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THE ADVENTURES OF WATERSHED WILLIE AND CACTUS CALLIE IN THEIR WATERSHED

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Resources for Activites

◆The Water Sourcebook: A Series of Classroom Activities for Grades K-2, Education Research and In-Service, University of North Alabama.

◆Source Water and Watershed Protection: Source Water and Watershed Education Division, San Antonio Water System, January 1999.

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INTRODUCTION

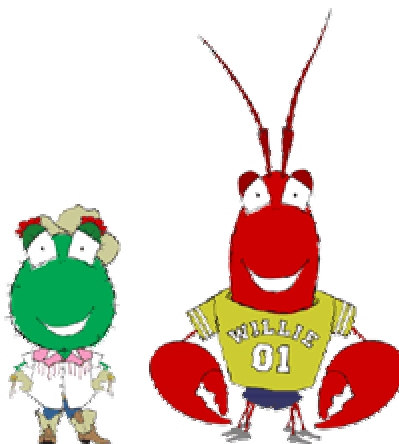
Water plays perhaps the most vital role in the growth and development of the San Antonio region. It is predicted that by the year 2049 the population of San Antonio will double, while the amount of water available for use will decrease. Education of today's youth insures plenty of quality water tomorrow.

The importance of water cannot be stressed enough. *The Adventures of Watershed Willie and Cactus Callie* has been developed to help you and your students understand the many roles water plays in our lives. The story line follows our two intrepid travelers as they walk through their watershed to a water festival. Along the way, they learn about what makes water, where water comes from, and how it is utilized, conserved and kept pollution free.

The activities included are designed for kindergarten through second grade age groups. Sections from *The Adventures of Watershed Willie and Cactus Callie* were created to cover social studies, music, art, language arts, math, and science as well as keeping the TEKS objectives in mind. Additionally, the book is formatted so activities can be pulled from the story for individual use or the whole story can be integrated into another curriculum.

The teacher's manual contains instructional activities that are written into the story. The student version contains the story and items needed by the student to complete the activities. At the end of the Student Story Book, fold out backdrops and puppets are included for students to act out their favorite scenes from the story. An audio tape is also provided with the entire story on side A and children's songs on side B.

The story and activities included in this kit are designed to stimulate interest in water and to promote protection of our most valuable resource through fun, interactive learning.



FORWARD

Dear Educator:

Each day, we work with local students from across the county to help them understand the water issues facing us all. While we believe that this is important work, we know that our schools play an even greater role in cultivating this environmental literacy. We also believe that it is a task that neither begins nor ends with formal education. Many parts of our society shape attitudes toward and knowledge about our natural resources --family, peers, religion, community, interest groups, government, the media, etc.

Knowledge alone doesn't necessarily mean more responsible civic behavior. Education goes much deeper. In fact, education provides the opportunity to connect personally and intellectually with members of the city and ultimately "sow the seeds" of civic responsibility within them. Our responsibility to you, lies in the production of the highest quality of educational materials in order to help you facilitate this learning.

Finally, we at SAWS H₂O University believe that a knowledgeable, skilled, and active youth citizenry is the key to resolving water issues that promise to become increasingly important into the next century and we are confident that the generations to come will become excellent stewards of the world around us.

SAWS H₂O University Staff

A NOTE TO EDUCATORS

THE ADVENTURES OF WATERSHED WILLIE AND CACTUS CALLIE IN THEIR WATERSHED

This educational program was created specifically to teach K-2 students the value of water preservation and conservation.

Activities in this program are compatible with the Texas Essential Knowledge and Skills (TEKS) created by the Texas Education Agency.

Nine specific units are presented including: Introduction to Water, Where Does Water Come From, Conservation, Pollution, Water Careers, Storm Water Quality, Runoff, Groundwater and Watersheds.

HOW TO BEGIN THIS PROGRAM

We suggest you begin the program by placing the Watershed Journey Tracking Map, included in this workbook, on a bulletin board in your classroom. As the students finish reading various sections of Willie and Callie's journey, they can color the dots and arrows on the map to mark their progress.

In addition, the front cover of this Educator's Workbook has been designed to show students how a watershed is affected when there is little or no protection. The back cover demonstrates what happens if we take a proactive watershed protection approach. You might wish to use this "cover" activity to begin your discussion on water quality and quantity. (See "Is it Healthy or Sick?" - Activity P.1 for instructions).

TEACHING OPTIONS

Here are some suggestions to help make the program user-friendly.

1. You may wish to first read the entire story to your class before attempting any activities. After completing the story, you can begin to introduce the corresponding activities doing one or several each day.
2. You can read the story out loud and introduce the corresponding activities as you come to them in the book. If you choose this option, remember that the story book has more pictures and activities than text so it might be necessary to review the story each day that you continue with the lesson.
3. Play the audio tape version of the story book while the students follow along in their books. Introduce the activities or choose not to use the activities at all.

(The Educator's Edition of the story book is located in this resource workbook). We encourage you to use this program to best suit your class and lesson.


HOW THE STORY BOOK IS ARRANGED


As you come to the different "adventures" in the journey (individual water units), you will notice a graphic of a "clip board" or "easels." The students will use these pages for various applications including taking notes, making sketches and recording findings from the various activities. Writing in the story book is encouraged.

Definitions of new terms will also appear in these graphics. These definitions will help the student understand the concepts presented in the story and in the activities that follow.

These activities aim to provide as much guidance as possible, yet have flexibility so you can adapt to your students and various situations.

LOOK FOR THESE SYMBOLS

( P.) The "Open book symbol" with the page number will remind you that there are activity sheets located in the story book that the students will use in the activity. This symbol will be found throughout the activity pages in this [Educator's Resource Workbook](#).

() The "Pencil" symbol, along with the activity name and page number, will prompt you to begin the appropriate activities at that time. It's found on various pages in the [storybook](#).

THE CLASSROOM BENEFITS OF THIS PROGRAM

TEKS OBJECTIVES

The Adventures of Watershed Willie and Cactus Callie in their Watershed is closely aligned with the Texas Essential Knowledge and Skills (TEKS) in five content areas. They include: English, Fine Arts, Mathematics, Science and Social Studies. Throughout the activities, various sections will be followed with a TEKS objective notification.

TEKS OBJECTIVES INDEX:

Subject	Activity Name	Page
<u>English</u>		
K.1-	Water is Very Special	A.1
	Water Goes Up and Down	C.1
	Water Works for Everyone	I.1
	Is it Healthy or Sick	P.1
K.3-	The Bad Guys vs. Good Guys	J.1
	Water Here and There	N.1
	Is it Healthy or Sick	P.1
	Willie and Callie Puppet Show	R.1
K.4-	What Shape is Water	B.1
	Bad Guys vs. Good Guys	J.1
K.8-	What Shape is Water	B.1
K.9-	Water Goes Up and Down	C.1
	Being a Hydrologist	H.1
K.10-	Water Here and There	N.1
K.11-	Willie and Callie Puppet Show	R.1
K.12-	What's the Point	F.1
K.15-	It's Time to Conserve	E.1
	What's the Point	F.1
	Oh Well...	L.1
K.16-	It's Time to Conserve	E.1
	Being a Hydrologist	H.1
	Is it Healthy or Sick	P.1

1.1-	Water is Very Special Water Goes Up and Down Water Works for Everyone Is it Healthy or Sick	A.1 C.1 I.1 P.1
1.3-	The Bad Guys vs. Good Guys Water Here and There Is it Healthy or Sick Willie and Callie Puppet Show	J.1 N.1 P.1 R.1
1.4-	What Shape is Water Bad Guys vs. Good Guys	B.1 J.1
1.11-	What Shape is Water	B.1
1.12-	Water Goes Up and Down Being a Hydrologist Water Here and There Is it Healthy or Sick Willie and Callie Puppet Show	C.1 H.1 N.1 P.1 R.1
1.13-	Water Here and There	N.1
1.15-	What's the Point	F.1
1.18-	It's Time to Conserve What's the Point Being a Hydrologist Oh Well... Is it Healthy or Sick	E.1 F.1 H.1 L.1 P.1
1.19-	Oh Well...	L.1
1.23-	It's Time to Conserve	E.1
2.1-	Water is Very Special Water Goes Up and Down Water Works for Everyone Is it Healthy or Sick	A.1 C.1 I.1 P.1
2.3-	Bad Guys vs. Good Guys Water Here and There Is it Healthy or Sick Willie and Callie Puppet Show	J.1 N.1 P.1 R.1
2.4-	What Shape is Water Bad Guys vs. Good Guys	B.1 J.1
2.8-	What Shape is Water	B.1

2.9-	Water Goes Up and Down Being a Hydrologist Water Here and There	C.1 H.1 N.1
2.10-	Water Here and There	N.1
2.12-	What's the Point Is it Healthy or Sick	F.1 P.1
2.14-	What Shape is Water It's Time to Conserve What's the Point Being a Hydrologist Is it Healthy or Sick	B.1 E.1 F.1 H.1 P.1
2.20-	It's Time to Conserve Oh Well...	E.1 L.1
<u>Fine Arts</u>		
K.1-	Water Goes Up and Down Water Here and There	C.1 N.1
K.2-	Water is Very Special Water Goes Up and Down It's Time to Conserve Being a Hydrologist Water Works for Everyone Bad Guys vs. Good Guys How Low Can You Go Water Here and There	A.1 C.1 E.1 H.1 I.1 J.1 M.1 N.1
K.3-	Water Goes Up and Down Water Works for Everyone Water Here and There Willie and Callie Puppet Show	C.1 I.1 N.1 R.1
1.1-	Water Goes Up and Down Water Here and There	C.1 N.1
1.2-	Water is Very Special Water Goes Up and Down It's Time to Conserve Being a Hydrologist Water Works for Everyone Bad Guys vs. Good Guys How Low Can You Go Water Here and There Willie and Callie Puppet Show	A.1 C.1 E.1 H.1 I.1 J.1 M.1 N.2 R.1

1.3-	Water Goes Up and Down It's Time to Conserve Water Here and There	C.1 E.1 N.1
1.5-	Water Goes Up and Down Water Works for Everyone	C.1 I.1
2.1-	Water Goes Up and Down	C.1
2.2-	Water is Very Special Water Goes Up and Down It's Time to Conserve Being a Hydrologist Water Works for Everyone Bad Guys vs. Good Guys How Low Can You Go Willie and Callie Puppet Show	A.1 C.1 E.1 H.1 I.1 J.1 M.1 R.1
2.3-	Water Goes Up and Down	C.1
2.5-	Water Goes Up and Down Water Works for Everyone	C.1 I.1
<u>Science</u>		
K.1-	What Rain Washes Away	K.1
K.2-	What is a Water Cycle How Clean is Your Stream What Rain Washes Away Oh Well... How Low Can You Go	D.1 G.1 K.1 L.1 M.1
K.4-	Water is a Water Cycle	D.1
K.5-	How Clean is Your Stream	G.1
K.6-	How Clean is Your Stream	G.1
K.7-	What is a Water Cycle What Rain Washes Away Water Here and There	D.1 K.1 N.1
K.9-	How Clean is Your Stream	G.1
K.10-	Water is Very Special What Shape is Water What Rain Washes Away Oh Well... How Low Can You Go Water Here and There	A.1 B.1 K.1 L.1 M.1 N.1

1.1-	What Rain Washes Away	K.1
1.2-	What is a Water Cycle	D.1
	How Clean is Your Stream	G.1
	What Rain Washes Away	K.1
	Oh Well...	L.1
	How Low Can You Go	M.1
1.5-	How Clean is Your Stream	G.1
1.7-	What is a Water Cycle	D.1
	What Rain Washes Away	K.1
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1.9-	How Clean is Your Stream	G.1
1.10-	Water is Very Special	A.1
	What is a Water Cycle	D.1
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	Oh Well...	L.1
	How Low Can You Go	M.1
	Water Here and There	N.1
2.1-	What Rain Washes Away	K.1
2.2-	What is a Water Cycle	D.1
	How Clean is Your Stream	G.1
	What Rain Washes Away	K.1
	Oh Well...	L.2
	How Low Can You Go	M.2
2.5-	How Clean is Your Stream	G.1
2.7-	What is a Water Cycle	D.1
	What Rain Washes Away	K.1
	How Low Can You Go	M.1
	Water Here and There	N.1
2.9-	How Clean is Your Stream	G.1

2.10-	Water Goes Up and Down What is a Water Cycle Oh Well... Water Here and There	C.1 D.1 L.1 N.1
<u>Math</u>		
K.9-	What Shape is Water	B.1
K.12-	Water Works for Everyone Bad Guys vs. Good Guys	I.1 J.1
1.6-	What Shape is Water	B.1
1.9-	Water Works for Everyone Bad Guys vs. Good Guys	I.1 J.1
1.10-	Water Works for Everyone Bad Guys vs. Good Guys	I.1 J.1
2.7-	What Shape is Water	B.1
2.11-	Water Works for Everyone Bad Guys vs. Good Guys	I.1 J.1
<u>Social Studies</u>		
K.5-	How Water Flows... San Antonio EnviroSnack	O.1 Q.1
K.6-	It's Time to Conserve Being a Hydrologist	E.1 H.1
K.7-	Water Works for Everyone	I.1
K.16-	San Antonio EnviroSnack	Q.1
K.17-	It's Time to Conserve What's the Point	E.1 F.1
1.5-	How Water Flows...	O.1
1.6-	It's Time to Conserve What's the Point Being a Hydrologist How Water Flows... San Antonio EnviroSnack This is Polluted	E.1 F.1 H.1 O.1 Q.1 S.1
1.9-	Water Works for Everyone	I.1
1.19-	It's Time to Conserve What's the Point	E.1 F.1

2.7-	It's Time to Conserve Being a Hydrologist How Water Flows... San Antonio EnviroSnack	E.1 H.1 O.1 Q.1
2.8-	It's Time to Conserve What's the Point Being a Hydrologist This is Polluted	E.1 F.1 H.1 S.1
2.19-	It's Time to Conserve What's the Point	E.1 F.1

THE ABC'S OF WATER EDUCATION

Information to help you plan

We all know that water is essential to life. However, many times we take this important resource for granted. We expect it to be clean and abundant, but we do not take the necessary precautions to protect or conserve it. Without an abundant supply of good quality water, San Antonio, as well as the entire state of Texas, could suffer an environmental and financial crisis in the future.

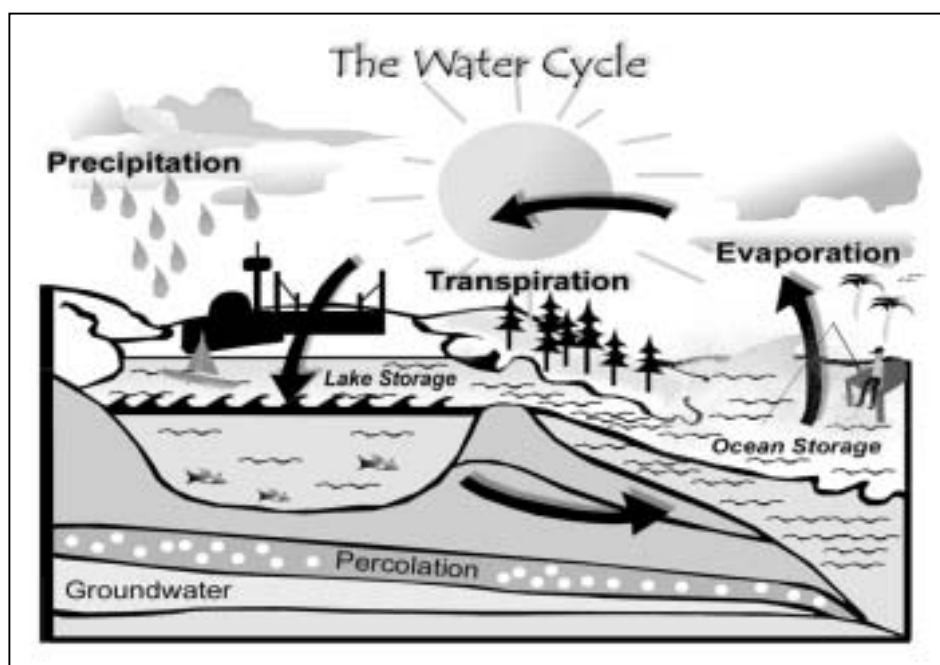
Texas is the second largest and the third most populated state in the United States supporting approximately 17 million people. As the state continues to prosper into the new century, the growing numbers of people will put a strain on the state's existing ground and surface water. Bexar county alone has 15 sub-watersheds serving more than 1.5 million people, and its population is expected to double over the next fifty years. In Texas, current water demand is 75% of existing capacity and in some basins, demand is approaching 100% of available supplies. Even with proactive efforts, demand for water in Texas will eventually exceed existing water supplies.

WATER IS...

- ◆ The only substance that occurs naturally in all three physical states (solid, liquid and gas)
- ◆ A large portion of all living materials
- ◆ Odorless, tasteless, colorless
- ◆ Essential to life
- ◆ The most abundant, unique and important substance on earth

EXACTLY WHERE IS WATER?

Water is essential to life on Earth. Water surrounds us. It is in the air as rain, ice, snow, steam and fog. It is in lakes, streams, rivers, oceans and glaciers. Earth has so much water, it has been given the nickname "the water planet". But this water really isn't new at all. In fact, at this very moment, we have all the water we will ever have or ever have had. No new water is being manufactured. This recycling process is called the hydrologic cycle.



Water's unique properties allow it to be a universal material. One of these special properties is its ability to change states very easily. Water can be found in three forms: a liquid, a solid, and a gas. While water can be found most often in its liquid form, it becomes a solid when the temperature drops below freezing at 32°F or 0°C and becomes a gas when the temperature rises to 212°F or 100°C. These forms play an important role in the hydrologic cycle process.

The hydrologic cycle, or water cycle as it is also called, takes place in the hydrosphere, a region containing all the water in the atmosphere and on the surface of the Earth. The process occurs through five vital stages: Condensation, Precipitation, Infiltration, Runoff, and Evaporation/Transpiration.

Condensation- When the Earth's air cools enough, water vapor condenses on particles in the air to form clouds. Clouds are then moved across the globe by winds which spread water vapor across the planet.

Precipitation- As the clouds become warmer and are "heavy" with vapor, they release this moisture to Earth in the form of precipitation, which can be snow, rain, hail or sleet.

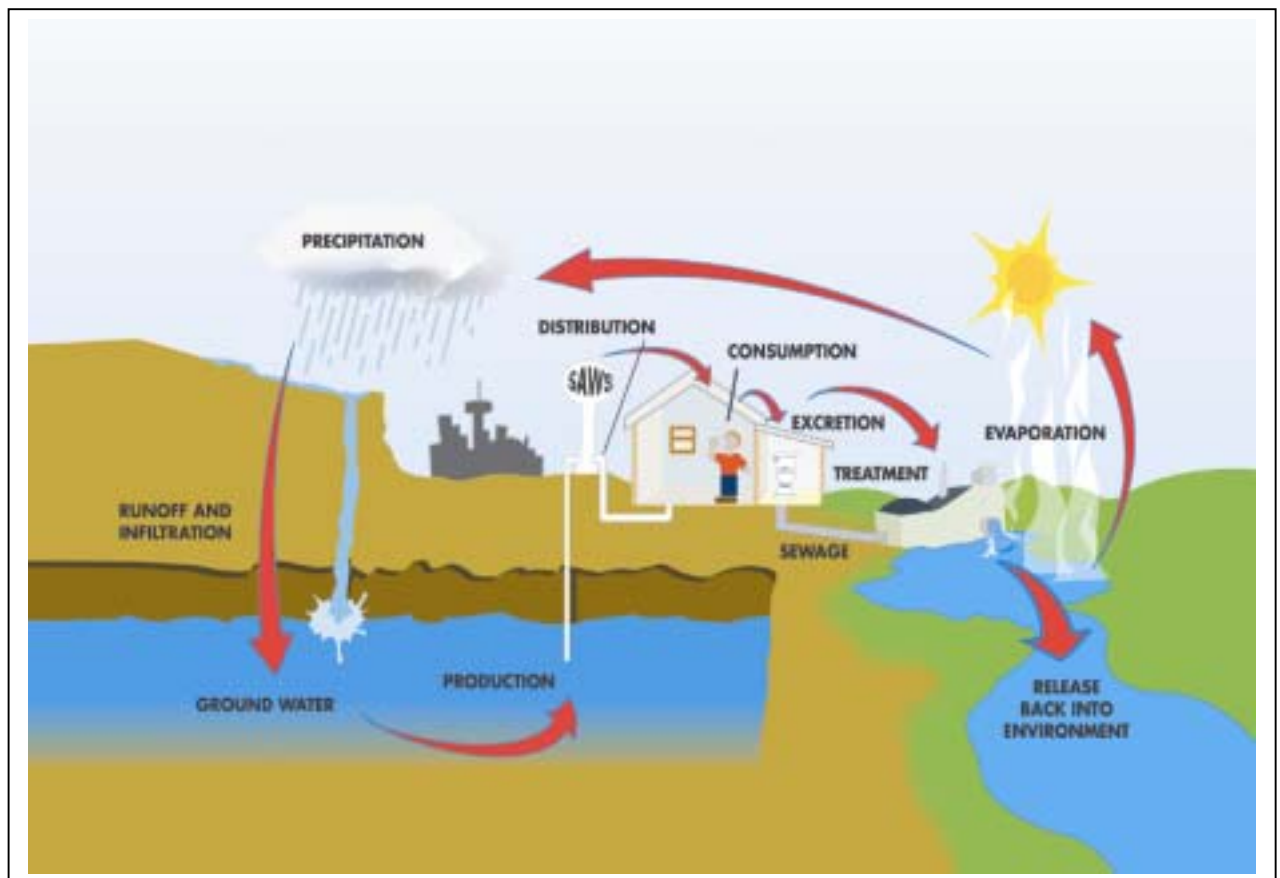
Infiltration, Runoff, Evaporation/Transpiration- The next three stages occur simultaneously after precipitation falls to the ground. Infiltration happens when precipitation seeps into the ground recharging shallow water tables and deep aquifers. The amount of infiltration depends heavily on the permeability of the ground. The more permeable the surface is, the more precipitation seeps into the ground. However, if precipitation occurs faster than it can infiltrate the ground, it becomes runoff. Runoff is precipitation that remains on the surface of the Earth flowing into streams, rivers and eventually large bodies of water such as lakes or oceans. Evaporation/Transpiration begins when the power of the sun (heat) changes the liquid water to a vapor. As the liquid heats, molecules are released and changed into a gas. Warm air rises up into the atmosphere and becomes vapor. Transpiration occurs when plants release water vapor through their leaves and into the atmosphere. Once the vapor enters the atmosphere, the entire hydrologic cycle begins again.

(Information adapted from Earthscape)

THE LIVING HYDROLOGIC CYCLE

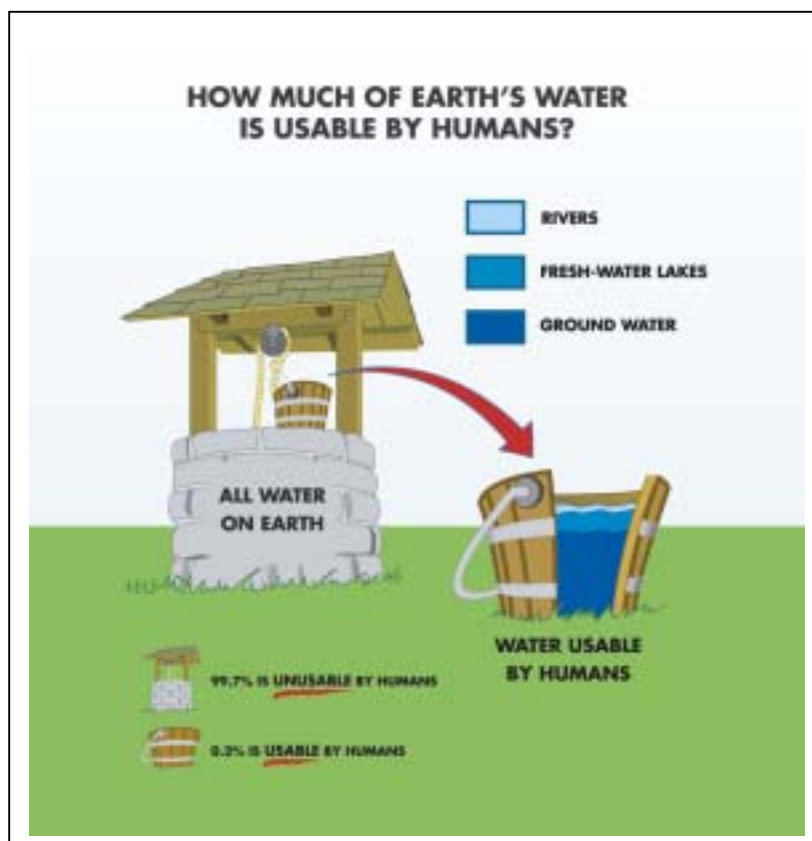
When you go to the faucet to get a drink of fresh clean water, that water is new to you. But it really isn't new water at all. As explained through the hydrologic cycle, the water has been recycled time and time again, from the very beginning of the Earth, through numerous life forms like dinosaurs, a rabbit or even Abraham Lincoln. Think about any organism that has lived in the past. Those organisms needed water to stay alive. As they lived, they released water back to the Earth in the form of exhaled water vapor, sweat and urine just as organisms do today. All organisms including humans are part of a living hydrologic cycle. How you might ask?

- ◆ After precipitation falls, humans capture runoff in reservoirs and pump infiltrated water from aquifers for human use.
- ◆ Through the process of production, the water is pumped, treated and distributed through a network of systems to people's homes and businesses.
- ◆ Next, humans utilize the water in many ways including consumption.
- ◆ Humans then rid the water from their bodies through perspiration, exhalation and excretion. Water vapor from perspiration and exhalation immediately enter back into the hydrologic cycle while excreted water is generally sent through a series of systems to be treated.
- ◆ Once treated, the water is then released back into the Earth's environment so the hydrologic cycle may begin again.



THE EARTH'S WATER USE

Water is the most abundant substance on Earth. Over 70% of the Earth's surface is covered with water making the world's supply about 326 million cubic miles. If it were poured on the United States, it would submerge the country to a depth of 90 miles. However, only a small portion of that water supply is usable fresh water. Most of the water on Earth is salt water, which is found in the oceans and seas. Salt water comprises over 97% of the water on the Earth. Just over two percent of the water on the Earth is fresh water frozen in glaciers and the polar ice caps.



Less than one percent of the water on Earth is fresh ground water and fresh water lakes, rivers and streams that is usable for humans.

(Information courtesy of the USGS)

TEXAS WATER USE

Municipal water use accounts for most of the water used in the state of Texas. Municipal water use generally includes water for households and businesses, restaurants and public offices, sanitation and landscaping and of course fire protection. Both the amount and type of water used depends a great deal on geographic location. Houston uses 12% of the overall municipal use, Dallas 9%, San Antonio 5%, Austin 3%, Fort Worth 3% and El Paso 3%. 65% is used by other people in the state.

WATER FACTS ABOUT SOUTH/CENTRAL TEXAS

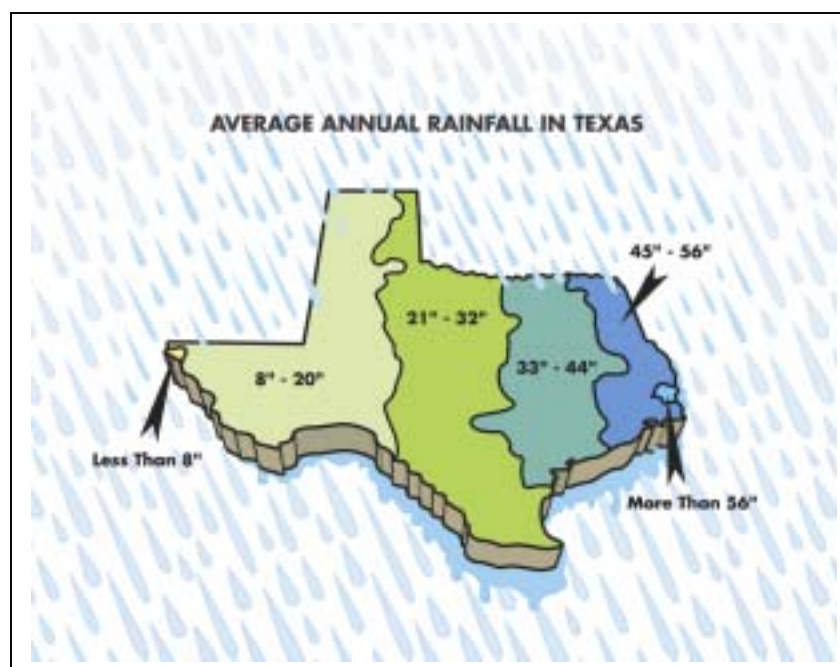
- ◆ San Antonio, Austin, San Angelo and Del Rio are the major population centers of this region.
- ◆ All of the largest springs in Texas are located in this region including the two largest- the San Marcos and Comal springs.
- ◆ San Antonio, the third largest metropolitan area in the state, currently is the only major city in the U.S. that obtains its entire water supply from a single aquifer.
- ◆ The longest dam in Texas is the 8-mile long dam at Twin Buttes Reservoir in San Angelo.
- ◆ The Medina Dam is the largest all-concrete dam in the state. It was completed in 1913 and created Medina Lake, at that time the largest reservoir in the state.
- ◆ The oldest continuously used irrigation system in the U.S. is the Mission San Francisco de la-Espada aqueduct in San Antonio. Built between 1740-1745, it still conveys water from the San Antonio River to the mission's crops.

RAINFALL

All the water on Earth comes from precipitation (the water cycle). Precipitation (mainly in the form of rain and snow) varies greatly across Texas. El Paso, for example, averages about 8 inches each year while places on the Texas-Louisiana border average 56 inches.

Historical records show the variable rates and magnitude of rainfall across the state.

- ◆ Presidio, in West Texas, has only 1.6 inches of rainfall in 1956.
- ◆ Clarksville, in Northeast Texas, experienced 109 inches of rainfall in 1873.
- ◆ Officially, the most rainfall recorded in a single day was 29 inches in Albany, in North Central Texas in August of 1978.
- ◆ From 1950-1956, Texas experienced a drought so severe that 94% of its counties were declared national disaster areas. It ended with serious flooding in 1957.
- ◆ Flash floods between the West Texas towns of Sheffield and Langtry, in June of 1956, produced an 86 foot-high wall of water that tumbled down the Pecos River Canyon.



WATERSHEDS

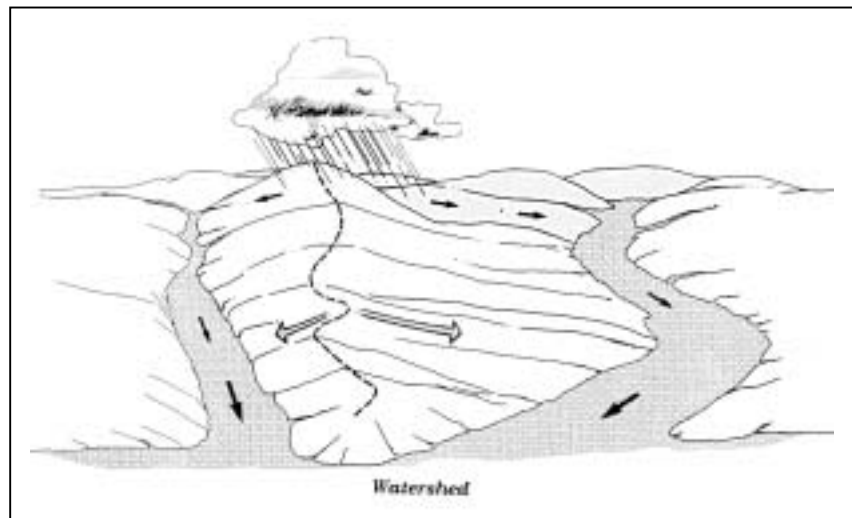
There are more than 40 rivers and 11,000 streams in Texas. Some of these waterways are wide and deep. Others are narrow and shallow. Some are always full of water, while others have just a little water for much of the year. Yet all rivers and streams change the land of Texas.

What happens to the water that falls on the land when it rains? Some water dries up. As we have already mentioned, some of the water sinks into the ground. The rest however, runs down the land's surface, through a watershed to become part of a river or stream.

Everyone lives in a watershed. A watershed is an area of land from which all the water drains (runs downhill) to a particular body of water such as a stream, pond, lake or river. A ridge or other area of elevated land, called a divide, separates one watershed from another. Streams on one side flow a different direction than streams on the other side.

A watershed can be large, such as the Upper San Antonio River Watershed or quite small, such as a couple of acres that drain into a pond. Larger watersheds are often called basins and usually contain many smaller watersheds. All the streams flowing into small rivers, larger rivers and eventually into the ocean, form an interconnecting network of waterways.

In Bexar County, all watersheds eventually flow into the San Antonio and Medina Rivers. Eventually, these two rivers merge to form the San Antonio River which eventually empties its water into the Gulf of Mexico.

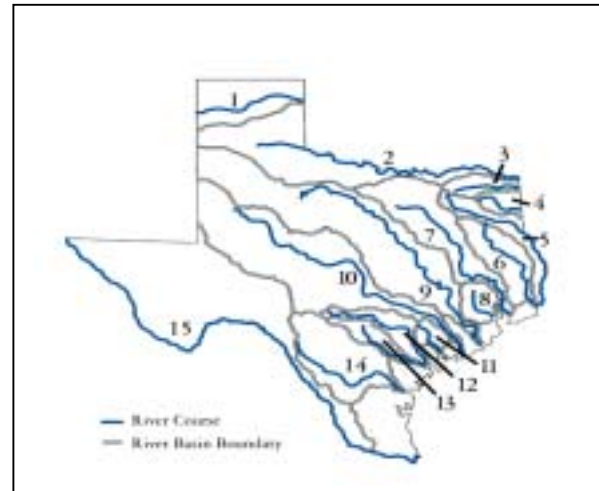


WATERWAYS

On the average, Texas receives 49 million acre-feet per year in runoff. Since one acre-foot is equal to 325,851 gallons (an area about the size of a football field covered with one foot of water), Texas experiences 15.9 trillion gallons of runoff during an average year. Most of this runoff is in the form of floodwaters that eventually flow into the Gulf of Mexico through the 80,000 miles of Texas' streams and rivers.

Texas has 15 major river basins and is second only to Minnesota in total surface miles of inland waterways.

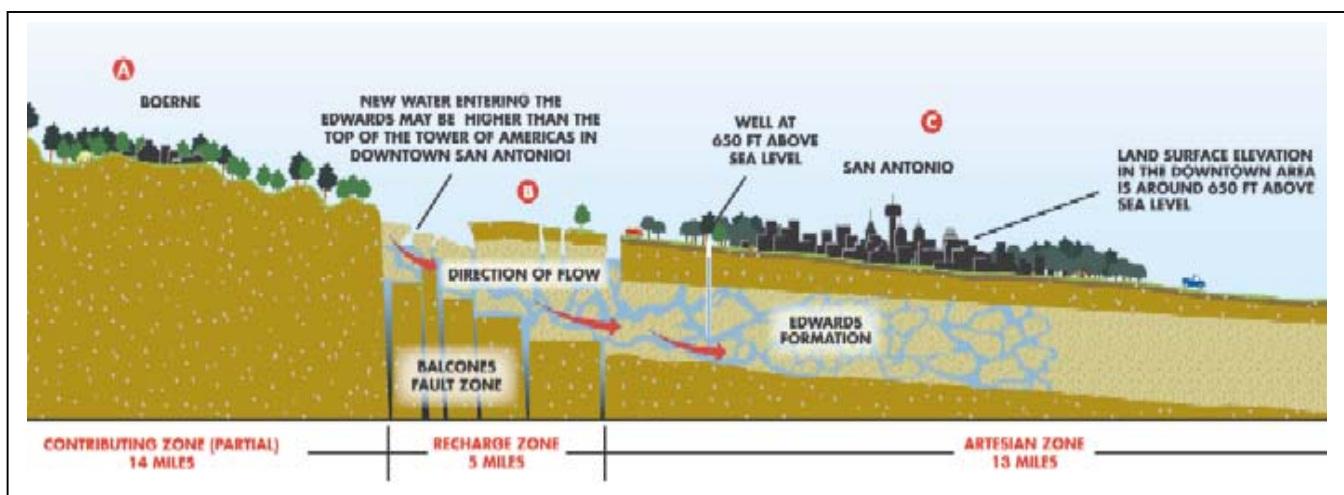
- | | |
|-----------------|-----------------|
| 1. Canadian | 12. Guadalupe |
| 2. Red | 13. San Antonio |
| 3. Sulphur | 14. Nueces |
| 4. Cypress | 15. Rio Grande |
| 5. Sabine | |
| 6. Neches | |
| 7. Trinity | |
| 8. San Jancinto | |
| 9. Brazos | |
| 10. Colorado | |
| 11. Lavaca | |



THE EDWARDS AQUIFER

The Edwards aquifer is a unique groundwater system. It is one of the greatest natural resources on Earth, serving the diverse agricultural, industrial, recreational, and domestic needs of almost two million users in south central Texas. Water from the Edwards is the reason that 18th century Spanish missionaries were able to establish footholds like the Alamo on the New World frontier. The Edwards is also the reason that San Antonio and many other cities in the surrounding region were able to grow and prosper for over two centuries without developing surface water or other water resources.

The San Antonio section of the aquifer extends in a 180-mile arc-shaped curve from Brackettville in the west to Kyle in the east. It provides the sole source of water for almost 2 million people in Bexar and surrounding counties.



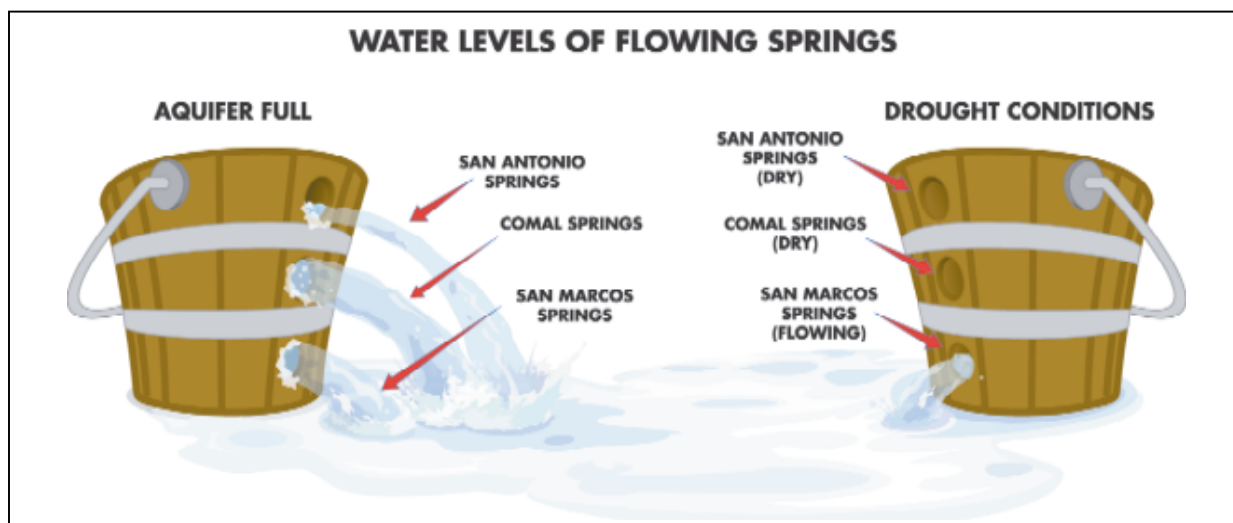
The aquifer is divided into three hydrologic and geologic zones: the Contributing Zone (also referred to as the Drainage Area or Catchment Area), the Recharge Zone and the Artesian Zone (see graphic). The **Contributing Zone** (Part A) occurs on the Edwards Plateau, also called the Texas Hill Country. When it rains over the Contributing Zone, the rainfall enters streams and rivers which then flows south toward the Recharge Zone.

Once the rainwater reaches the **Recharge Zone** (Part B), it flows over fractured limestone forcing the water to flow underground and down into the aquifer. Approximately 80% of aquifer recharge is through a sinking stream.

The water is now in the **Artesian Zone** (Part C) where it is confined underground by “waterproof” layers of rock above and below the water. Because the water is confined in this zone, it is under pressure. If a well is drilled into the aquifer here, the water will rise up in the well. If the pressure is high enough and the elevation of the well is low, the water may rise all the way to the surface in what is known as an artesian well. In other areas, the water may need to be pumped in order to get it all the way to the surface.

In a balanced system, the amount of water being removed from the aquifer does not exceed the amount going in as recharge. There are two ways that water is removed from the aquifer. The first way is by drilling wells into the aquifer and the second way is through natural springflow. Flowing springs in this area include the San Marcos Springs and Comal Springs in the northeast and San Antonio Springs and San Pedro Springs in the southwest. The largest springs are in New Braunfels at Comal Springs and in San Marcos at the San Marcos Springs. In fact, Comal Springs is probably the largest spring west of the Mississippi River. Springs can be thought of as holes in the side of a bucket, representing natural “leaks” in the aquifer. If enough water is in the aquifer, water would be lost as springflow even if all wells were shut down. When the aquifer has a lot of water and the “bucket” is full, water will gush from the “holes” resulting in higher spring flows.

As the water level in the “bucket” drops and the pressure diminishes, the springflow decreases or ceases all together. Comal Springs would go dry before San Marcos Springs because the level of the “hole” for Comal is higher than the “hole” for San Marcos.



THE EDWARDS AQUIFER: SAN ANTONIO'S MAIN SUPPLY OF DRINKING WATER

The world's supply of water is 326 million cubic miles. But only a small portion of that water supply is usable fresh water. In fact, of the Earth's total water supply, less than one-half of one percent is usable fresh water.

The United States is water "rich." For example, we have 39,400,000 acres of lakes and reservoirs. The Great Lakes contain about 1/5 of the world's fresh water supply.

80% of U.S. communities use groundwater as their primary source of drinking water and San Antonio is one such community. In order to have quality drinking water, three important factors must be present: Quality, Quantity & Location. The Edward's Aquifer, the first aquifer to be designated a sole source drinking supply by the Environmental Protection Agency (EPA), supplies water to the citizens of San Antonio and historically has possessed all three factors. Although San Antonio's water is considered to be slightly hard because of the calcium and magnesium that comes from the limestone aquifer, the QUALITY of water has never been a problem. However, recently the QUANTITY of water in the Edward's has come into question.

The aquifer level measurement that is typically given on TV is taken from a single monitor well at Fort Sam Houston, known as "J-17". Water levels have been recorded from this location since the 1930s and it therefore gives a good historical perspective on aquifer level fluctuations. In a balanced system, the amount of water being removed from the aquifer does not exceed the amount going in as recharge.

No one really knows exactly how much water is in this aquifer, but it is generally agreed that if you took the water out of the aquifer, you would be able to fill the state of Texas to about 1 foot in depth. Although San Antonio receives 22- 24 inches of rain a year, the recent droughts in South Texas combined with increased population growth has put a strain on this groundwater source.



ISSUES FACING OUR WATER RESOURCES:

POLLUTION ISSUES

Pollution exists in many forms including silt deposits, excessive nutrient content, high water flows, and toxins. There are two very different types of water pollution: point and non-point.

POINT SOURCE-If a single source can be identified as the cause of the pollution, such as a pipe or a ditch ("out of pipe"), this is called point source. Most of the time, point source pollution is controlled to some degree by treatment, either chemical or biological.

NON-POINT SOURCE-Non-point source pollution comes from many diverse sources and is therefore hard to identify its source. It is found in water that runs in a layer over the land during rainfall. This rainfall runoff carries pollutants from the land, through the watershed and into the stream. Excess farm and lawn nutrients such as fertilizers are one example of non-point source pollution, as is storm water runoff from construction sites and forestry operations.

Various types of water pollution include:

- Sediment (such as construction dirt)
- Nutrients (such as fertilizers)
- Toxic Substances (such as anti-freeze and oil)
- Organic Wastes (improper septic systems)
- Floatable debris (such as cups, bags, etc.)

THE CONCRETE JUNGLE

Today's common urban landscape includes -- more pavement, roads, parking lots, and buildings, and less natural areas. In natural landscapes, precipitation falls on porous earth, where some of it slowly seeps into the ground to help recharge underground aquifers. This is Mother Nature's way of regulating water runoff into rivers. Some of the water that falls in a watershed is absorbed into the ground. Only a portion of the precipitation runs off the land directly into the river.

Impervious areas are places like parking lots, which do not allow precipitation to soak through. Water must be "captured" by curbs, drains, and pipes and funneled into storm drains. Storm drains then deliver the collected storm water to local creeks and streams. A storm drain usually serves as a "short cut," so the water shoots through the pipe to the stream very quickly, instead of making its way very slowly through the ground-water system. If runoff from the drainage basin around the local creek reaches the creek too fast and all at once, then all that water may overwhelm it, resulting in a small flood.

STORM WATER RUN-OFF

Have you ever considered what happens to the fertilizers and pesticides that wash off your yard during a thunderstorm? Rainwater or excessive watering washes yard chemical residue into neighborhood gutters and storm drains that flow directly into our rivers, creeks and streams untreated. All rivers and creeks in Bexar County drain to the San Antonio River and eventually drain into the Gulf of Mexico. These pollutants could harm wildlife, fisheries and ruin recreation areas. They can even harm humans if not properly treated.

CAR CARE FOR CLEAN WATER

We all know that cars cause air pollution and sometimes even noise pollution. But cars may also cause water pollution? The fluids that leak from vehicle such as antifreeze, oil, grease, and transmission fluid run off into storm drains, which in turn can re-enter the water supply. Here are some common garage hazardous waste:

- ◆ Antifreeze
- ◆ Transmission fluid
- ◆ Brake fluid
- ◆ Gasoline
- ◆ Car batteries
- ◆ Old paint/thinner
- ◆ Wood stain and finishes

Used motor oil is the largest single source of pollution in our water. People often dump their used oil in the street or on the ground, which could end up back in the water. Recycle oil and antifreeze instead of using it to kill weeds and wildlife. Look for service stations that accept oil for recycling. Don't throw old batteries in the trash or bury them. Old batteries contain hazardous chemicals that can soak through the soil and pollute our water. Plus, it's against the law. Instead, look for recyclers located in the yellow pages under "Batteries Mfrs."

WEARING DOWN THE LAND: EROSION

Rivers and streams have great power to shape the land. Once rock has been broken up by weathering, the small pieces can be moved by water, ice, wind or gravity. The totality of forces that carry rocks and earth away is called erosion. In Bexar County, the erosion caused by flowing water has formed many of the area's land features.

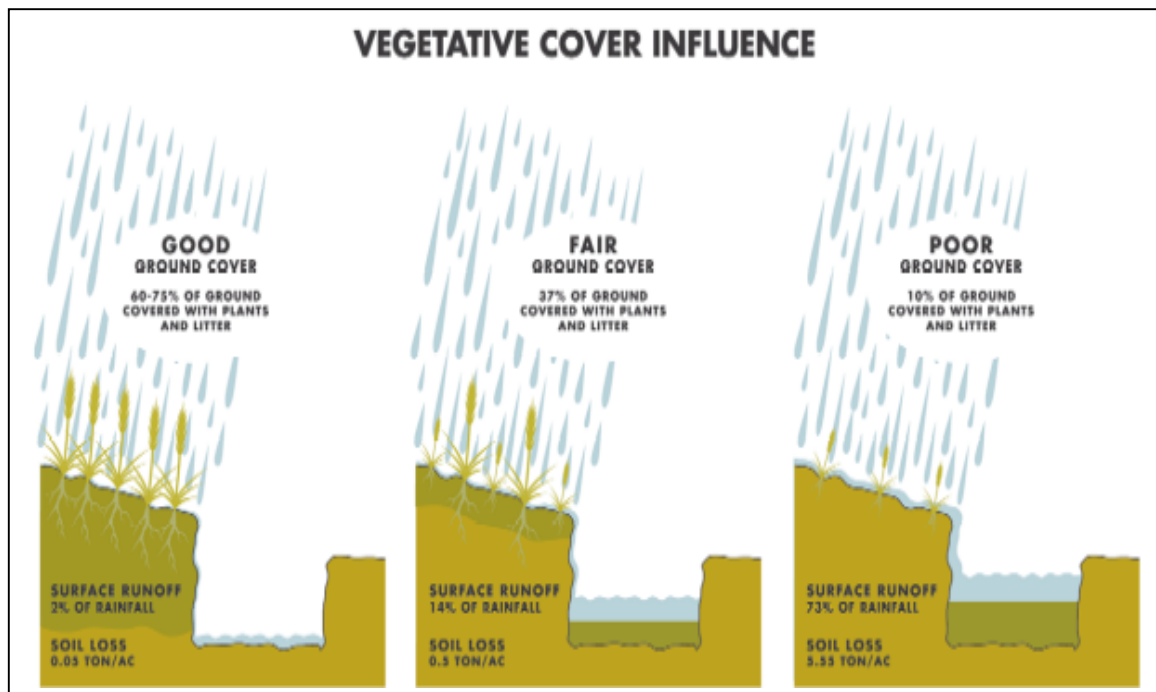
As water moves downhill, it is able to carry off pieces of the material over which it is flowing. The volume of water, the slope and the amount of ground cover all play a role in the amount of material that is eroded. Various factors influence the rate of erosion. Faster moving streams that have a greater volume of water are able to cut away at the stream bank more rapidly. Over time, faster moving streams are able to change their appearance as the stream bank erodes. As changes to the stream occur, different types of organisms and vegetation will be evident.

SPLASH EROSION

The first step in the erosion process is splash erosion. Raindrops strike the earth with considerable energy and are the major cause of soil particle detachment. A single raindrop may seem insignificant, yet when accumulated, raindrops strike the ground with a surprisingly large force. Raindrops can be especially erosive when residue, mulch, or vegetation are not present to absorb the impact forces. During an intense storm, rainfall can loosen and detach up to 100 tons of soil per acre. A raindrop falling on a thin film of water detaches soil particles more readily than a drop falling on dry soil. Detachment increases as the water on the soil surface becomes deeper, but only up to a depth about equal to the raindrop diameter. Once the water becomes deeper than this, detachment by raindrops is reduced and eventually eliminated because the water layer acts as a cushion.

During rainstorms, a two-fold problem often occurs. The rate of rainfall may exceed the rate at which water can enter the soil. The excess water either collects on or runs off the soil surface. Secondly, raindrop impact forces can result in a partially sealed soil surface, thus reducing infiltration of water into the soil which causes more runoff.

If all the water could always enter the soil, detachment and splashing of soil particles would be of minor concern and soil loss would be minimal. However, when the rainfall rate exceeds the soil's infiltration rate and the soil surface storage is filled, runoff will begin. This runoff will travel downhill, carrying soil particles with it.



CONSERVATION

The average American uses about 150 gallons of water a day. That makes daily water consumption in the U.S. alone over 372 billion gallons per day. San Antonio is no different. The city is the largest city in the U.S. to receive its drinking water exclusively from an aquifer.

SAWS is a permitted water system with overall regional limits to pumping. Translated into English, this means it is only allowed so much water from the Edwards Aquifer. That's why it's so important to save it. Conservation is the cheapest source of water. Water we save is water we don't have to buy. So it's important to do everything we can to decrease our water consumption. Plumbing fixture retrofits, watersaver landscapes, and improved habits are all ways we can make low water use a part of our everyday life.

A toilet, for instance, is the fixture that uses the most water in an average household, usually around 26% a day. Old toilets can use from 3.5 to 7 gallons per flush. Low flow toilets used in new construction or sold at the hardware store today are 1.6 gallon capacity.

Did you know that a five-minute bath uses more water than a five-minute shower? Baths can use up to 50 gallons of water whereas a shower with a low flow showerhead would only use 10 gallons. Low flow showerheads can save over 2 gallons per minute.

Voluntary restrictions on our water usage around the house is a good thing. But in times of drought, additional water restrictions may be needed to ensure that the aquifer remains at a safe level. When the level gets too low, mandatory water conservation measures are announced in order to get the community to take extra water saving precautions.

The Aquifer Management Plan restricts water use based on specific levels of the Edwards Aquifer. They include:

STAGE ONE

Stage One Alert begins when the Aquifer level reaches 650 feet mean sea level at the monitored well.

STAGE TWO

Stage Two Alert begins when the Aquifer level reaches 640 feet mean sea level at the monitored well.

STAGE THREE

Stage Three Alert begins when the Aquifer level reaches 630 feet mean sea level at the monitored well.

(For more information on the measures implemented at each stage, go to the SAWS web site at www.SAWS.org.)

WATER RIGHTS

Water rights are used to allocate water in an organized and systematic manner. A water right allows an individual, business, community or agency to use a specified amount of water. People may own the water right; but never the water.

The history of water rights is closely related to Settlement and land ownership. If a person owned the land, he or she could readily make use of water on or adjacent to their property. Over time, however, this simple allocation didn't work well because people began to settle areas alone, rivers upstream of the first settlers. These new settlers, although arriving later in time, now began to use water once only used by those downstream. In times of water scarcity, the downstream user might receive less water than they felt entitled to. The conflict that emerged pitted neighbor against neighbor in a fight for water, and ultimately resulted in a fight for basic survival.

A region's water rights doctrine is the result of many human and environmental factors. The successful settlement of the west was as closely tied to water as to any other factor. Limited water quantity is usually not the only issue. How people use water is also critical. For example, in the past few decades many changes have occurred that have added new dimensions to water rights and water allocation programs. Irrigated agriculture is one large consumer of water. Individuals and corporations invest millions of dollars in irrigation systems to grow crops and to produce forage for livestock which feed a hungry world. Cities also need water to meet the needs of residents, businesses, and industry. Water for recreation, fish and wildlife is receiving growing attention and is pressuring policy makers to reshape traditional water allocation patterns.

WATER IS LIFE

Water is of major importance to all living things. In fact, water deprivation kills faster than lack of any other nutrient. A person can live without water for only 5 to 7 days.

The unique qualities and properties of water are what make it so important and basic to life. The cells in our bodies are full of water. The excellent ability of water to dissolve so many substances allows our cells to use valuable nutrients, minerals, and chemicals in biological processes. Water's "stickiness" (from surface tension) plays a part in our body's ability to transport these elements all through ourselves. The carbohydrates and proteins that our bodies use as food are metabolized and transported by water in the bloodstream. No less important is the ability of water to transport waste material out of our bodies.

Water is a lubricant and the presence of water in and around body tissues helps defend the body against shock. The brain, eyes and spinal cord are among the body's most sensitive structures that depend on a protective water layer.

Water regulates body temperature. Our health and well-being are dependent on keeping body temperature within a very narrow range. The human bodies water make-up serves this function well. Evaporation of water from the body surface also helps the body stay cool. Sweat loss that occurs every day and night is barely noticeable. People may lose up to a pint of water each day in this manner. In hot, humid weather or during exercise, increased sweating and losses are more visible.

There isn't a "recommended daily allowance" for water consumption. Part of the reason for this is the difference in individuals related to the climate in which you live, physical activity, age, present physical condition and body size. Healthy adults require at least eight to ten cups of water each day. Although many times we drink milk, fruit juices, coffee, tea and sodas instead of water, our bodies still are able to extract the water from these sources through digestion and metabolism. The most important thing to remember is that proper hydration is extremely important to maintain optimal health.

(Excerpts courtesy of Bodybuilding.com- Water the Nutrient of Life, Rob Wilkins.)

HUMAN WATER REQUIREMENTS

- <1% deficit makes us thirsty
- 5% deficit causes fever
- 8% shortage halts saliva production and the skin turns blue
- 10% deficit prevents walking
- 12% shortage brings on death

WATER MANAGEMENT

Wise management of our valuable water resources will ensure that there is enough water to meet all future needs. Large users of water and land must be regulated to prevent using up or polluting water supplies. In this way, all water users will be protected. The duty of the state and federal governments is to establish suitable water quality standards. There is a need for cooperation between states and countries in this matter, because water knows no political boundaries.

Due to these urgent and important water problems, large numbers of scientists and government employees today are involved in water management. Some of the careers related to water management include:

Biologists- Study life and the processes that permit life

Chemists- Study the composition, structure, properties, and reactions of matter

Engineers- Apply scientific principles to designing, constructing, and operating structures or equipment

Geologists- Study the origin, history, and structure of the earth

Government Officials- Carry out the rules and regulations adopted by the public

Hydrologists- Study the properties, distribution, and effects of water on and in the earth and the atmosphere

Lawyers- Study and interpret the rules that govern our society

Mathematicians- Study number, form, arrangement, and associations

Meteorologists- Study the atmosphere, especially weather and weather conditions

Physicists- Study matter and energy and how they interact

Planners- Develop management guidelines and programs

Soil conservationists- Study methods of best using and maintaining soils

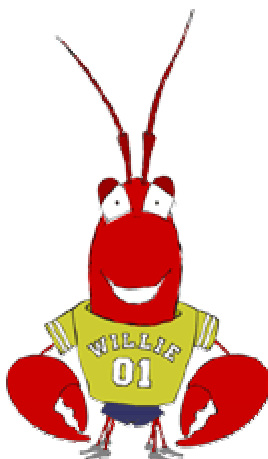
Soil scientists- Study the origin, distribution, and physical properties of soil

Well-drillers- Construct wells and water supply systems.

WHY WILLIE AND CALLIE?

WATERSHED WILLIE-Watershed Willie is a crawfish. Crawfish live in fresh water such as streams and creeks and are very sensitive to pollution in their water.

Watershed Willie therefore reminds students to be responsible and not to pollute his home.



CACTUS CALLIE-Callie, a prickly pear cactus, symbolizes one of the most water conservative plants in south/central Texas. Cacti live in very arid regions of the U.S. and through design, can absorb as much water as needed which can sustain them through long periods of drought.

Willie and Callie teach us that although we may live in different watersheds (different parts of the city) we all must work together and learn from each other in order to help protect our watersheds.



USEFUL DEFINITIONS

Aquifer-Porous, water bearing layer of sand, gravel and rock below the Earth's surface that acts as a reservoir for groundwater.

Condensation-Process by which a liquid is removed from a vapor or vapor mixture.

Conserve-To preserve and protect a natural resource from wasteful use.

Drought-A long period of time without a sufficient amount of rain.

Edward's Aquifer-An underground, water bearing area which is the sole drinking source for 1.5 million people in South/Central Texas.

Erosion-The wearing away of the Earth's surface by running water, wind, ice, or other geological agents by which material is removed from the Earth's surface.

Evaporation-Process in which the heat energy of the sun causes the water on the Earth's surface to change into a vapor.

Groundwater-Water that infiltrates into the Earth and is stored in usable amounts in the soil and rock below the Earth's surface, water within the zone of saturation.

Impermeable-Material that will not allow water to pass through it.

Hydrologist-A person that applies scientific knowledge and mathematical principles to solve water-related problems in society including problems of quantity, quality and availability.

Hydrology-The science that encompasses the occurrence, distribution, movement and properties of waters of the Earth and their relationship with the environment.

Nonpoint Source Pollution-Pollution that cannot be traced to a single point source, because it comes from many individual places or from over a widespread area.

Percolate-Water moves into the aquifer by passing through a porous layer of rock.

Pollution-An unwanted change in air, water or soil that negatively affects the health and survival of humans and other organisms.

Point Source Pollution-Pollution that can be traced to a single point source, such as a pipe or culvert.

Recharge-Process where water flows into the aquifer.

Runoff-Water (originating as precipitation) that flows across surfaces rather than soaking in; eventually enters a water body; may pick up and carry a variety of pollutants.

Sediment-Solid material that has been moved from its original site by water and has been deposited on the land or in the sea.

Spring-A place where water flows naturally from underground in the aquifer to the surface.

Surface Water-Water that is stored on the earth's surface.

Water Cycle-Continuous movement of water from the oceans and fresh water sources to the air and land and then back to the oceans.

Watershed-Land area from which water drains to a particular surface water body.

OVERVIEW OF ACTIVITIES

How are they designed?

Activities are designed for the kindergarten through second grade age groups and cover units in Social Studies, Fine Arts, English, Math, and Science.

Each activity is broken into 8 different sections . They include: **Objectives, Subjects, Time, Materials, Background Information, Terms, Advance Preparation, Procedure, and Resources.** Following is a summary of what you will find in each activity.

Objectives-What the students should be able to accomplish after completing the activity.

Subjects-Denotes the educational objective of the activity.

Time-The time frame to complete the activity.

Materials-All the supplies needed for the activity. Some supplies are included with this workbook while others must be collected by the teacher.

Background Information-Gives an expanded version of the Educator's Water Introduction through additional information related specifically to the activity.

Terms-Definitions specific to the activity.

Advance Preparation-Pre-planning and collection of all supplies.

Procedure-Steps to accomplish the activity. This section is broken into four sub-categories:

Setting the Stage-Discussion questions or steps that introduce the activity. Note: Many of these questions are related to TAAS objectives.

Activities-Instructions on how to do the activity. (TAAS Objectives included).

Follow-Up-Any pictures to be drawn, data sheets to be completed or questions to be answered by the students. (TAAS Objectives included).

Extension-Additional activities used in conjunction with the main activity. This section is optional, however, many of the activities are educational and entertaining. (TAAS Objectives included).

Resources-Sources used to develop the activity or additional sources of information to help further develop the subject matter.

ADDITIONAL RESOURCES

Addresses:

◆American Water Works Association
6666 W. Quincy Ave.
Denver, CO 80235
(303)794-7711
<http://www.awwa.org>

◆Environmental Protection Agency-Region 6
Fountain Place 12th Floor, Suite 1200
1445 Ross Avenue
Dallas, TX 75202-2733
(214)665-2200
<http://www.epa.gov/region06/>

◆Keep America Beautiful
9 West Broad St.
Stamford, CT 06902
(203) 323-8987

◆North American Association of Environmental Educators (NAAEE)
410 Tarvin Rd.
Rock Springs, GA 30739
www.naaee.org

◆Texas Agricultural Extension Service-State Headquarters
106 Administration Building
Texas A&M University
College Station, Texas 77843-7101

◆Texas Environmental Center
Box 220, S-300
Austin, Texas 78767-0220

◆Texas Commission on Environmental Quality(TCEQ)
P.O. Box 1308
Austin, TX 78719-3087
<http://www.tnrcc.state.tx.us/>

◆Texas Parks and Wildlife
4200 Smith School Road
Austin, Texas 78744
<http://www.tpwd.state.tx.us>
<http://www.tpwd.state.tx.us/nature/ecoreg/pages/blkp.htm>

◆Texas State Soil & Water Conservation Board
311 North 5th Street

P.O. Box 658
Temple, Texas 76503

◆ U.S. Fish and Wildlife Service
P.O. Box 1306
Albuquerque, New Mexico 87103-1306

◆ Water Education Foundation
717 K Street, Suite 517
Sacramento, CA 95814
<http://www.water-ed.org/>

◆ Water Environment Federation
601 Wythe Street
Alexandria, Virginia 22314-1994
<http://www.wef.org/wefstudents/#>

Web Pages:

◆ 4-H Wetland Wonders
<http://www.reeusda.gov/4h/curricul/dbd20.htm>

◆ Aquarena Center-Southwest Texas State University
<http://www.continuing-ed.swt.edu/aquarena/>

◆ Cyberways and Waterways
<http://www.cyberwaysandwaterways.com/en/CW3Home/>

◆ Educating Young People about Water
<http://www.uwex.edu/erc/ey paw/>

◆ Edwards Aquifer Authority
<http://www.edwardsaquifer.org/>

◆ Edwards Aquifer Home Page
<http://www.edwardsaquifer.net>

◆ Edwards Aquifer Research and Data Center
<http://eardc.swt.edu/>

◆ Enviroscape
<http://www.enviroscapes.com/>

◆ Global Rivers Environmental Education Network
<http://www.green.org/>

◆ Keep San Antonio Beautiful
<http://www.KSAB.org/>

◆ Lady Bird Johnson Wildflower Center
<http://www.wildflower.org/npin/index.html>

◆ Missions National Park Service

<http://www.nps.gov/saan/>

◆ National Gardening

<http://www.kidsgardening.com/grants.asp>

◆ Natural Resources Conservation Service

<http://www.nrcs.usda.gov/>

◆ Nature Conservancy

<http://nature.org/>

◆ Project WET

<http://www.montana.edu/wwwwet/>

◆ Rangeland Ecology and Management-Texas A&M University

<http://rangeweb.tamu.edu/>

◆ San Antonio Botanical Garden

<http://www.sabot.org/>

◆ San Antonio River Improvements

<http://www.sanantonioriver.org/overview.html>

◆ San Antonio Water System

<http://www.saws.org/>

◆ Surf Your Watershed (EPA)

<http://www.epa.gov/surf/>

◆ Teaching Environmental Sciences

<http://www.tnrcc.state.tx.us/exec/oppr/pubeduc/teach.html>

◆ Texas Project Learning Tree

<http://www.plttexas.org/Default.htm>

◆ Texas Watch

<http://www.texaswatch.geo.swt.edu/>

◆ US Geologic Survey (USGS) GIS Data for Water Resources

<http://water.usgs.gov/public/GIS/>

◆ Water Environment Federation

<http://www.wef.org/>

◆ Water Resource Education Network (WREN)

<http://pa.lwv.org/pa/wren/>

◆ Wet Net

<http://www.glo.state.tx.us/wetnet/>

◆ Witte Museum

<http://www.wittemuseum.org/>

◆ World Wildlife Fund

<http://www.worldwildlife.org/>

http://www.worldwildlife.org/wildworld/profiles/terrestrial/na/na0814_full.html

◆ Youth Net

<http://youth.net/>

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"W.E.T. Instruction Handbook," Texas Natural Resource Conservation Commission, 1990.

"Clean Water in Your Watershed: A Citizens Guide to Watershed Protection in cooperation with the U.S. Environmental Protection Agency Region VI Water Management Division," Terrene Institute, 1993.

"Envirosnacks", Laura DeGuire, made available from Linda Humphreys Department of Environmental Quality.