cotton farm. Recently Farmer Ted has decided to convert half of his farm to rangeland and graze cattle. Looking for new water sources for their growing population, a nearby City has asked Ted to sell some of his groundwater. The city would then install new pipelines and pumps to his water wells.

Question: Under the Rule of Capture, is Farmer Ted allowed to pump water from underneath his property and sell it to others?

CASE 3:
Mr. Burns and Mr. Powers (both pecan growers) have been bitter rivals for several decades. The adjoining farms each have several water wells used to flood irrigate their pecan trees. For many years, the two have refused to speak to each other and often engage in petty sabotage and pranks just to get under each other's skin. During a particularly harsh drought, several of Mr. Power's water wells began going dry. In addition, a portion of the land began sinking even causing damage to his barn. After investigating the situation, it was learned that Mr. Burns had recently installed a deep, high capacity well. Suspecting this was the cause of all his problems, Mr. Power's took pictures of water flooding off Mr. Burn's farm, running down bar ditches and flowing into a nearby ravine.

Question: Mr. Power's suspects that what Mr. Burns has done violates the Rule of Capture. How would he support this argument?

MAJOR AQUIFERS OF TEXAS



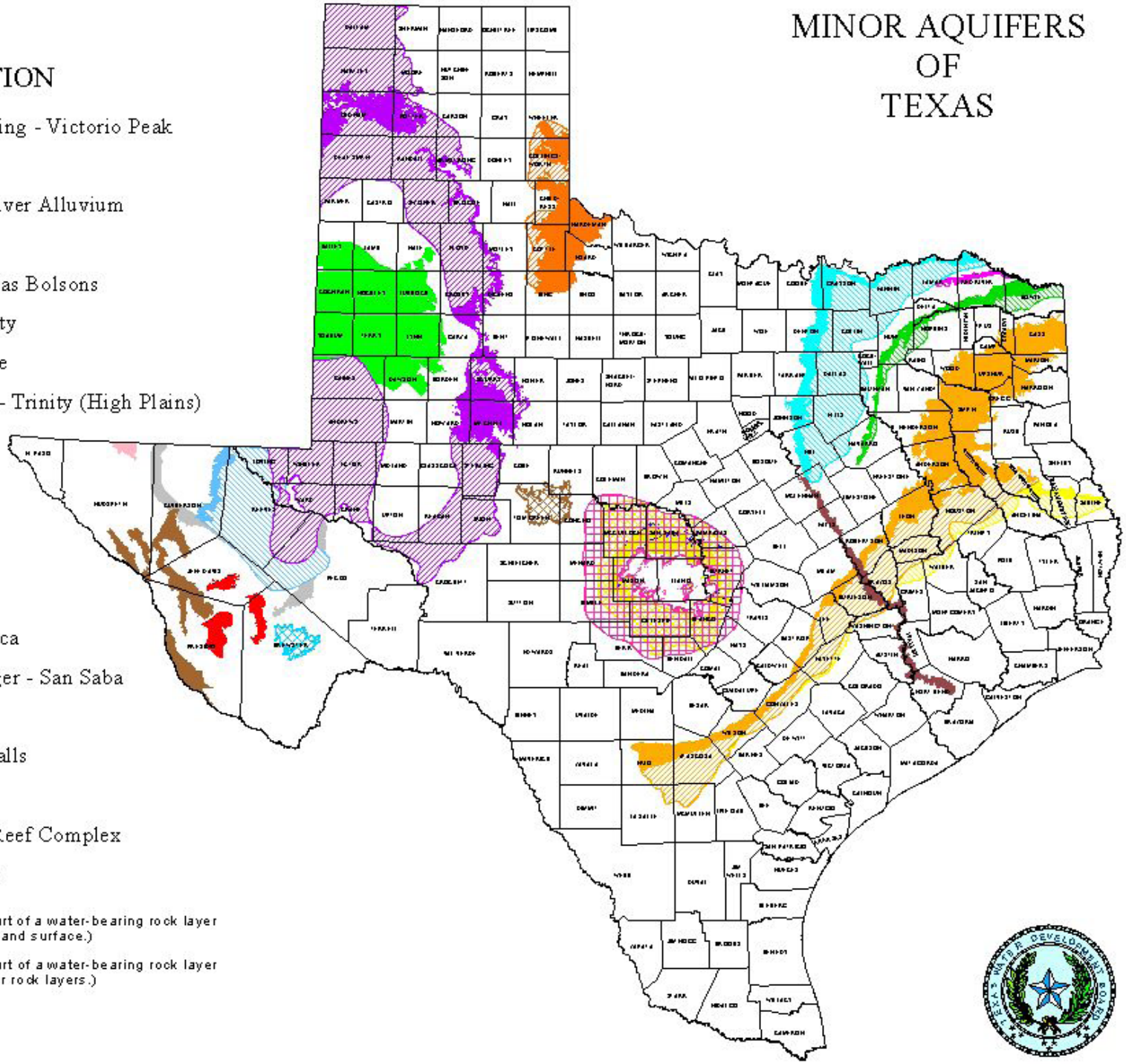
EXPLANATION

- Ogallala
- Gulf Coast
- * Edwards (BFZ)
- * Carrizo-Wilcox
- * Trinity
- * Edwards-Trinity (Plateau)
- Seymour
- Hueco-Mesilla Bolson
- Cenozoic Pecos Alluvium

OUTCROP (That part of a water-bearing rock layer which appears at the land surface.)

* DOWNDIP (That part of a water-bearing rock layer which dips below other rock layers.)

MINOR AQUIFERS OF TEXAS



EXPLANATION

- Bone Spring - Victorio Peak
- Dockum
- Brazos River Alluvium
- Hickory
- West Texas Bolsons
- Queen City
- Woodbine
- Edwards - Trinity (High Plains)
- Blaine
- Sparta
- Nacatoch
- Lipan
- Igneous
- Rita Blanca
- Ellenburger - San Saba
- Blossom
- Marble Falls
- Rustler
- Capitan Reef Complex
- Marathon

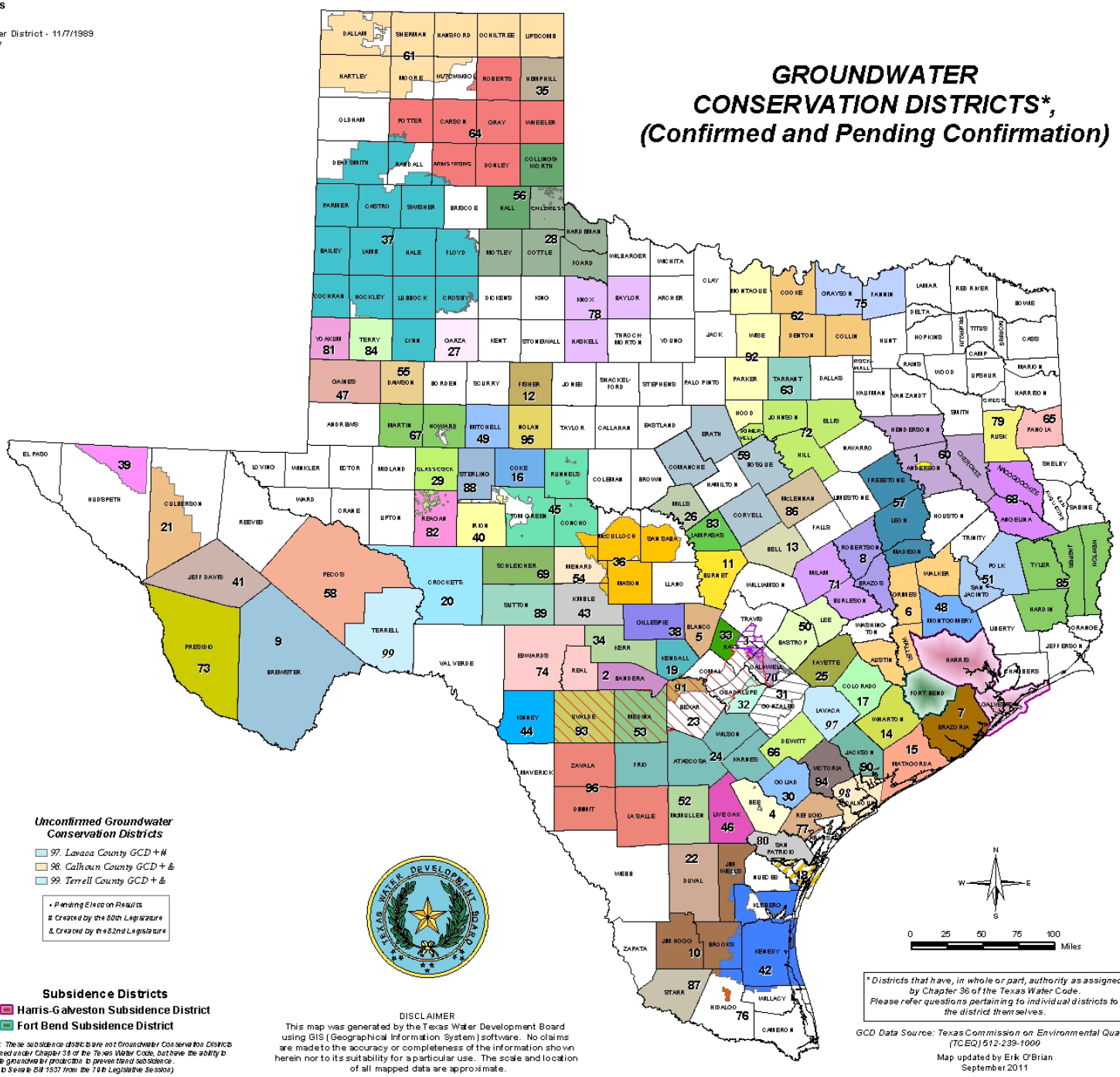
OUTCROP (That part of a water-bearing rock layer which appears at the land surface.)

* DOWNDIP (That part of a water-bearing rock layer which dips below other rock layers.)

GROUNDWATER CONSERVATION DISTRICTS*, (Confirmed and Pending Confirmation)

Confirmed Groundwater Conservation Districts

1. Anderson County UWCD - 10/17/1987
2. Bandera County River Authority & Ground Water District - 11/7/1989
3. Barton Springs/Edwards Aquifer CD - 8/13/1987
4. Bee GCD - 1/20/2001
5. Blanco-Pedernales GCD - 1/23/2001
6. Bluebonnet GCD - 11/5/2002
7. Brazoria County GCD - 11/8/2005
8. Brazos Valley GCD - 11/5/2002
9. Brewster County GCD - 11/6/2001
10. Brush Country GCD - 11/3/2009
11. Central Texas GCD - 9/24/2005
12. Clear Fork GCD - 11/5/2002
13. Clearwater UWCD - 8/21/1999
14. Coastal Bend GCD - 11/6/2001
15. Coastal Plains GCD - 11/6/2001
16. Coke County UWCD - 11/4/1986
17. Colorado County GCD - 11/6/2007
18. Corpus Christi ASRCD - 6/17/2005
19. Cow Creek GCD - 11/5/2002
20. Crockett County GCD - 1/26/1991
21. Culberson County GCD - 5/2/1998
22. Duval County GCD - 7/25/2009
23. Edwards Aquifer Authority - 7/28/1996
24. Evergreen UWCD - 8/30/1965
25. Fayette County GCD - 11/6/2001
26. Fox Crossing Water District - 4/4/1986
27. Garza County UWCD - 11/5/1996
28. Gateway GCD - 5/3/2003
29. Glasscock GCD - 8/22/1981
30. Goliad County GCD - 11/6/2001
31. Gonzales County UWCD - 11/2/1994
32. Guadalupe County GCD - 11/14/1999
33. Hays Trinity GCD - 5/3/2003
34. Headwaters GCD - 11/5/1991
35. Hemphill County UWCD - 11/4/1997
36. Hickory UWCD No. 1 - 8/14/1982
37. High Plains UWCD No.1 - 9/29/1951
38. Hill Country UWCD - 8/8/1987
39. Hudspeth County UWCD No. 1 - 10/5/1957
40. Irion County WCD - 8/2/1985
41. Jeff Davis County UWCD - 11/2/1993
42. Kenedy County GCD - 11/2/2004
43. Kimble County GCD - 5/3/2002
44. Kinney County GCD - 1/12/2002
45. Lipan-Kickapoo WCD - 11/3/1987
46. Live Oak UWCD - 11/7/1989
47. Llano Estacado UWCD - 11/3/1998
48. Lone Star GCD - 11/6/2001
49. Lone Wolf GCD - 2/2/2002
50. Lost Pines GCD - 11/5/2002
51. Lower Trinity GCD - 11/7/2006
52. McMullen GCD - 11/6/2001
53. Medina County GCD - 8/26/1991
54. Menard County UWD - 8/14/1999
55. Mesa UWCD - 1/20/1990
56. Mesquite GCD - 11/4/1986
57. Mid-East Texas GCD - 11/5/2002
58. Middle Pecos GCD - 11/5/2002
59. Middle Trinity GCD - 5/4/2002
60. Neches & Trinity Valleys GCD - 11/6/2001
61. North Plains GCD - 1/2/1955
62. North Texas GCD - 12/1/2009
63. Northern Trinity GCD - 5/15/2007
64. Panhandle GCD - 1/21/1956
65. Panola County GCD - 11/6/2007
66. Pecan Valley GCD - 11/6/2001
67. Permian Basin UWCD - 9/21/1985
68. Pineywoods GCD - 11/6/2001
69. Plateau UWC and Supply District - 3/4/1974
70. Plum Creek CD - 5/1/1993
71. Post Oak Savannah GCD - 11/5/2002
72. Prairielands GCD - 9/1/2009
73. Presidio County UWCD - 8/31/1999
74. Real-Edwards C and R District - 5/30/1959
75. Red River GCD - 9/1/2009
76. Red Sands GCD - 11/5/2002
77. Refugio GCD - 11/6/2001
78. Rolling Plains GCD - 1/26/1999
79. Rusk County GCD - 6/5/2004
80. San Patricio County GCD - 5/12/2007
81. Sandy Land UWCD - 11/7/1989
82. Santa Rita UWCD - 8/19/1989
83. Saratoga UWCD - 11/7/1989
84. South Plains UWCD - 2/8/1992
85. Southeast Texas GCD - 11/2/2004
86. Southern Trinity GCD - 6/19/2009
87. Starr County GCD - 1/6/2007
88. Sterling County UWCD - 11/3/1987
89. Sutton County UWCD - 4/5/1986
90. Texana GCD - 11/6/2001
91. Trinity Glen Rose GCD - 11/5/2002
92. Upper Trinity GCD - 11/6/2007
93. Uvalde County UWCD - 9/1/1993
94. Victoria County GCD - 8/5/2005
95. Wes-Tex GCD - 11/5/2002
96. Wintergarden GCD - 1/17/1998



Unconfirmed Groundwater Conservation Districts

97. *Lavaca County GCD + #*
98. *Calhoun County GCD + &*
99. *Terrell County GCD + &*

+ Pending Election Results
 # Created by the 80th Legislature
& Created by the 82nd Legislature

Subsidence Districts

- Harris-Galveston Subsidence District
- Fort Bend Subsidence District

NOTE: These subsidence districts are not Groundwater Conservation Districts as defined under Chapter 36 of the Texas Water Code, but have the ability to regulate groundwater production to prevent land subsidence. (Refer to Senate Bill 1537 from the 70th Legislative Session)

DISCLAIMER
This map was generated by the Texas Water Development Board using GIS (Geographical Information System) software. No claims are made to the accuracy or completeness of the information shown herein nor to its suitability for a particular use. The scale and location of all mapped data are approximate.

** Districts that have, in whole or part, authority as assigned by Chapter 36 of the Texas Water Code. Please refer questions pertaining to individual districts to the district themselves.*

GCD Data Source: Texas Commission on Environmental Quality (TCEQ) 512-239-1000

Map updated by Erik O'Brian
September 2011

MARKING INSTRUCTIONS

CORRECT: ● INCORRECT: ✓ ✗ ◐ ◔

4-H Explore
Project Book Evaluation - Water

1. Please read the statement in the left column of the table below. Bubble in the circles that describe your level of understanding **BEFORE** attending this program. In the section on the far right, bubble in the circles that describe your level of understanding **AFTER** attending this program. You will have two bubbles per row.

LEVEL OF UNDERSTANDING: 1 = Poor, 2 = Average, 3 = Good, 4 = Excellent	BEFORE				AFTER			
As a result of participating in the Water project lessons and activities…	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
I understand the challenges we face in providing a safe and reliable source of water.	○	○	○	○	○	○	○	○
I understand the key parts of the hydrologic cycle.	○	○	○	○	○	○	○	○
I understand the many factors that impact water avaialbility in my community.	○	○	○	○	○	○	○	○
I understand the common souces of water contamination in my watershed.	○	○	○	○	○	○	○	○
I understand how surface water rights are granted in Texas.	○	○	○	○	○	○	○	○
I understand the general differenc between surface and grounwater rules in Texas.	○	○	○	○	○	○	○	○

2. For each statement below, fill in the bubble that best describes you.

INTENTIONS TO ADOPT: **As a result of participating in the Water Project lessons and activities…**	**Yes**	**No**	**Unsure**
I can discuss with others the importance of water in our daily lives.	○	○	○
I can identify the major sources of water pollution and help to prevent contamination.	○	○	○
I will use what I have learned to be a better steward of water.	○	○	○
I plan to become more informed about water in my community.	○	○	○
I plan to apply what I have learned about water in educating my peers.	○	○	○
I plan to learn more about the importance of water to my local economy.	○	○	○

3. For each statement below, fill in the bubble that best describes your level of agreement with the following statements.

BEHAVIOR CHANGES: **As a result of participating in the Water Project lessons and activities…**	**Strongly Disagree**	**Disagree**	**Agree**	**Strongly Agree**
I am more comfortable working in a team.	○	○	○	○
I am more willing to listen to others.	○	○	○	○
I am more comfortable speaking with others.	○	○	○	○
I am more confident in my abilities as a leader.	○	○	○	○

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Please continue on the back.

MARKING INSTRUCTIONS

CORRECT: ● INCORRECT: ⊘ ⊗ ◒ ◓

3. What is the most significant thing you learned in the Water project?

Please tell us about yourself.

Gender: ○ Female ○ Male

I consider myself to be:
○ African American
○ Asian American
○ Native American
○ White
○ Other

I consider myself to be: ○ Hispanic ○ Non-Hispanic

Grade: ○ 3rd ○ 5th ○ 7th ○ 9th ○ 11th
○ 4th ○ 6th ○ 8th ○ 10th ○ 12th

Most of the time, you live . . .
○ Farm or ranch
○ Town less than 10,000
○ City between 10,000 - 50,000
○ Suburb of city between 50,000
○ Central city/urban center with more than 50,000

Please provide any additional comments below.

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Thank you!