Post Oak Savannah Groundwater Conservation District
Burleson County & Milam County, State of Texas

2013-2014 Water Wizards
Seventh-Grade Educational Program
Teacher's Reference Guide

Mission: The Post Oak Savannah Groundwater Conservation District (POSGCD) was created by the Texas Legislature to protect the groundwater supply for the residents of Burleson and Milam Counties. The District is charged with determining how best to protect the underground aquifers so that there will be enough water for everyone, now and in the future.

Program Goals: Through participation in the Water Wizards Program, students will gain a general understanding of the water cycle, watersheds, aquifers, the unique characteristics of their local aquifer, the importance of good groundwater quality, and the relationship between groundwater and surface water in a watershed.

Program Objectives:

- Students will gain a general understanding about the dynamics and hydrogeology of groundwater resources in Texas as well as a familiarity with local groundwater resources.
- In extension activities, students will have an opportunity to learn about residential uses of water, pro-active efforts for the prevention of non-point source pollution, and ways they can personally contribute to water conservation at home.
- In a class demonstration students will observe:
    - how to locate a well using a handheld Global Information System device,
    - how to take well water samples and water depth measurements,
    - how to test samples for several water quality parameters, and
    - how groundwater data is recorded.

Program Description/Curriculum:

Representatives from the POSGCD will visit each participating seventh-grade classroom on two class days, depending on the length of the class period and the time available. The presentations will include visual aids and several demonstrations about the hydrologic cycle, groundwater and surface water, watersheds, aquifers, the local Carrizo-Wilcox Aquifer, and an overview of actual procedures used to measure the water level and other parameters at a water well site. A 20-minute video will be sent in advance.

Activities giving students an opportunity to repeat some of the demonstrations will be available to teachers. Internet sites are included for further student research.

Extension activities focusing on conservation and household pollution may also be provided for use in the classroom and as homework. These activities will allow the students to depart from a technical analysis of the aquifer to a more personal and cultural one, both in the community and in their own home, with an emphasis on conservation measures and proactive efforts to prevent groundwater pollution.

Key TEKS correlation to seventh grade Texas Essential Knowledge and Skills (TEKS) requirement (6.14) Science Concepts: "The student knows the structures and functions of Earth systems. **(B) The student is expected to identify relationships between** groundwater and surface water in a watershed."

References/Resources: Our appreciation goes to all those organizations whose work contributed to this program:

- Barton Springs/Edwards Aquifer Conservation District
- Bureau of Economic Geology, The University of Texas at Austin.
- Cyberways and Waterways
- National Wildlife Federation: Texas Living Waters Project
- Texas Commission on Environmental Quality
- Texas Water Development Board
- U.S. Environmental Protection Agency
- Brazos River Authority, Lower Colorado River Authority

HOME ACTIVITIES: Before the District's visit, the teacher is encouraged to make copies of the following two activities, found in this reference guide, and assign them as homework over several days or a weekend. The activities are designed to raise student awareness of their personal and family use of water, and of hazardous products commonly found in homes.

Americans use an average of 60 gallons of water per person every day. Even if it is raining outside, you are still pumping water inside. Lawns, gardens and flowerbeds account for about 35% of a home's total water use. Some water supplies loose 20% or more of their water through leaks in pipes. One of the best things you can do to conserve water and lower your home's water bill is to repair any leaks or dripping faucets. Do any of your families collect rainwater?

1. Home Water Use Inventory. (page 6) Ask students to look at a recent home water bill, identify their water provider, and note how much that provider charges (amount per 1000 gallons) for water supplied to their home. Students can also research whether they use surface water or groundwater, and determine if their family has a well on any family property.

2. Household Hazardous Waste. (page 8-9) This activity relates water pollution to use of hazardous products in the home.

- Teacher may review homework and discuss student findings.
- Teacher may also choose to distribute the Water Use Survey. Give students 10 minutes to prioritize the 22 items from the highest priority for them, marked with '1', to the lowest, marked with '22'. Ask students how they would personally choose to conserve water if a severe drought greatly restricted water use.

Presentation Outline

Introduction

I. **The Water Cycle & Water Use**
   A. Discussion of Water Use Inventory and Survey (if presented as homework)
   B. Conservation Issues: Mean Indoor Water Use, Top Water Conservation Tips
   C. Conservation Items: (rulers, erasers, brochures)
   D. VIDEO: Water for the Life of Texas (4:15)
   E. <u>Slides</u>:
   - The Hydrologic Cycle (Water Wise Texas/EPA)
   - Eastern Hemisphere photo from space
   - Water Use by Humans
   - How Groundwater Occurs in Rocks

   F. Bookcovers illustrating water cycle

II. Watersheds
   A. <u>Slides</u>:
   - Watershed
   - Little Bear Creek Watershed
   - DEMONSTRATION: Watershed Model (colored vinyl)
   - Reading a Topo Map
   - Reference Square

   B. My Local Watershed Map: Watersheds
   C. Topo map and Geo map of Burleson & Milam Counties

III. Surface Water
   A. <u>Slide</u>: River Basins of Texas (BEG)
   B. Questions about rivers to encourage student participation
   C. Rainfall & Historical Records
   D. <u>Slide</u>: Water Service Areas in the Brazos River Basin (BRA)

IV. Groundwater in Texas
   A. VIDEO: Water Well Basics (9:46)
   B. <u>Slide</u>:
   - Estimated Groundwater Use in Texas 2000 (TWDB)
   - Groundwater Systems (Project WET)

   C. DEMONSTRATIONS: Aquifer Model & Water Table

V. Aquifers
   A. Bookcover with Groundwater Cycle diagram
   B. DEMONSTRATION: Large Aquifer Model & Nomenclature of Aquifer
   C. Outcrop & Recharge
   D. <u>Slide</u>: Gulf Coast Formations
   E. Porosity & Permeability
   F. Confined & Artesian Aquifers
   G. <u>Slide</u>: Major Aquifers of Texas (TWDB)
   H. <u>Slide</u>: Minor Aquifers of Texas (TWDB)
   I. <u>Slide</u>: Burleson & Milam Counties (TWDB)
   J. DEMONSTRATION: Rate of Absorption in Different Materials
   K. VIDEO: Foundations (7:47)

VI. Pollution

A. Non-Point Source Pollution & Hazardous Household Waste (Homework)
B. DEMONSTRATION: Aquifer Model: run with red dyes
C. DEMONSTRATION: Water Movement/Flow Rate (see appendix)

V. The Carrizo-Wilcox Aquifer

A. Slides:
- Geological Atlas Map of region (BEG, paper)
- Principal Aquifers of U.S.
- Aquifers of Texas #2
- Geology of Texas; Land Resources of Texas
- Formation of the Carrizo-Wilcox Aquifer
- Geologic Cross-section of the Carrizo-Wilcox Aquifer

B. DEMONSTRATION: Karst and Sandstone

VI. Threats to the Aquifer

A. Slide: Groundwater Conservation Districts
B. Rule of Capture/Springs Stories:
Ogallala, Water Marketing, Rule of Capture, Ozarka, Comanche Springs
C. Slide: Water Wizards Program
D. DEMONSTRATION: Well Model & Measurement
E. Parameters: GIS, water depth, clarity/color, odor, iron, Ph, conductivity, chloride, temperature, nitrate

Extension Activities in Math – for teacher's use as desired:

- Look up the total area for your county. Using figures for the county's average annual precipitation, calculate the volume of precipitation for one year in your county.
- Extend calculations to your school grounds, a football field, or your family home or ranch by measuring and calculating the area of each. Area = length X width. Average rainfall in feet X Area = Volume of rainfall in cubic feet.
- Determine the weight of water at each location. Water weighs 62.5 pounds per cubic foot.
- Calculate the amount of rainfall in one or more of these locations in gallons or liters.
- One acre foot is the amount of water it would take to cover one square acre one foot deep. How much would that weigh? You will first need to determine how many square feet are in an acre.
- Use 5 gallons to represent all the water on earth. If 5 gallons = 1280 tablespoons (one tablespoon = 25 drops) calculate how many tablespoons (or drops) would represent the oceans (97%), glaciers and ice caps (1.74%), freshwater lakes (.007%), rivers (.0002%), and fresh groundwater (.76%). (Saltwater lakes, brackish groundwater, water vapor, soil moisture and other sources of water make up the missing numbers to equal 100%.)

Student Groundwater Glossary

An **AQUIFER** is a water-bearing, geologic formation (sand, gravel, rocks, etc.) that is capable of yielding significant quantities of groundwater to wells and springs. **GROUNDWATER** lies beneath the surface of the ground in some areas, while **SURFACE WATER** lies upon the surface of the earth in lakes, streams, rivers, and oceans.

A geological **FORMATION** is a grouping of similar materials, rocks, or sediments.

If a material is **PERMEABLE**, water can permeate, pass through, or flow through it. If water cannot pass through it, the material is **IMPERMEABLE**. A **POROUS** rock has lots of pores or open spaces that allow water to flow through the rock formation.

The sedimentary layers of the Carrizo-Wilcox Aquifer dip or tilt, sloping ever deeper beneath the ground toward the coast. **DOWNDIP** is in the direction of the dip or tilt beneath the ground. DOWNDIP is that part of a water-bearing layer of sand or rock which dips below other layers.

Groundwater **RECHARGE** is the intake (percolation) of rainfall into an underground formation. An aquifer is recharged or replenished by rain and stormwater runoff in outcrop areas. A **WATERSHED** is the geographic area from which water drains toward a particular stream, lake or bay.

The **OUTCROP** or **RECHARGE ZONE** is the part of a water-bearing formation that is exposed at the surface of the ground. It allows recharge water to plunge (percolate) directly into the subsurface rocks or sands that make up the aquifer.

Most of the water in the Carrizo-Wilcox Aquifer is under **CONFINED** or **ARTESIAN** conditions. Where the permeable, sandy layers are buried under younger, less permeable clay layers, the water-bearing layers can become confined. The sands, fully saturated with water, are under **ARTESIAN PRESSURE** due to gravity and the weight of the water. If a well is drilled into a confined aquifer, the pressure in the aquifer will cause groundwater to rise up the well bore to the top of the aquifer. The water we drink today from the wells in the Carrizo-Wilcox Aquifer was likely recharged hundreds to thousands of years ago.

GROUNDWATER LEVEL is the elevation to which water rises in a well. It may vary according to rainfall, pumping in the surrounding area, and leakage or discharge which releases water into springs, rivers, or adjacent rock formations. Any groundwater withdrawals from a confined aquifer result in a reduction in the artesian pressure or in physically draining a portion of the unconfined aquifer.

DRAWDOWN is the lowering of the groundwater level water table, or water level in a well.

The term **FLUVIAL** relates to action by rivers and streams. The term **DELTAIC** refers to the discharge of water and sediments at the mouth or DELTA of a river. Roughly triangular in shape, the delta takes its name from the Greek letter Delta: Δ.

SEDIMENT is material that is carried by water and may settle to the bottom of the water.

An **ACRE FOOT** refers to the amount of water needed to cover one acre of land one foot deep, or about 326,000 gallons. An acre is roughly the size of a football field.

- Name: ________________________________ Date: ___________

Home Water Use Inventory

Use the following chart to calculate how much water is used in your home for **one day**. Ask each member of your family to cooperate by **estimating** their water use, too. Look at your **home water bill** for one month to compare how accurate you are. It will include outdoor use, too.

1. Each time that one of the activities listed in the **Water Use Activity** column occurs, write it down in the **How Many Times a Day** column.
2. By using the amounts provided in the **Gallons Per Use** column, calculate the **Total Gallons** for each row. (For example, suppose 4 people flush 8 times each = 32 flushes times 3.5 gallons = 112 gallons)

Water Use Activity	How many times a day for total # people in household	Multiply times (X) # of Gallons Per Use	Total Gallons
Flushing Toilet		**X 3.5 gallons/flush =**	
Dishwashing: Automatic		**X 10 gallons/load =**	
By Hand		**with tap running X 25 gallons =**	
Washing Machine		**X 40 gallons/full load =**	
Shower (minutes running)		**X 3 gallons/minute =**	
Bath (minutes running)		**X 3 gallons/minute =**	
Open Faucet (minutes running) Washing hands		**X 1.5 gallons/minute =**	
Brushing Teeth		**X 1.5 gallons/minute =**	
		TOTAL Household Water Usage =	

Name: ______________________________ **Date:** _____________

Water Use Survey

Directions: What water uses are most important to you? If water became scarce, what would you eliminate first? Rank the following uses of water on a scale of 1 (highest priority) to 22 (lowest priority).

Water Use	**Ranking**
Drinking	________
Bath/Shower	________
Swimming	________
Washing Clothes	________
Washing Car	________
Flushing Toilet	________
Cooking	________
Watering Vegetable/Herb Garden	________
Watering Lawn	________
Washing Hands	________
Brushing Teeth	________
Shaving	________
Washing Dogs	________
Watering Outdoor Landscape	________
Making Ice	________
Maintaining a Fish Aquarium	________
Enjoying a Hot Tub	________
Watering House Plants	________
Mopping Floors	________
Washing Dishes (By hand or machine)	________
Cleaning Kitchens and Bathrooms	________

Name: ___________________________ Date: ____________

Household Hazardous Waste

What is Household Hazardous waste?

Household hazardous waste may be any discarded liquid or solid material or containers holding gases, which may have an adverse, harmful, or damaging, biological effect on an organism or upon the environment itself. When household hazardous waste is disposed of improperly it can contaminate our environment by polluting our water and soil.

What is Hazardous?

A substance is considered hazardous if it:

- Can catch fire
- Can react or explode when mixed with other substances
- Is corrosive
- Is toxic

The six classes of household hazardous waste are:

1. Cleaning products:
   * Aerosols, bathroom cleaners, drain cleaners, chlorine bleach, oven cleaners, and toilet cleaners
   * Solvents and spot removers
2. Automotive Supplies:
   * Car waxes, batteries, repair products
   * Starting fluids and motor oil
3. Hobby Products:
   * Paints, stains, and finishes
   * Thinner and chemical strippers
   * Glue and contact cement
4. Personal products/Pharmaceuticals:
   * Prescription drugs
   * Nail polish remover
5. Pesticides:
   * Lawn chemicals
   * Weed and pest killer
   * Herbicides, insect repellents, and insecticides
6. Home Environmental supplies
   * Flea collars and sprays
   * Fire extinguishers
   * Kerosene and lighter fluid
   * Lye, mothballs, and pool chemical

Some facts about household hazardous waste:

- One liter of motor oil can contaminate two million liters of drinking water.
- The average household has between 3-10 gallons of hazardous materials.
- Products such as motor oil contain toxic chemicals and metals that will contaminate groundwater, drinking water, and freshwater wildlife habitats.
- Never dump hazardous wastes on the ground, and always check the label before pouring them down the drain.

Directions: Fill out the Household Hazardous Waste inventory documenting all of the hazardous household materials in your home. On a separate sheet of paper, write a brief summary of things you can do to minimize household hazardous waste in and around your home.

Class	Materials/Items	Location	Quantity
Cleaning Products			
Automotive Supplies			
Hobby Products			
Personal Products/ Pharmaceuticals			
Pesticides			
Home Environmental Supplies			

Groundwater Websites for teachers and students

- http://earthobservatory.nasa.gov/Newsroom/BlueMarble. Great space photo of Earth.
- For a very cool animated water cycle, go to this website from Canada at http://www.region.waterloo.on.ca/web/region.nsf/0D78CB956F92D4BB85256C6B005A62C7/$file/hydrologic2.swf?openelement

- Read about the water cycle and see a diagram (in 33 languages) on the US Geological Survey website at http://ga.water.usgs.gov/edu/watercycle.html
- How much water does it take to grow a hamburger? http://ga.water.usgs.gov/edu/sc1.html
- USGS Aquifer Basics. http://capp.water.usgs.gov/aquiferBasics/index.html

- Challenge yourself with this groundwater quiz from the Wisconsin Department of Natural Resources. http://www.dnr.state.wi.us/org/caer/ce/eek/earth/groundwater/gquiz.htm
- Three groundwater games featuring Wellhead Willy at the Lower Platte South Natural Resources District site. http://www.lpsnrd.org/docs/Games/games.htm
- Try this water quiz from the IEPA at http://www.epa.state.il.us/kids/fun-stuff/quiz/water-quiz.html

- Check out "What is Groundwater?" http://www.groundwater.org/KidsCorner/what1.htm
- Create a model aquifer out of ice cream and other tasty stuff. You can experiment with "polluting" your aquifer and creating a well to "pump" something to drink. Groundwater Foundation site. http://www.groundwater.org/KidsCorner/activity.htm

- American Meteorological Society has a great site called WES or Water in the Earth System. Information and good links. http://www.ametsoc.org/amsedu/WES/home.html
- Aquifer in a Bottle. www.fhsu.edu/kga/lp/5/janzen.html
- Aquifer, Build your own. http://www.epa.gov/OGWDW/kids/aquifer.html
- Cyberways & Waterways: Lesson plans about aquifers and many detailed links with other water sites. www.cyberwayswaterways.com
- What is Ph? www.epa.gov/airmarkets/acidrain/ph.html

- Texas American Water Works Assoc. Quiz. www.tawwa.org
- Texas Commission on Environmental Quality, lesson plans. www.tceq.state.tx.us
- Texas Water Development Board www.twdb.state.tx.us → mapping for maps of River Basins, Aquifers and more information about Texas water
- Texas Water Resources Institute http://twri.tamu.edu/
- Texas River Systems Institute http://rivers.txstate.edu/

- Texas Water Wise Council promotes conservation. www.waterwisetexas.org
- The Water Systems Council will answer all kinds of questions about groundwater and well care. http://www.wellcarehotline.org/wellcare/index.cfm
- Virtual fieldtrips www.vftn.org → see watershed awareness

- www.bedisclosure.com/pdf_dir/44%20what%20aquifer.pdf is an environmentally-focused demo of aquifers.
- Texas Natural Resources Information System www.tnris.state.tx.us
- Science Olympiads http://www.groundwater.org and click on KidsCorner
- Teachers can join a list-serve to receive updates on interesting websites from Dr. Bob Williams Http://www.siue.edu/OSME/river

Water Table/Rate of Absorption

Directions: Follow the procedures listed and answer the following questions.

1. In Styrofoam or paper cup, punch holes with pencil lead, used to simulate rain.

2. In clear cup, layer (in order) stones, gravel, bits of sponge or sand, soil, vegetation. Layers may vary in thickness.

3. Add 2 or 3 drops of red dye to the water. Holding perforated cup over the model, pour the tinted water into the cup to simulate rain. Pour until the water collects up to or into the gravel.

4. Mark the water level all around the glass with the grease pencil or Vis-a-Vis marker. This line represents the water table.

Compare and describe water distribution in the different layers.

____

____

5. Fill 3 identical clear cups 2/3 full: one with **sand**, one with **gravel**, one with **rock** (these must be dry). Write predictions as to which will absorb water fastest, which will have the lowest water table and which could hold the most water before it is saturated (the water then floods the surface).

Predictions: Absorb		Water Table		Water Storage	
Fastest	_______________	Lowest	_____________	Most	_______________
Middle	_______________	Middle	_____________	Middle	_______________
Slowest	_______________	Highest	____________	Least	_______________

6. Add 1/8 cup of tinted water to all 3 glasses, one at a time, using the perforated cup. **Time the rate of absorption** for each, and record these.

Rate of Absorption (seconds)	Sand	Gravel	Soil

7. With grease pencil, **mark the water table level** around each cup. Record the levels. Compare the results to your predictions, then write your observations on the lines provided.

Water Table level:

Lowest ____________________

Middle ____________________

Highest ____________________

Comparison:____

____

8. Continue adding small amounts of water to each glass, recording the amounts, until all have reached saturation. Record which material held the most water, using the words "porosity" and " infiltration."

Reached Total Saturation	First	Second	Third

THE UNIQUE CHARACTER OF THE CARRIZO-WILCOX AQUIFER

Background Information for Teachers

One of the great blessings of Burleson and Milam Counties has always been the Carrizo-Wilcox Aquifer, a natural, underground reservoir, which is the only dependable source of drinkable groundwater for our farms and ranches, homes, cities and businesses. It is also a comparatively inexpensive source of water, since drilling wells costs much less than treating surface water. In addition to providing plentiful water for more than 40,000 people in our two counties, this unique aquifer provides water to all or parts of 60 counties in Texas.

Eighty percent of water for domestic use in Milam and Burleson counties is from groundwater, while only twenty percent comes from surface water*. (Almost all of the surface water use is in Cameron (Little River) and Buckholts (Lake Belton). Both have water treatment facilities. Each of the larger cities in the District has a wastewater facility – Cameron, Rockdale, Somerville and Caldwell.)*

One of nine major aquifers in Texas, the Carrizo-Wilcox is the longest and one of the most prolific aquifers in the state, stretching from Mexico across Texas and into Arkansas and Louisiana. It contributes water to the Colorado and Brazos Rivers as well as to many springs and local streams throughout the area that provide water for a diversity of fish and wildlife, oak and pine forests, and livestock that sustain our way of life. Usable quality water occurs at greater depths in this aquifer than in any other Texas aquifer.

Because the two main aquifer layers are composed mostly of sand, it is easier for the water to go through them, giving better water quality. The longer water stays in mineral settlements, the worse the quality tends to get. The water gradually absorbs the minerals of the rocks and sediments and tastes bad. Since the easily dissolvable minerals have been flushed out of this aquifer's sandy layers over thousands of years, the water is pretty clean and its quality is generally high. That makes this water very precious.

The ancient sandstone formation of the Carrizo-Wilcox Aquifer goes back to the Eocene Epoch, or "Age of Mammals" in the **Cenozoic Era**. Geologists believe the Eocene era began about 54 million years ago, ten million years after the extinction of the dinosaurs. Ancestors of modern mammals lived during the Eocene – animals like small rodents, bats, early whales and horses, and very early primates like tarsiers, lemurs and tree shrews.

The coastline at that time was very close to where the aquifer is now, and rivers carried sand, mud, clay and silt to the mouths of their channels as they emptied into what was to become the Gulf of Mexico. It was not unlike the present-day Mississippi Delta, an environment like the swamps and marshes you find along the coastline. Thus the Carrizo-Wilcox Aquifer is composed mostly of river sediments. Consequently, the material in the Carrizo-Wilcox Aquifer is primarily **terrigenous** -- that is, it is derived from the land rather than the sea. Instead of the limestone and seashells of the Edwards Aquifer, the Carrizo-Wilcox is composed mostly of river sediments - clays, mud, and sands.

Many Central Texans are familiar with the Edwards Aquifer, which is a much older, karst formation of rough, eroded limestone with many caves and sinkholes, formed under sea. It was laid down in the Cretaceous Period (130 million years ago) of the Mesozoic Era, when Tyrannosaurus was at his peak and butterflies appeared to pollinate the newly created flowers. Scientists believe the first, egg-laying mammals developed, and the Rocky Mountains were formed during the Cretaceous Period. You can even find seashell fossils in the Edwards Aquifer.

In the Cretaceous, the proto-Gulf was an inland sea, covering much of Texas. The shells and skeletons of sea creatures sank to the bottom when they died, layer upon layer over millions of years. In a karst aquifer like the Edwards, which is made of limestone and dolomite beds from these sea deposits, materials like the calcium carbonate of the seashells dissolve very readily, leaving a system of fractures, faults, sinkholes, and caves through which water flows rapidly. It is very different from the major water-bearing layers of the Carrizo-Wilcox, which are composed of porous, permeable sand and sandstone. So, to understand the Carrizo-Wilcox Aquifer, you have to forget everything you know about the Edwards Aquifer. The Carrizo-Wilcox Aquifer is entirely different, composed of very densely packed, fine-grained sandstone, and water moves through it very slowly.

Another important difference is that the Edwards Aquifer is recharged primarily through leakage of stream bottoms (which could present problems if the streams carry pollutants). The Carrizo-Wilcox is recharged directly at the outcrop by rainfall.

Contamination from pesticides and fertilizers is less of a concern in Burleson and Milam Counties. Since the land is mostly rangeland, there is little use of chemicals. Water moves very slowly relative to the Edwards. The sand and clay grains act as filters, and there isn't much industrial development around the outcrop.

The Carrizo-Wilcox Aquifer is made up of four **formations**, each of which was laid down over the years, one on top of the other, by the action of the rivers and deltas. The **Hooper** Formation is the oldest. It is about 500 feet thick and is predominantly mud sediments of clay and silt. Then comes the **Simsboro** Formation, which is from 100 to 700 feet thick and predominantly coarse sand. The next layer is the **Calvert Bluff**, which is up to 1000 feet thick and is mostly clay. This layer is where the lignite mined by Alcoa is found. It was necessary for Alcoa to pump water out of the Simsboro in order to reduce the artesian pressure below their mines and keep them from being flooded.

Finally, the **Carrizo** overlies the these three formations of the Wilcox Group, and is also primarily sand. The Simsboro and Carrizo Formations are both water-bearing, sandy aquifers, but the Simsboro is the principal aquifer in our area. We believe that there is little or no hydraulic connection (movement of water) between the Simsboro and Carrizo.

Today there are threats to this ancient aquifer. The biggest concern is that more water will be taken out than can be replenished naturally. Will there be enough water for everyone who wants it? Without a doubt, there is a large amount of groundwater available for municipal, agricultural, and industrial use in the Carrizo-Wilcox Aquifer. There is, however, a legitimate concern that the resource is not inexhaustible. At some point groundwater mining could take place. When this occurs, more water is being withdrawn than can be naturally replenished. This situation has already occurred in the **Ogallala** Aquifer in the 1980's. Five times the annual recharge amount was withdrawn, resulting in significant **drawdown**. Water levels dropped significantly and left many springs and wells dry.

The Carrizo-Wilcox Aquifer is an irreplaceable natural resource. A complete understanding of the hydrogeology of the aquifer system is essential if supply and water quality problems are to be avoided. It must be recalled that at one time groundwater supply in the Ogallala Aquifer beneath the Texas High Plains seemed unlimited and inexhaustible.

If we are to avoid the mistakes of our forerunners, we must learn from those mistakes and understand the nature and distribution of groundwater in the Carrizo-Wilcox Aquifer System and its relationship with surface water. POSGCD is involved in extensive research and studies to better understand and project conditions in these formations of the Carrizo-Wilcox Aquifer to be better able to manage the groundwater resources of Milam and Burleson counties to meet the future needs of the citizens in the District.

AN ENDANGERED AQUIFER: The Downside of Drawdowns

Surface or above-ground water includes rivers, lakes, streams, and reservoirs. Surface water is highly regulated by the state because it is considered to be owned by the state. Most anyone wishing to use surface water must get a water rights permit through the Texas

Commission on Environmental Quality (TCEQ). The user must demonstrate beneficial use of water, and must not infringe on another's use under existing water rights.

Burleson and Milam Counties are in the area of the BRA (Brazos River Authority). The BRA generates electricity and regulates Brazos River water.

Groundwater, on the other hand, is almost always privately owned. It belongs to the owner of the land above it, unless the owner sells or transfers his rights.

When it comes to groundwater in Texas, according to the "Rule of Capture" there are no rules for withdrawing the water. In 1904, the Supreme Court of Texas deemed underground water to be too "mysterious, occult, and concealed" to be regulated.

The right to pump water is not limited to the groundwater presently under your own land. If you decide to install wells large and powerful enough to cause water to migrate from under your neighbor's land to under yours, you are entitled to do that. Groundwater Conservation Districts have authority over a landowner's right of capture, and they generally have authority to restrict the amount of water pumped by a landowner. GCDs can modify the Rule of Capture in their district to suit that area's needs. Well-spacing is taken into consideration when evaluating whether a new well will have an impact on one's neighbors. The POSGCD also has a program to plug abandoned wells, covering up to 75% of the well-owner's costs. This will help address water quality issues.

Various people have challenged this "Rule of Capture," but it was upheld again as recently as 1998 in the case against **Ozarka** Water's effect on Roher Spring in Henderson County. Bart Sipriano owned one of the wells that went dry. He was a man of very modest means. For over ten years he and his family took baths and washed their laundry in a stock tank until his neighbors finally raised enough money for Mr. Sipriano to dig a deeper well.

Back in 1954 **Comanche Springs** went dry. The Overland Trail from San Antonio to San Diego went past those springs, and the Comanche and Kiowa horse-raiding trail ran all the way from Guatemala up to those springs and north to the Plains. That's why the government put Fort Stockton there -- to separate the Comanches and the white people going west in Conestoga wagons. That, and the location of the springs themselves. Rainfall is less than ten inches a year in that area, and by the 1950s Comanche Springs served as an irrigation district for 90 farmers. One farmer drilled a lot of wells to irrigate alfalfa for his cattle, and the springs went dry. The court upheld the Rule of Capture. Those wells are still pumping, without regard for the neighbors or the townspeople who used the springs.

In Milam and Burleson counties, we raise Coastal Bermuda and other types of hay as well as pecans, corn, milo (maize), soybeans, watermelon, and turf grasses, all of which require irrigation, and 90% of the irrigation water is groundwater, primarily from the Little River Alluvium and Brazos River Alluvium. A large percentage of the cotton raised in the state is raised in Burleson County. The land here is not flat enough for growing rice, which accounts for 70% of the total groundwater use in Texas. But because of the competition for surface water, there is a lot of interest all over Texas in mining groundwater to export it to other areas of the state for city and suburban water supplies. This is known as **water marketing**. There is a great deal of interest in exporting water to areas just west of our District.

Selling water to cities outside Burleson and Milam Counties would not drain the Carrizo-Wilcox Aquifer, but it would probably lower the water table, and it would lower the pressure in the aquifer. However, if you lower the pressure, you increase the lift cost, making the use of water by local people more expensive and more difficult. Lift is the distance from the water level to the ground surface. Bigger pumps would be more expensive, and there would be a greater expenditure in energy cost. The pump itself must be below the water table level, so you may have to deepen the well or change out the pump. A pump that can lift 50 feet may be incapable of lifting 500 feet, and the pump that will lift 500 feet may not fit in your old well.

If more water is being withdrawn than can be naturally replenished, water levels could decline, perhaps to the point that water levels are drawn down below the top of the water-bearing sands. This would affect many of the smaller wells in the area. Creeks could dry up sooner after storms. Rivers, lakes, and streams may tend to loose more water. Over long periods of time (on the order of hundreds or thousands of years) recharge or intake of water is equal to discharge or output through leakage. However, pumpage does not have to be greater than the recharge for tributary creeks to dry up.

Since much of the rainfall on the outcrop of the Carrizo-Wilcox is eventually discharged to the Brazos and Colorado Rivers via springs, creeks, and direct leakage, the result of additional pumpage could affect the amount of water discharged to these rivers.

Scientists believe that overpumping can endanger an aquifer's water supply. To a great extent they are hypothesizing, but we know what happened to the Ogallala Aquifer. In heavily pumped irrigation areas, such as the Winter Garden area in south Texas – where vegetables can be grown in the winter with irrigation water from the Carrizo-Wilcox, water levels in the aquifer have declined and pumping costs have increased significantly. The water level in the Winter Garden area was lowered 400 feet, causing encroachment of poor quality water into the deeper parts of the aquifer there.

In the recent study by the UT Bureau of Economic Geology, sponsored by the Texas Water Development Board, Alcoa, San Antonio, and Aqua Water Supply of Bastrop, the drop in water level in the deeper parts of the aquifer by the year 2050 is projected to be 370 feet - equivalent to a 37-story building. The tallest building in Austin, One American Center at 6th and Congress, is only 24 stories high, just 2/3 as high as the drawdown would be deep. According to the study, the water levels could be much lower in 2050 than they are now. At some point the aquifer will no longer be full. We don't know when because projections of the study only go out 50 years.

The Carrizo-Wilcox Aquifer is an irreplaceable natural resource. It is not inexhaustible. The biggest concern is that more water will be taken out than is put in. That's not so terrible in itself, but how long can you sustain it? You can choose to manage an aquifer so it supplies in perpetuity, or you can choose to manage an aquifer for a finite period of time, but you can't do both. As Ben Franklin said, "When the well's dry, we know the worth of water."

POSGCD has chosen to manage the aquifers in this District based on drawdowns measured in water levels recorded annually in monitor wells strategically located across the aquifers and management zones in the District. The wells and drawdown levels have been identified through much research and evaluation and have been adopted by the District to provide protection for not only the aquifers, but also the citizens who depend on the groundwater from wells in those aquifers. When certain levels of drawdown are approached in District monitor wells, permitted production will be decreased so that the aquifers will be maintained at those levels in perpetuity.