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## INTRODUCTION

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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. Conservation and preservation of existing water supplies is the key to San Antonio's water future. Education of today's youth helps insure plenty of quality water tomorrow.

The importance of water cannot be stressed enough. *The ABC's of Water Education* has been developed to help you "self discover" the many roles water plays in our lives.

The program, which encompasses the "ABC's of water", is divided into seven units: San Antonio Water from the **B**eginning, **C**hemical Properties, **G**eographically and **G**eologically, **H**istorically, **N**aturally, **P**ipes, **P**lanning, **P**olitics and **P**eople, **Q**uality and **Y**ou.



# SAN ANTONIO WATER FROM THE **B**EGINNING

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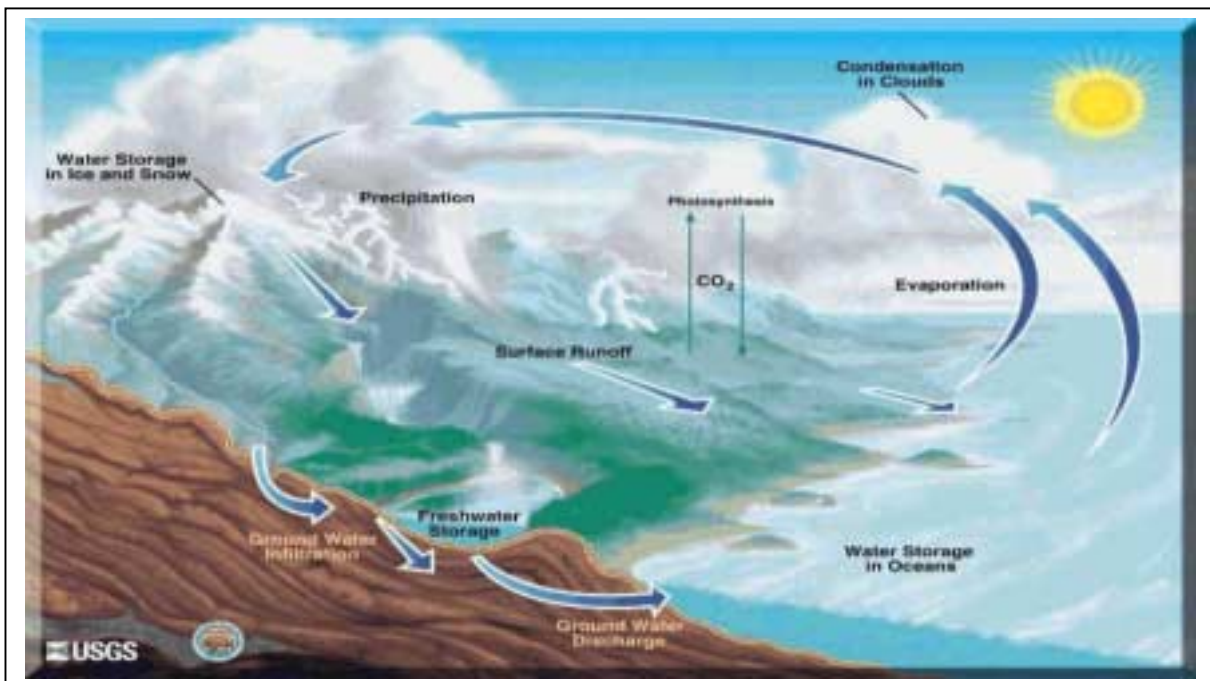
**“If there is magic on this planet, it is contained in water.”**  
*-Loren Eiseley*



## **Background Information**

### **EXACTLY WHAT IS WATER?**

Water surrounds us. It is in the air as rain, ice, snow, steam and fog. It is in lakes, streams, rivers, oceans and glaciers. When you go to the water fountain to get a drink of fresh clean water, that water is new to you. But it really isn't new water at all. That 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. This is called the water cycle and it happens through condensation, precipitation, evaporation, surface runoff, and percolation. One very important fact to remember is that at this moment, we have all the water we will ever have, or ever have had. No new water is being manufactured.

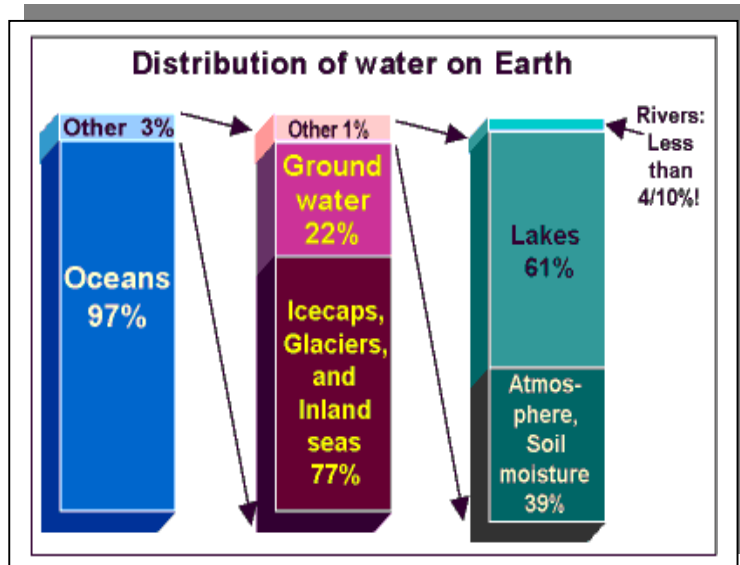


## WATER IS ALSO...

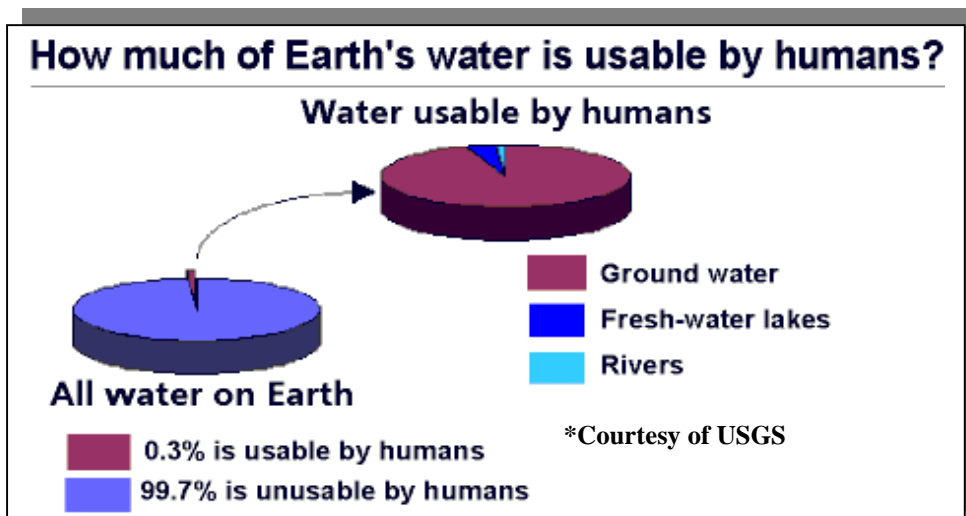
- \*Made of two elements: hydrogen and oxygen.
- \*The only substance that occurs naturally in all three physical states (solid, liquid and gas).
- \*A large portion of all living materials. Humans are composed mostly of water but also lose water through perspiration, respiration and waste elimination. Plants also lose water through a process called transpiration.
- \*Odorless, tasteless, colorless.
- \*Essential to life.
- \*The most abundant, unique and important substance on earth.

## WATER USE

Water is the most abundant substance on Earth. Over 70% of the Earth's surface is covered with water. The world's supply of water is 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.



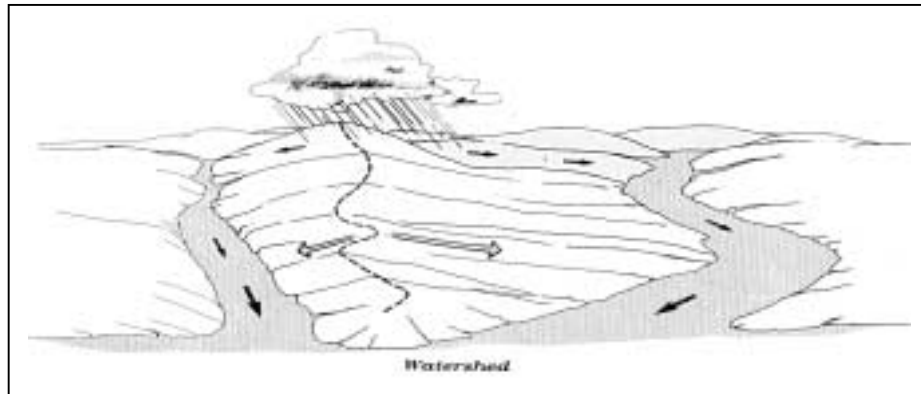
Water can be found in three forms: a liquid, a solid, and a vapor. Water can be found most often in its liquid form and becomes a solid when the temperature drops below freezing at 32° F or 0°. Water becomes a vapor when it escapes into the air. The more heat that is applied to water, the faster it vaporizes. Water is in a constant cycle of changing from a liquid to a vapor because it is made up of millions of molecules that are in constant motion.

## **WATERSHEDS AND WATERWAYS**

**WATERSHEDS**-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.

Human activities can have a great impact on what happens to a watershed and subsequently a waterway such as a creek. Therefore, waterways are good indicators of events that occur on the land in the watershed.



**RIVERS**-Rivers are large natural waterways that flow to the ocean. They are important as sources of water supply for farms, industry and even drinking water. The amount of water a river will yield is the result of various factors including climate of the area and the size of the river's drainage basin.

**CREEKS**-A creek is a small waterway that is usually a shallow or intermittent tributary to a river.

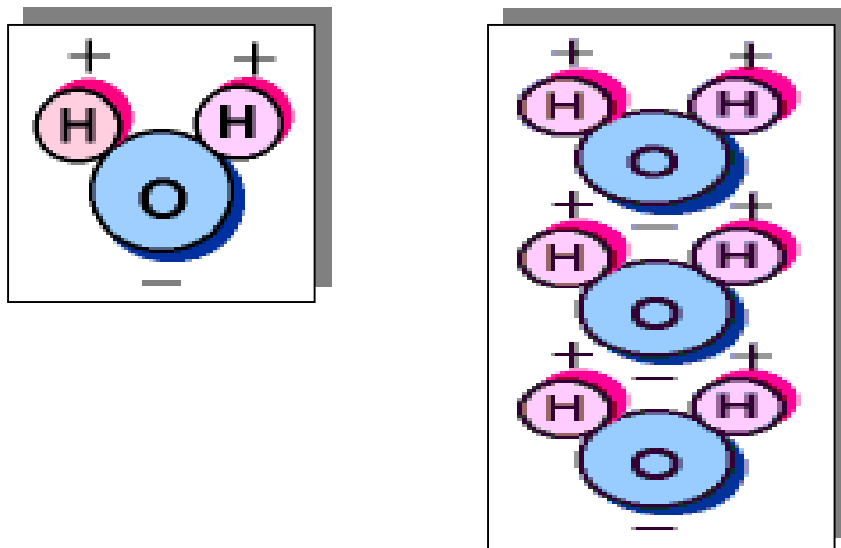


# SAN ANTONIO WATER CHEMICAL PROPERTIES

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## WATER'S CHEMICAL PROPERTIES

You probably know water's chemical description is  $H_2O$ . As the diagram shows, one atom of oxygen is bound to two atoms of hydrogen. The hydrogen atoms are "attached" to one side of the oxygen atom, resulting in a water molecule having a positive charge on the side where the hydrogen atoms are, and a negative charge on the other side, where the oxygen atom is. Since opposite electrical charges attract, water molecules tend to attract each other, making water kind of "sticky." As the right-side diagram shows, the side with the hydrogen atoms (positive charge) attracts the oxygen side (negative charge) of a different water molecule.



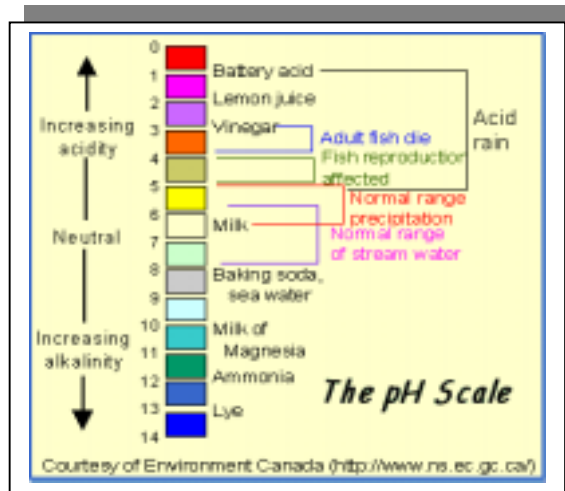
## WATER MEASUREMENTS

Taking a single measurement of a water's properties is actually less important than looking at how the properties vary over time. For example, if you take the pH of the creek behind your school and find that it is 5.5, you might say "Wow, this water is acidic!" But, a pH of 5.5 might be "normal" for that creek. It is similar to how your normal body temperature (when you're not sick) is about 97.5 degrees, but a third-grader's normal temperature is "really normal" -- right on the 98.6 mark. As with our temperatures, if the pH of your creek begins to change, then you might suspect that something is going on somewhere that is affecting the water, and possibly, the water quality. So, often, the *changes* in water measurements are more important than the actual measured values.

Some types of measurements include:

## pH

pH is a measure of how acidic/basic water is. The range goes from 0 - 14, with 7 being neutral. pHs of less than 7 indicate acidity, whereas a pH of greater than 7 indicates a base. pH is really a measure of the relative amount of free hydrogen and hydroxyl ions in the water. Water that has more free hydrogen ions is acidic, whereas water that has more free hydroxyl ions is basic. Since pH can be affected by chemicals in the water, pH is an important indicator of water that is changing chemically. pH is reported in "logarithmic units," like the Richter scale, which measures earthquakes. Each number represents a 10-fold change in the acidity/basicness of the water. Water with a pH of 5 is ten times more acidic than water having a pH of six.



## Water temperature

Water temperature is not only important to swimmers and fisherman, but also to industries and even fish and algae. A lot of water is used for cooling purposes in power plants that generate electricity. They need cool water to start with, and they generally release warmer water back to the environment. The temperature of the released water can affect downstream habitats. Temperature also can affect the ability of water to hold oxygen as well as the ability of organisms to resist certain pollutants.

## Conductivity

Conductivity is a measure of the ability of water to conduct an electrical current. It is highly dependent on the amount of dissolved solids (such as salt) in the water. Pure water, such as distilled water, will have a very low conductivity, and sea water will have a high conductivity. Rainwater often dissolves airborne gasses and airborne dust while it is in the air, and thus often has a higher conductivity than distilled water. Conductivity is an important water-quality measurement because it gives a good idea of the amount of dissolved material in the water.

### Turbidity

Turbidity is a measure of the cloudiness of water. It is measured by passing a beam of light through the water and seeing how much is reflected off particles in the water. Water cloudiness is caused by material, such as dirt and residue from leaves, that is suspended (floating) in the water. Crystal-clear water, such as Lake Tahoe (where they work hard to keep sediment from washing into the lake) has a very low turbidity. But look at a river after a storm -- it is probably brown. You're seeing all of the suspended soil in the water. Lucky for us, the materials that cause turbidity in our drinking water either settle out or are filtered before the water arrives in our drinking glass at home. Turbidity is measured in nephelometric turbidity units (NTU).

### Dissolved oxygen

Although water molecules contain an oxygen atom, this oxygen is not what is needed by aquatic organisms living in our natural waters. A small amount of oxygen, up to about ten molecules of oxygen per million of water, is actually dissolved in water. This dissolved oxygen is breathed by fish and zooplankton and is needed by them to survive.

Rapidly moving water, such as in a mountain stream or large river, tends to contain a lot of dissolved oxygen, while stagnant water contains little. The process where bacteria in water helps organic matter, such as that which comes from a sewage-treatment plant, decay consumes oxygen. Thus, excess organic material in our lakes and rivers can cause an oxygen-deficient situation to occur. Aquatic life can have a hard time in stagnant water that has a lot of rotting, organic material in it, especially in summer, when dissolved-oxygen levels are at a seasonal low.

### Hardness

The amount of dissolved calcium and magnesium in water determines its "hardness." Water hardness varies throughout the United States. If you live in an area where the water is "soft," then you may never have even heard of water hardness. But, if you live in the San Antonio area and get your water from an aquifer, you may notice that it is difficult to get a lather up when washing your hands or clothes. And, industries in the area might have to spend money to soften their water, as hard water can damage equipment. Hard water can even shorten the life of fabrics and clothes!

## **CAPILLARY ACTION**

Even if you've never heard of capillary action, it is still important in your life. Capillary action is important for moving water (and all of the things that are dissolved in it) around. It is defined as the movement of water within the spaces of a porous material due to the forces of adhesion, cohesion, and surface tension.

Capillary action occurs because water is sticky -- water molecules stick to each other and to other substances, such as glass, cloth, organic tissues, and soil. Dip a paper towel into a glass of water and the water will "climb" onto the paper towel. In fact, it will keep going up the towel until the pull of gravity is too much for it to overcome.

Consider this:

\*When you spill a glass of soda (which is, of course, mostly water) on the kitchen table you rush to get a paper towel to wipe it up. First, you can thank surface tension, which keeps the liquid in a nice puddle on the table, instead of a thin film of sugary goo that spreads out onto the floor. When you put the paper towel onto your mess the liquid attaches itself to the paper fibers.

\*Plants and trees couldn't thrive without capillary action. Plants put down roots into the soil which are capable of carrying water from the soil up into the plant. Water, which contains dissolved nutrients, gets inside the roots and starts climbing up the plant tissue. As water molecule #1 starts climbing, it pulls along water molecule #2, which, of course, is dragging water molecule #3, and so on.

\*Think of the tiniest blood vessels in your body -- your capillaries. Your blood is mostly water, and capillary action assists the pumping action of your heart to help keep blood moving in your blood vessels.

*(information courtesy of USGS)*

### **ETC.**

Here's a quick rundown of some of water's properties:

- Weight: 62.416 pounds per cubic foot at 32°F
- Weight: 61.998 pounds per cubic foot at 100°F
- Weight: 8.33 pounds/gallon, 0.036 pounds/cubic inch
- Density: 1 gram per cubic centimeter (cc) at 39.2°F, 0.95865 gram per cc at 212°F

By the way:

1 gallon = 4 quarts = 8 pints = 128 ounces = 231 cubic inches

1 liter = 0.2642 gallons = 1.0568 quart = 61.02 cubic inches

1 million gallons = 3.069 acre-feet = 133,685.64 cubic feet

*(Courtesy of USGS)*

# SAN ANTONIO WATER GEOGRAPHICALLY AND GEOLOGICALLY

## SAN ANTONIO, TEXAS

Latitude 28°30" N

Longitude 98°31" W



## Background Information

Bexar County is in the south-central part of Texas and falls into three distinct eco-zones: the **Blackland Prairie** to the east and north, the **South Texas Brush Country** to the south and west and the **Edwards Limestone** to the north and northwest. Each eco-zone is unique containing its own flora, fauna and geology. The county covers 798,720 acres. It is irregularly pentagonal in shape and is about 45 miles from north to south and 43 miles from east to west.

The southern two-thirds of the county is a nearly level or undulating plain sloping upward from the southeast to the northwest and rising from about 500 feet to 1,000 feet in elevation. The northern third lies directly over the Balconies Fault Line and has been dissected by streams. It is strongly sloping to steep and rises from 1,000 feet to about 1,900 feet in elevation.

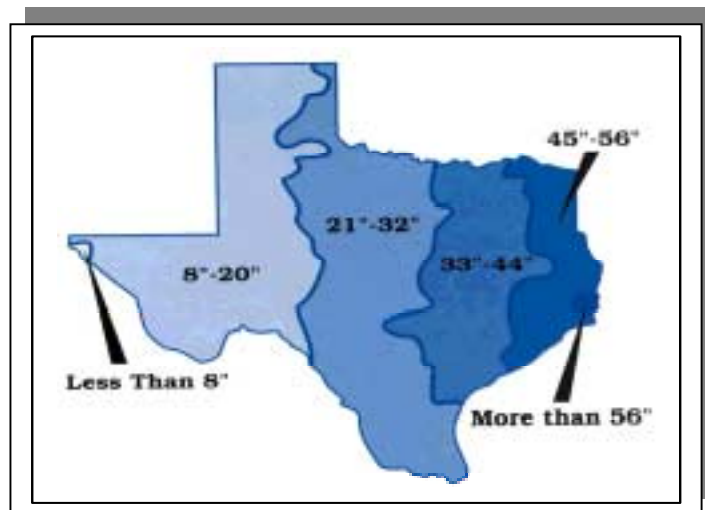
Sprawling across the county is the 8<sup>th</sup> largest city in the U.S., San Antonio. San Antonio's location along the Balconies Fault Line has always made it an excellent place for settlement. Although it lies just on the eastern edge of the Chihuahuan Desert and averages only 21 inches of rain a year, the abundant supply of water issuing forth from the subterranean Edwards Aquifer gives rise to crystal clear rivers, creeks and streams.

## 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, had 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.



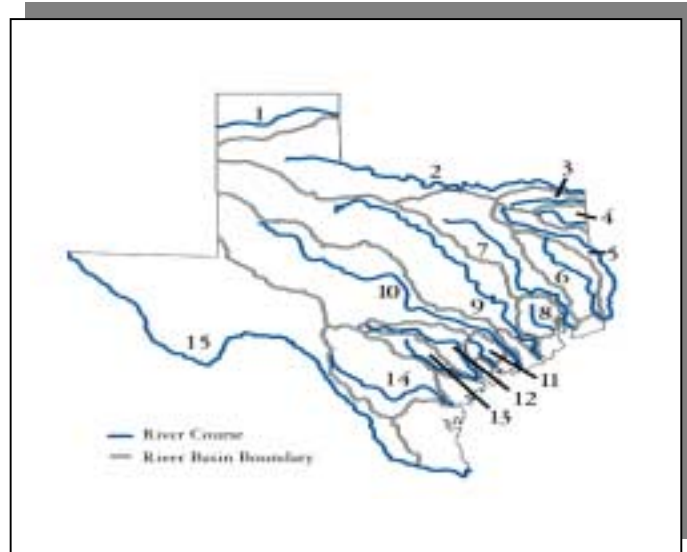
Average Annual Rainfall in Texas

## SURFACE WATER

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



### **DRAINING THE LAND**

When rain or snow falls onto the earth, it just doesn't sit there -- it starts moving according to the laws of gravity. A portion of the precipitation seeps into the ground to replenish Earth's ground water. Most of it flows downhill as runoff. Runoff is extremely important in that not only does it keep rivers and lakes full of water, but it also changes the landscape by the action of erosion. Flowing water has tremendous power -- it can move boulders and carve out canyons (check out the Grand Canyon!).

Some definitions of runoff:

- (1) That part of the precipitation, snowmelt, or irrigation water that appears in uncontrolled surface streams, rivers, drains or sewers. Runoff may be classified according to speed of appearance after rainfall or melting snow as direct runoff or base runoff, and according to source as surface runoff, storm interflow, or ground-water runoff.
- (2) The sum of total discharges described in (1), above, during a specified period of time.
- (3) The depth to which a drainage area would be covered if all of the runoff for a given period of time were uniformly distributed over it.

Some of the meteorological factors that affect runoff are:

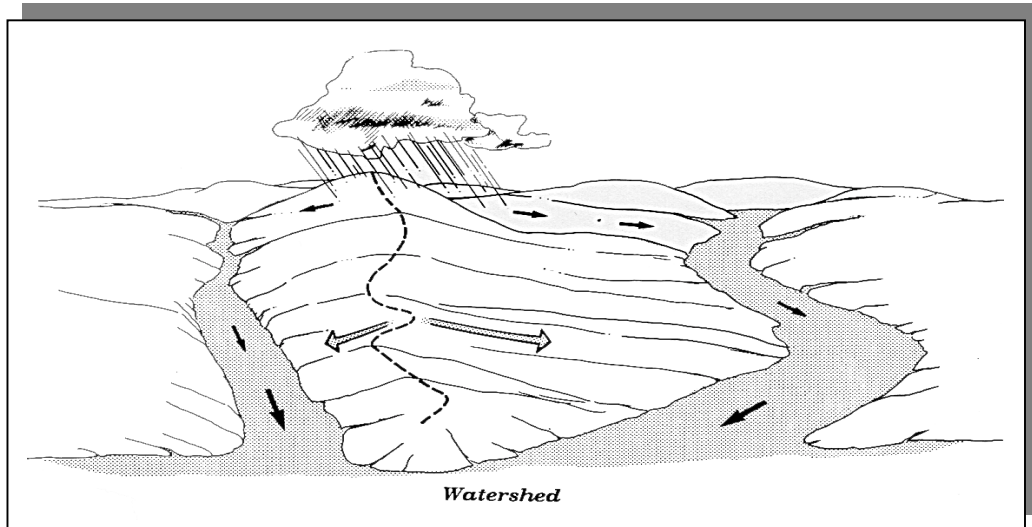
- \*Type of precipitation (rain, snow, sleet, etc.)
- \*Rainfall intensity
- \*Rainfall amount
- \*Rainfall duration
- \*Distribution of rainfall over the drainage basin
- \*Direction of storm movement
- \*Antecedent precipitation and resulting soil moisture
- \*Other meteorological and climatic conditions that affect evapotranspiration, such as temperature, wind, relative humidity, and season.

Some of the physical characteristics affecting runoff include:

- \*Land use
- \*Vegetation
- \*Soil type
- \*Drainage area
- \*Basin shape
- \*Elevation
- \*Slope
- \*Topography
- \*Direction of orientation
- \*Drainage network patterns
- \*Ponds, lakes, reservoirs, sinks, etc. in the basin, which prevent or alter runoff from continuing downstream

*(Information courtesy of Nevada Division of Water Planning and USGS)*

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.



As already mentioned, a watershed describes an area of land that contains a common set of streams and rivers that all drain into a single larger body of water, such as a larger river, a lake or an ocean. A watershed can cover a small or large land area. Small watersheds are usually part of a larger watershed. All the streams flowing into small rivers, larger rivers and eventually into the ocean form an interconnecting network of waterways.

In Bexar County, there are sixteen sub-watersheds where all streams and creeks 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.

Not only does water run into the streams and rivers from the surface of a watershed, but water also moves down through the soil. Some of this water even drains back into the same streams and rivers. These two processes, surface runoff and infiltration, are important for a number of reasons.

Water that runs off the surface of the Earth picks up water pollution and deposits the pollution in streams and rivers as it drains the watershed. Water that filters into a recharge feature such as a cave, can also become contaminated with pollution that is left over from agricultural, industrial, commercial and other types of human activity. Along with many different types of pollution that are carried by surface runoff, soil also becomes a water pollutant as it is eroded from farm lands and construction sites.

### **WEARING DOWN THE LAND**

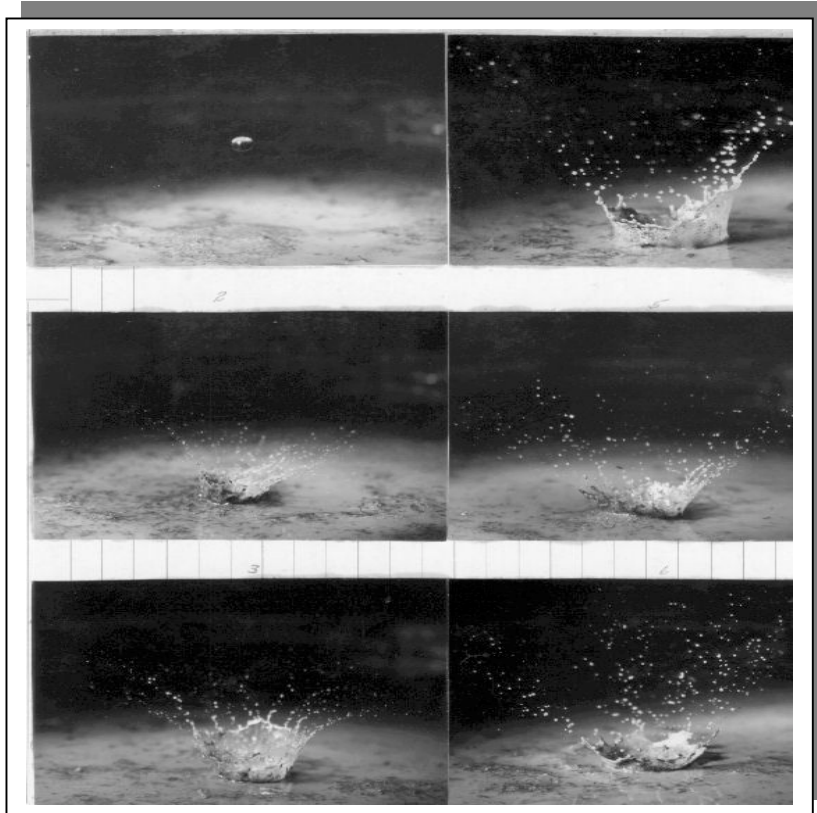
Rivers have great power to shape the land. Once rock has been broken up by weathering, the small pieces can be moved by water, ice, wind or gravity. The totality of forces that carry rocks and earth away is called erosion. In Bexar County, the erosion caused by flowing water has formed many of the area's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



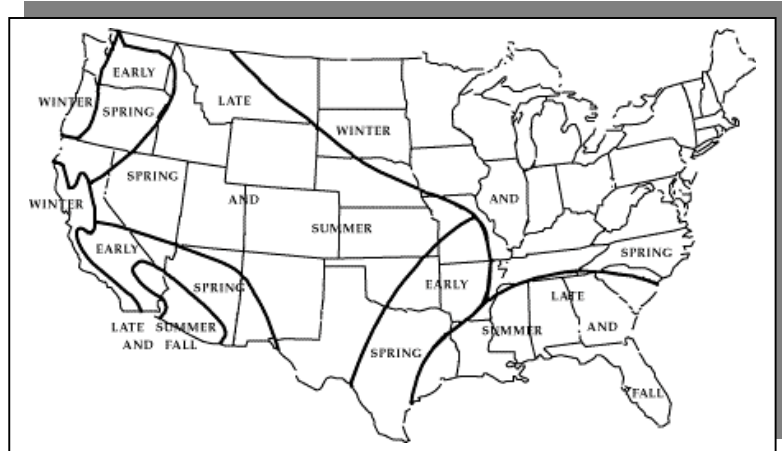
## **FLOODS AND FLOOD PLAINS**

Floods are common and costly natural disasters. When rivers overflow their banks, or flood, they can cause damage to property and crops. Floods are common and costly natural disasters. In the United States, the average annual cost of flood damage is more than \$2 billion. Each year about 100 people lose their lives to floods.

Floods usually are local, short-lived events that can happen suddenly, sometimes with little or no warning. They usually are caused by intense storms that produce more runoff than an area can store or a stream can carry within its normal channel. Rivers can also flood when dams fail, when ice jams or landslides temporarily block a channel, or when snow melts rapidly. In a broader sense, normally dry lands can be flooded by high lake levels, by high tides, or by waves driven ashore by strong winds. Small streams, particularly in the Southwest, are subject to flash floods (very rapid increases in runoff), which may last from a few minutes to a few hours. On larger streams, floods usually last from several hours to a few days. A series of storms might keep a river above flood stage (the water level at which a river overflows its banks) for several weeks.

## **WEATHER PATTERNS CAN DETERMINE WHEN FLOODS OCCUR**

Floods can occur at any time, but weather patterns have a strong influence on when and where floods happen. Cyclones, or storms that bring moisture inland from the ocean, can cause floods in the winter and early spring in the western United States. Thunderstorms are relatively small but intense storms that can cause flash floods in smaller streams in late summer and fall in the Southwest. Frontal storms form at the front of large, moist air masses moving across the country and can cause floods in the northern and eastern parts of the United States during the winter and spring. Hurricanes are intense tropical storms that can cause floods in the Southeast during the late summer and fall.

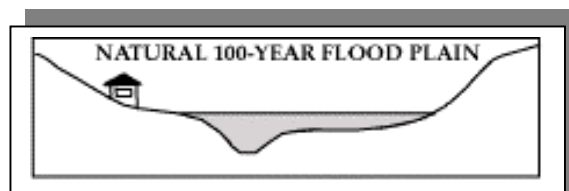
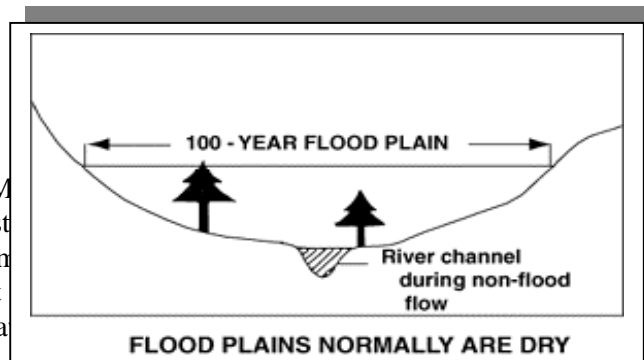


**VERY LARGE FLOODS HAPPEN VERY SELDOM**

The size, or magnitude, of a flood is described by a term called recurrence interval. By studying a long period of flow records for a stream, it is possible to estimate the size of a flood that would, for example, have a 5-year recurrence interval (called a 5-year flood). A year flood is one that would occur, on the average, once every five years. Although a 100-year flood is expected to happen only once in a century, there is a 1 percent chance that a flood of that size could happen during any year. The magnitude of floods can be altered if changes are made in a drainage basin. Harvesting timber or changing land use from farmland to housing developments can cause the runoff to increase and cause an increase in the magnitude of flooding. Building dams that store water can reduce the magnitude of floods

Flood plains normally are dry Flood plains are lands bordering rivers and streams that normally are dry but are covered with water during floods. Buildings or other structures placed in flood plains can be damaged by floods. They also can change the pattern of water flow and increase flooding and flood damage on adjacent property by blocking the flow of water and increasing the width, depth, or velocity of floodwaters.

**ZONING RESTRICTIONS CAN LIMIT** Flood-plain zoning, which places restrictions on the cost of flood damage. Local government development on flood plains to limit areas that adopt local ordinances or la



the g or rs in flood

insurance to help cover the cost of damage from floods. Dams and levees can reduce the risk of floods.

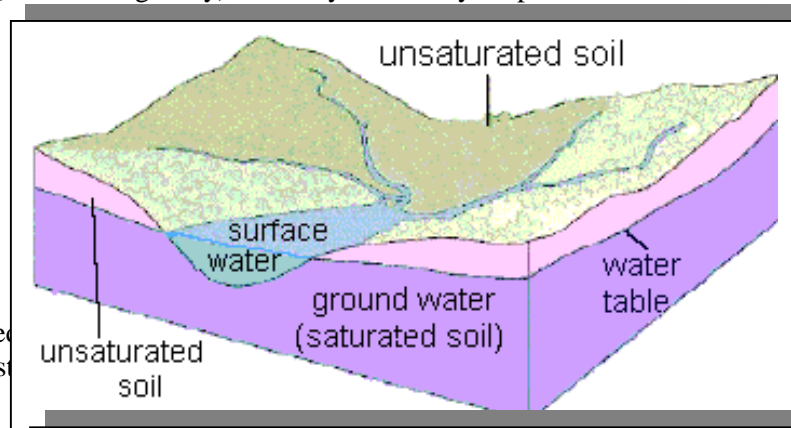
### THE CONCRETE JUNGLE

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 drainage basin 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 sewers. Storm sewers then deliver the collected water to local creeks and streams. A storm sewer 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.

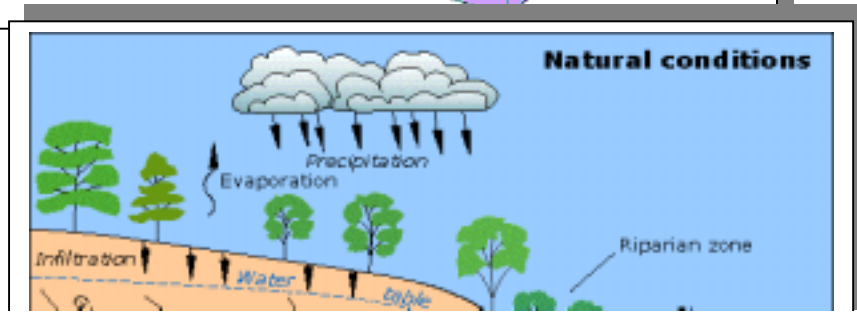
### GROUNDWATER

Ground water is the part of precipitation that seeps down through the soil until it reaches rock material that is saturated with water. Ground water slowly moves underground, generally at a downward angle (because of gravity), and may eventually seep into streams, lakes, and oceans.

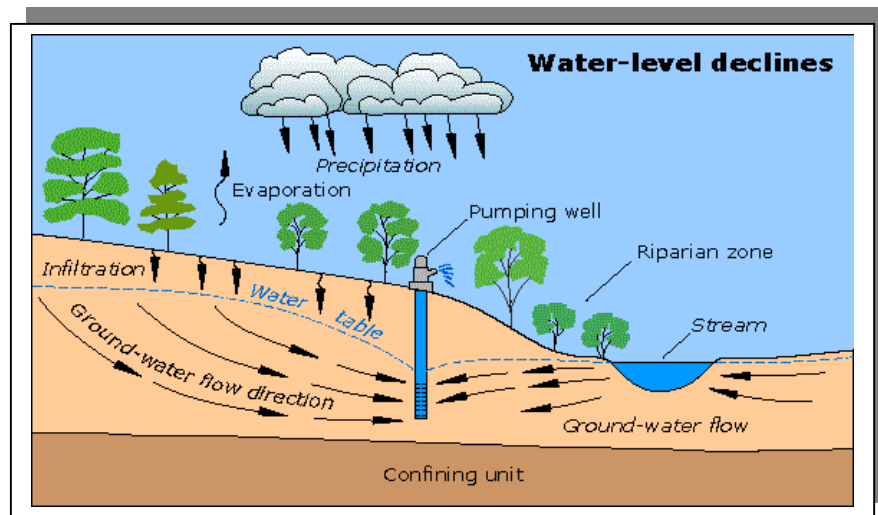


Water is recharged then flows to the stream

precipitation and



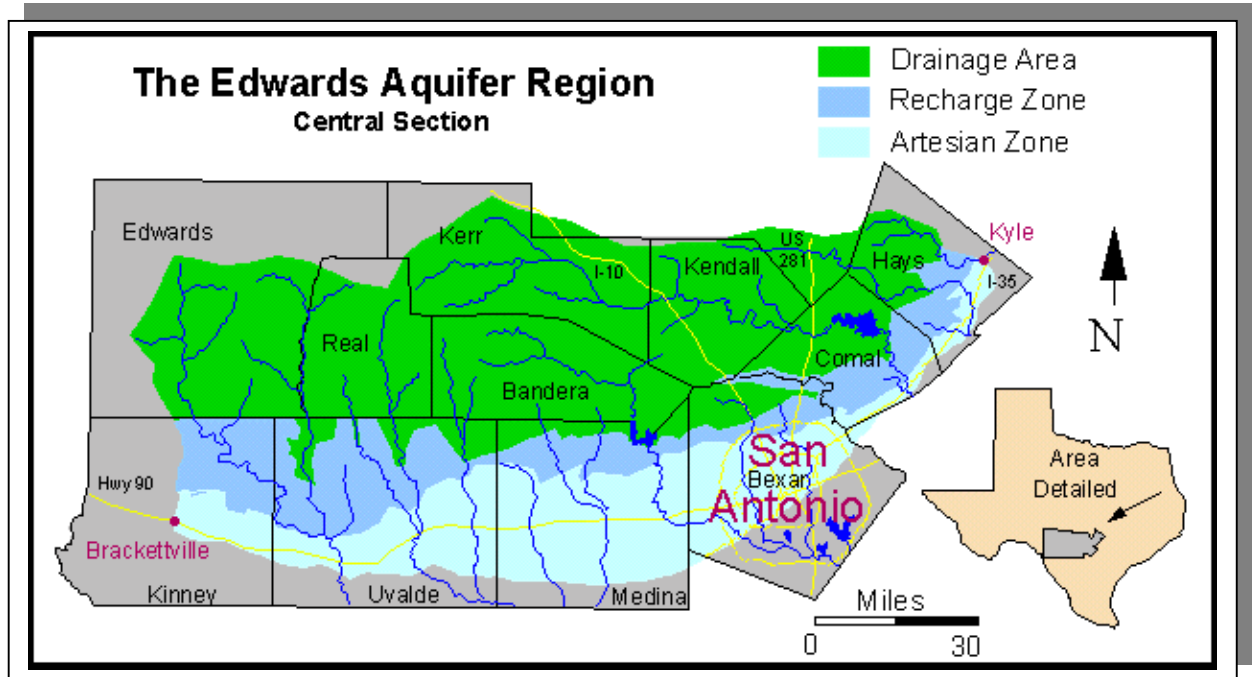
Water pumped from the ground-water system causes the water table to lower and alters the direction of ground-water movement. Some water that flowed to the stream no longer does so and some water may be drawn in from the stream into the ground-water system, thereby reducing the amount of stream flow.



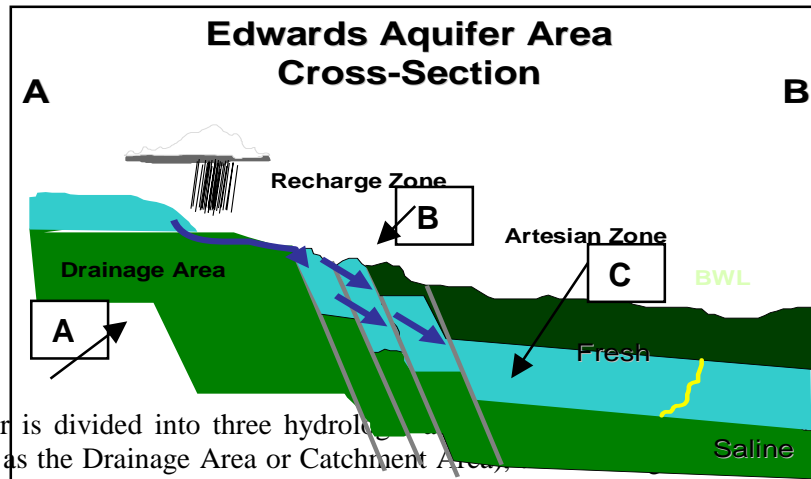
#### THE EDWARDS AQUIFER: OUR LOCAL GROUNDWATER STORY

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. It also supplies water for agriculture, industry, the military and tourism throughout the region.



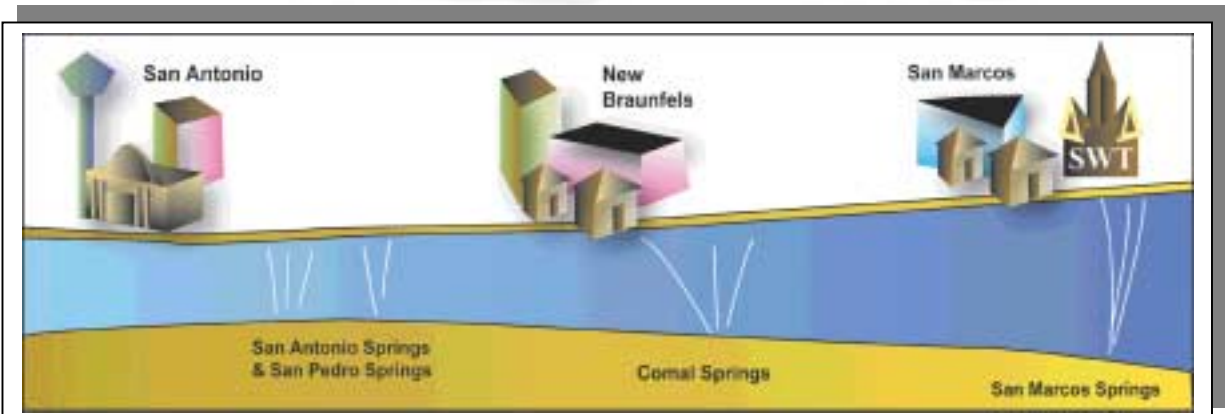
The aquifer is divided into three hydrologic zones: the **Contributing Zone** (also referred to as the Drainage Area or Catchment Area), the **Recharge Zone**, and the **Artesian Zone** (see graphic on previous page). The **Contributing Zone** (Part A) occurs on the Edwards Plateau, also called the Texas 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.

Now the water is 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. 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.

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. The largest springs are in New Braunfels at Comal Springs and in San Marcos. Comal Springs probably is 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.



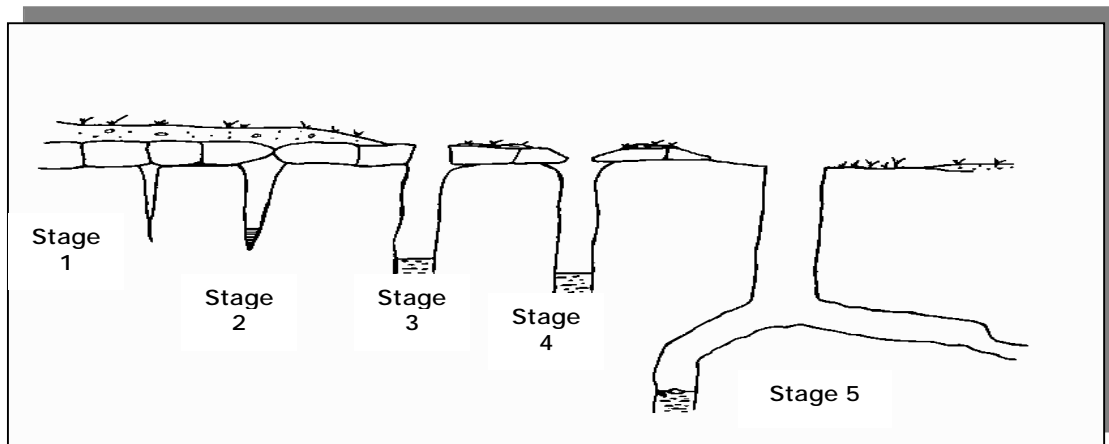
expensive and perhaps even impossible to clean.

## AN EDWARDS AQUIFER CAVE

It takes water and stone to make a cave. Limestone is the prevalent rock in Edward's Aquifer caves. Caves start as cracked limestone rock exposed at the surface of the Earth. Weathering of the Earth's surface causes the cracks to widen allowing water to seep into the cracks when it rains. Small traces of acid in the water begin to slowly dissolve away the limestone. As the cracks become bigger and bigger, more and more water can flow through. Overtime, the water may become an underground stream.

Over a period of thousands of years, the cracks get bigger. Some of the cracks turn into tunnels and as the tunnels grow, they join up with other tunnels to form a cave system. Occasionally the ceiling of a cave might dissolve away to the point that it collapses. This is called a sinkhole. In the Edwards Aquifer Recharge Zone, many recharge features are sinkholes. Water seeping into these sinkholes may continue to form new caves or it may flow directly into the Edwards Aquifer.

**Model of a sink hole development in Bexar County**



Over the Recharge Zone, water enters caves in a number of ways. In addition to directly flowing down large sinkholes, a stream or creek may cross a permeable layer of limestone and then disappear underground. This is called a sinking stream. Water also seeps down through the ground when it rains. After it moves down through the porous limestone, it drips into the cave from the roof. This dripping process may eventually form two of the most recognizable features of a cave; stalactites and stalagmites. As water drips down through the ground, it picks up tiny bits of limestone. When a drop hits the ground, the water dries up but the limestone crystals are left behind. If they build up on the roof of the cave, they might form an "icicle" structure called a stalactite. If they rise from the floor of the cave, they are called a stalagmite. For thousands of years, the dripping water causes the stalactite to get longer and the stalagmite to get a little taller. The rock formations grow bigger, day by day, year by year. Finally, when a stalactite and a stalagmite come together at a point, the structure is called a column.

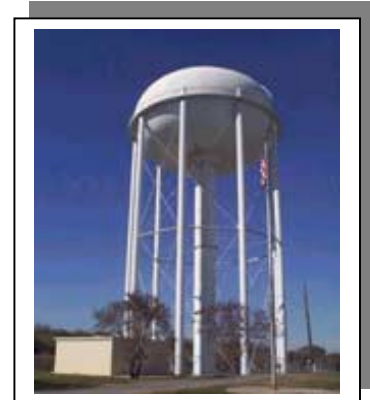


Thousands of sinkholes and caves located in the Texas Hill Country help to recharge the Edwards Aquifer and to keep this unique groundwater system healthy and full.

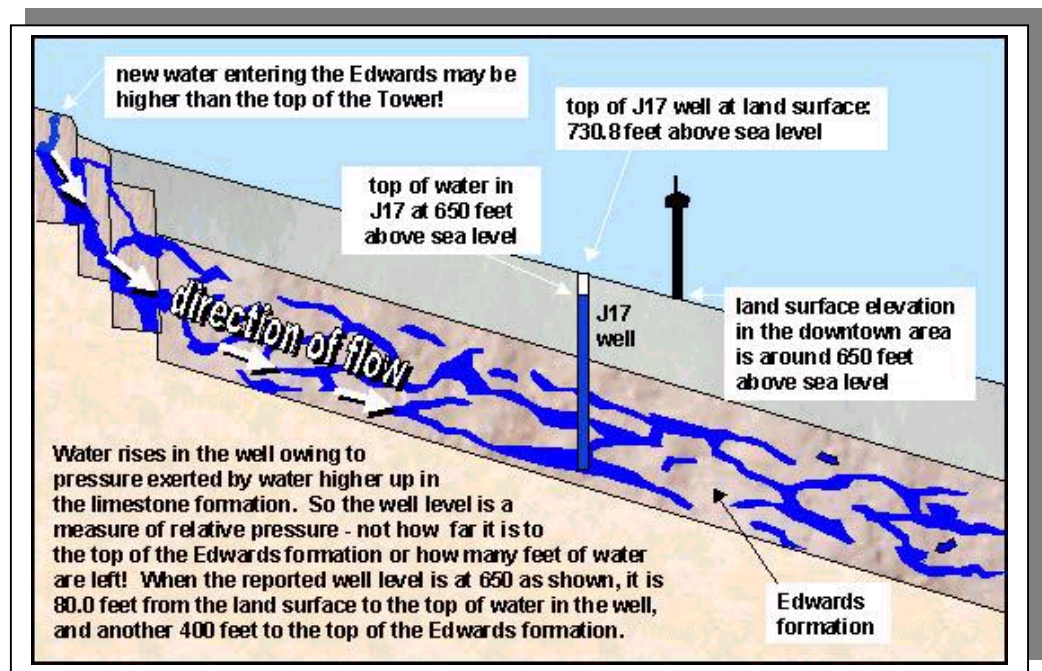
### **MEASURING THE EDWARDS AQUIFER**

The J-17 index well is located in the small building at the base of the large water tower near the national cemetery at Fort Sam Houston in San Antonio. It is on a major Edwards flowpath and responds quickly to pumpage and recharge, so it has been used since 1956 to record changes in the level of the Aquifer in the San Antonio area. The level of the J-17 well has ranged from 612 feet during the 1950's drought to 703 feet after historic rains in 1991 and 1992. There is much confusion about what the reported Aquifer level means. When weathercasters say the Aquifer stands at 650 feet, it does NOT mean there is 650 feet of water left or that it is 650 feet to the top of the Edwards formation. The number is simply an indication of relative pressure being exerted on water at the location of the test well.

The figure below illustrates this concept...the Edwards formation is between 400 and 600 feet thick, so it is about as thick as the Tower of the Americas is tall. Out to the west in the recharge zone, the Edwards outcrop at the land surface is higher than the top of the Tower. Water tends to flow downhill, and it so happens that "downhill" is directly under most of San Antonio. Water is heavy stuff, and as new water enters the formation in the recharge zone, it places tremendous pressure on water already deep inside, forcing water up through cracks and wells toward the land surface. So water rises in the test well because of pressure being exerted by water higher up in the Edwards formation out to the west. It does not rise all the way to the elevation of water to the west because of friction. When water does rise all the way to the top of a well in this manner, the well is called artesian and water flows out without pumping. A good index well such as J-17 is one in which pressure is never sufficient to cause the well to become artesian. To get water out of J-17, it would have to be pumped.



The land surface at the top of the J-17 well is at 730.8 feet above sea level, and the downtown area around the Tower of the Americas is around 650 feet above sea level. A reported Aquifer level of 650 feet, for example, would indicate the top of water in the well is about even with the bottom of the Tower. The water in the well is still 80.8 feet below the land surface, so to extract water from the well it would have to be pumped that distance. It is still another 400 feet from 650 to the top of the Edwards limestone formation.



There is a good relationship between the level of the J-17 well and flows at Comal Springs. Most of the water that becomes Comal springflow originates with recharge far to the west of the Springs and moves past the J-17 well on its way toward New Braunfels. In contrast, much of the water discharging at San Marcos Springs originates from recharge in the vicinity of the Springs and does not move past the J-17 well. This is why the relationship between the J-17 well and San Marcos Springs is not as pronounced.

Flows at Comal Springs become intermittent when the level of the J-17 monitoring well drops below 620 feet. All flow at Comal ceases at an elevation of 618 feet. During the '50s drought, the Springs were dry from June to November of 1956. In a repeat of the 1950's drought, Comal Springs would be dry for a number of years.

*Comal Springs*



History does not record a time when the San Marcos Springs have ceased to flow. The lowest recorded flow rate was 46 cubic feet per second in August of 1956. San Marcos Springs would cease to flow with a water elevation of about 574 feet at the springs.

Before 1956, a different well was used to measure the Edwards level. However, it was very close to the J-17 well and readings from it can be used to predict J-17 levels very well.

You can retrieve the latest J-17 levels from the homepage of the [Edwards Aquifer Authority](#) or from the [San Antonio Water System](#).

*(Information taken from the Edwards Aquifer Homepage-Gregg A. Eckhardt)*

## **CONCLUSION**

The water cycle (precipitation, runoff, evaporation and condensation) forms the basis of the most important element for life on earth. The rain falls and infiltrates into aquifers which become drinking sources, recreational uses and homes for endangered plants and animals. As in the case of San Antonio, these aquifers usher in the beginning of large, growing cities.

Much of the rain falls and travels across the ground wearing away the soil to create new land forms. Along the way, this water might also carry pollutants through the watershed and dump them into a larger body of water.

Whatever this rainfall does, water is the most important element of life on Earth. Whether it's the citizens of Bexar County, Texas, the Unites States or the planet Earth, many try to understand its importance and many more still become educated daily on its wise use.

# SAN ANTONIO WATER HISTORICALLY

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## Background Information

Gunnar Brune, in his 1971 study entitled “Springs of Texas,” identifies Bexar County as one of Texas’ richest counties in history that “is inextricably tied to the large springs which were found here.” If it weren’t for these springs, San Antonio and its present day population of 1.5 million people would have probably never settled in this part of Texas.

## CHRONOLOGY OF SAN ANTONIO’S WATER

**1519-** The Pineda expedition draws the first map of Texas. Six rivers are indicated on the map including one that will someday be named the San Antonio.

**1690-** Alonso de Leon Jr. accompanied by Father Damian Massanet cross the San Antonio River and note its perfect location for a future settlement and fort.

**1691-** Domingo Teran de los Rios, first governor of the new Province of Texas, accompanies Father Damian Massanet on his return to East Texas. Camping at a rancheria of Payaya Indians on a stream called Yanaguana, they celebrate mass and rename the stream *San Antonio* because it was the feast of Saint Anthony of Padua.

**1709-** The Espinosa-Aguirre-Olivares expedition stops at the springs which Father Espinosa names San Pedro. Father Olivares notes the river as a good site for missions. Father Antonio Olivares, in a new expedition to the area, notes the river as a good site for a mission.

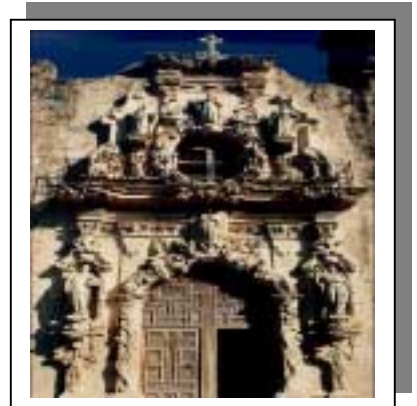
**1716-** The Spanish Council of War approves a site on the San Antonio River for a fortified presidio (fort.) The presidio is later recognized as the beginning of a villa, or settlement. This same council also approves the request by Father Olivares to establish a mission near the site.

**1718-** Father Olivares establishes mission San Antonio de Valero. The mission is later moved to two additional locations and renamed the Alamo.

**1720-** Mission San Jose y San Miguel de Aguayo is founded on the river. Concepcion Ditch, the first acequia to be dug, becomes operational supplying water to the growing presidio.

**1730-** The San Jose Acequia is begun. Settlers from the Canary Islands arrive at the presidio to establish the first legally recognized civil settlement. They call it Villa de San Fernando in honor of Fernando II.

**1731-** Three missions, Mission Concepcion, Mission San Juan Capistrano and Mission San Francisco de la Espada are moved from East Texas to the banks of the San Antonio River. San



Juan Acequia, Concepcion Acequia, Espada Dam, acequia and aqueduct are constructed between 1731-1739.

**1776-** Beginning of the American Revolution

**1793-** The missions are secularized by order of the Spanish crown.

**1809-** La Villita develops across the river from Mission San Antonio and the Villa de San Fernando.

**1830-** The first city regulations for the use of the river, creek and ditch waters are put into effect.

**1836-** Texas Declaration of Independence signed. Battle of the Alamo and Battle of San Jacinto occur.

**1840s-** Extensive German immigration to Texas. German immigrants settle in La Villita area to be joined by the Swiss and French.

**1850s-1890s -** The King William area develops on land that had been Alamo farmlands.

**1861-1864-** U.S. Civil War

**1865-** A cholera epidemic strikes San Antonio. Drinking water from the acequias are blamed for the sickness. 292 people die.

**1877-** The first San Antonio water works is established.

**1889-** The first artesian well is bored into the Edwards Aquifer by the new water works led by George W. Brackenridge.

**1900-** The city of San Antonio's first sewage system is fully operational.

**1921-** Cloudburst over the Olmos Basin and San Antonio River puts 9 feet of water on Houston Street. The flood kills 50 people and causes millions of dollars in damage.

**1925-** The San Antonio Water Works is bought by the city of San Antonio and is renamed the City Water Board (CWB). At the time of purchase, the company is pumping an average of 25 million gallons daily to serve some 38,000 customers.

**1927-** Olmos Dam completed.

**1936-** Texas Centennial. Jack White, owner of the Plaza Hotel visits City Hall to urge a clean-up and beautification of the river. White and the Mexican Businessman's Association stage "A Venetian Night," the first river parade.

**1941-** A river carnival and night parade are held. The walkways, staircases to street level, footbridges and rock walls lining the banks and Arneson River Theater are completed as is restoration in La Villita.

**1946-** A major flood hits downtown San Antonio, but damage is minimized by Olmos Dam and the flood bypass channel.

**1962-** The Parks and Recreation Department completes a major landscape program along two miles of the river walk, including 17,000 trees, shrubs, vines and ground cover.

**1963-** The San Antonio Chapter of the American Institute of Architects unveils a plan for the Paseo del Rio.

**1968-** HemisFair '68 opens.

**1973-** San Antonio City Council declared Mitchell Lake a Wildlife Sanctuary

**1985-** San Antonio River tunnel project begun. Tunnel will carry storm water 150 feet underground and return them to the river channel at Lone Star Boulevard.

**1987-** Dos Rios Recycling Center begins operation and effluent discharge is stopped at Mitchell Lake.

**1992-** The City Water Board becomes the San Antonio Water System (SAWS).

**1994-** The San Antonio Water System adopts the Conservation and Reuse plan. Funding for Conservation Programs such as the Watersaver Landscape Rebate and Kick the Can are established for Residential Customers.

**1998-** The SAWS board of trustees and the San Antonio city council approves the 50 year water plan entitled "Securing our Water Future Together". Groundbreaking begins on the recycled water project.

**1999-** The city of San Antonio becomes the eighth largest city in the U.S.

**2000-** The San Antonio River begins utilizing recycled water.

*Source: The San Antonio River, Mary Ann Noonan Guerra, 1987  
The San Antonio Conservation Society*



## Early Texans

*“We are of the soil and the soil is of us. We love the birds and beasts that grew with us on this soil. They drank the same water we did and breathed the same air. We are all one in nature.”*

From a description of Native Americans by Chief Luther Standing Bear



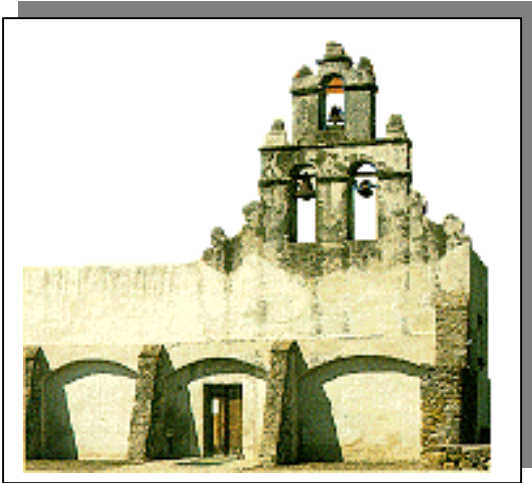
The earliest people to come to the land that we now call Texas arrived perhaps 12,000 years ago. When these people first arrived, the land was much different than it is today. Rainfall was greater and rich prairies and forests covered most of the land. Herds of giant deer, buffalo and huge mammoths grazed on the prairies. The earliest people that entered Texas were hunters looking for food.

Around 2,000 years ago, many of these early Texans found flowing springs in South/Central Texas bubbling up from a hidden source that we now call the Edwards Aquifer. The water was abundant, cool and clear. The rivers and streams that issued forth from these springs provided habitat for an abundance of deer, turkey and buffalo and the land was rich and fertile for farming. In fact, today it is believed that the area around the San Marcos springs is perhaps the oldest continually inhabited site in North America. In addition to the San Marcos springs site, early people hunted, gathered and traded around Comal springs in New Braunsfels and the San Antonio and San Pedro springs in San Antonio.

One of the earliest groups of Texans found in the Bexar County region was from a culture called the Coahuiltecan (koh • uh • weel • the • kuhnz). The Coahuiltecan were made up of many groups of natives found living from San Antonio to Corpus Christi to Old Mexico. Like their neighbors the Karankawas (kuh • rang • kuh • wawz), the Coahuiltecan were nomadic hunter gatherers. Since food was scarce in this dry grassland, the Coahuiltecan ate anything they could hunt or gather including prickly-pear cactus fruit, mesquite tree beans and agave.

Many of these San Antonio Coahuiltecan were part of the Payaya Indians. The Payaya lived along the San Antonio and Medina Rivers. They called their river Yanaguana (which means “the clear water”) and they peacefully shared it with other bands of Indians. Today we call this area the San Antonio Springs.





## **Spanish Settlers and the Development of a Community in Need of Water**

*“We marched five leagues over a fine country with broad plains-the most beautiful in New Spain. We camped on the banks of an arroyo, adorned by a great number of trees, cedars, willows, cypresses, and osiers, oaks and many other kinds... This I called San Antonio de Padua because we had reached it on his day.”*

Domingo Teran de los Rios, 1691

In 1716, Spain and France were at war and the fighting carried over to the New World, America. The French controlled much of the mouth of the Mississippi River and south along the Gulf Coast. Spain, recognizing this as an immediate threat to their holdings in New Spain, quickly created a three-pronged imperial policy to strengthen their borders. The policy was unique in that it included the natives in the colonization plan rather than displacing them from their land.

As part of the plan, the natives would become the defenders of the Spanish Crown in the New World. They would be gathered together in missions, converted to Christianity and taught the principles of farming before being settled in new colonies.

The second part of the plan involved soldiers being garrisoned in nearby presidios to keep order. And third, once the native farmers had established settlements, Spanish colonists would be attracted to this area to begin new lives.

Although some historians believe Alvar Nunez Cabeza de Vaca camped at the headwaters of the San Antonio River in the 1520's which would make San Antonio one of the oldest historical sites in North America, the first true entrada, or formal Spanish expedition, began in 1690. Alonso de Leon and Fray Damian Massanet were sent to Northeast Texas to explore, expand and take possession of Spanish claim. The entrada was made up of three segments: religious, military and civilian members. The military oversaw protection of the expedition while the religious division focused on the spiritual needs of the expedition members and natives they encountered along the way. Families of the soldiers and other settlers made up most of the civilian group.

In 1691, Domingo Teran de los Rios accompanied by Fray Massanet, led another expedition to East Texas. They were instructed to establish missions among the Tejas Indians and to record their observations in this part of the territory. On June 13, 1691, the expedition came upon the Yanaguana for the first time and christened it, the San Antonio River. Not far from the San Antonio Springs, were the San Pedro Springs, which contributed a large source of water to the San Antonio River. Isidro Felix de Espinosa gave the springs their name on St. Peter's Feast Day in 1716. The Franciscan held a mass and dedicated it to St. Peter "in whose honor we gave this name to the place...San Pedro."

On April 13<sup>th</sup> 1709, another entrada stopped at the San Antonio River and San Pedro creek to take on water before continuing eastward. Father Antonio de San Buenaventura Y Olivares, a member of the religious sector of the expedition, was extremely pleased with the river and the friendly Payayas found there. He began petitioning the Spanish leaders to establish a mission.

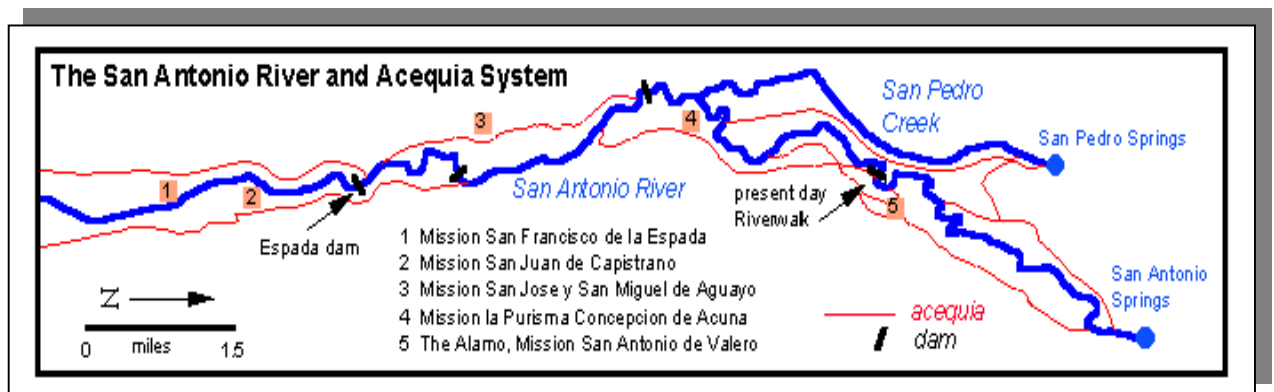
Meanwhile in 1716, Captain Domingo Ramon and seventy eight members of the entrada were once again sent to East Texas. Captain Ramon was also ordered to inspect Father Olivares river site along the way. Upon reaching East Texas, the expedition established six missions and a presidio that would further reinforce New Spain's eastern border with France.

Although Spain's three-pronged plan was working, Spanish leaders soon realized that they must establish a "halfway presence" between their new eastern settlements and the capital of New Spain in Mexico City. The newly discovered San Antonio River seemed a logical choice. Finally, in 1718 after nine years of campaigning for a mission at his river site, Father Olivares and Don Martin de Alarcon arrived at the San Antonio River to establish a mission.

It was also the clean, abundant supply of water that inspired Friar Olivares to abandon his mission on the Rio Grande and establish Mission San Antonio de Valero (The Alamo) in the Spring of 1718 on the banks of San Pedro Creek. Once again, it would be water that ultimately controlled the destiny of San Antonio.

By 1731, two missions, Mission San Antonio de Valero, Mission San Jose y San Miguel (both originally established in the region), were joined by three other missions moved from East Texas: Mission Concepcion, Mission San Juan Capistrano and Mission San Francisco de la Espada. These missions and ranches were on the best land along the rivers and they had a huge impact on the Coahuiltecan living in the region. Once the Spanish came, many of the Coahuiltecan bands moved into the missions. The steady source of food and water and the protection from stronger tribes was very appealing to them. Once in the missions, many of them married Spanish soldiers and settlers. Later, more Spanish and Mexican immigrants settled in the region and started ranches that attracted local Indians for the same reasons the missions did.

Early Spanish settlers in San Antonio knew the success of the region was dependent upon the planting and harvesting of crops. The need for water to irrigate fields and for direct use by the settlers gave rise to a series of water carrying "ditches" called acequias. The earliest acequias were constructed by the missionaries and Indians, but the settlers eventually carried out the major acequia building. Each acequia was built so that running water could be obtained on the mission grounds. A dam was built on the river, which raised the water level to the ditch. The water in the acequia paralleled the river, was used by the settlers, and then re-entered the river at a downstream position. The purity of the water was fiercely protected in the early days of the acequia system. Rows of cactus plants were even planted along either side of the acequia to keep cattle and other livestock away from the water.



Map of the acequia system

Although the acequias would remain the main source of water in San Antonio for more than 100 years, the springs still played a major role in the growth of region. San Pedro Springs became a public park in 1729 when King Philip V made a royal land grant to San Antonio settlements named San Antonio de los Llanos (San Antonio of the plains). The grant included 26,570 acres with some parcels of land being reserved for the King to grant to future settlers and other parcels of land being given to existing settlers. The area around San Pedro Springs was declared to be an *ejido* or public land to be used and owned by all people of the town. This fact makes the San Pedro Springs Park the second oldest park in the nation, second only to The Boston Commons.



By 1800, the Missionary period had, for all practical purposes, ended. San Antonio's clean, plentiful supply of water, was in jeopardy. The attention that the acequias received under the direction of the padres no longer existed. Citizens of San Antonio began using the ditches as a de facto sewer system. Early San Antonians deposited their garbage and other wastes into the ditches where they were carried downstream. By 1830 the acequia's water quality needed public regulation.

In 1836, the San Pedro Acequia was designated solely for drinking and cooking purposes. San Pedro Creek and the San Antonio River were for bathing and laundry. Fines were imposed on offenders. In addition, the town of San Antonio was growing to the point that the springs were no longer within an easy walk of the houses. Water was now a valuable commodity in San Antonio.

Water rationing had become a reality in the early 1800's. Water quantity problems soon gave rise to water quality concerns, especially during drought years. During an 1866 cholera epidemic that was blamed on water, civic-minded people began talking of organizing a water company. However, it would take a couple of years before this revolutionary idea would come to existence.

## A New Water Supply for a Growing City

*"We thought how easy to make San Antonio the most famed city for natural beauty on the continent...water pipes could be laid from the head fountains of the river...supplying water to residences...and then lead to the city...to supply it with spring water, or to feed a thousand dancing fountains."*

San Antonio Express, July 23, 1867

In 1877, the city of San Antonio created a water works. Still using the San Antonio springs as its main supply, water was pumped to a reservoir on a high hill and then released using gravity through a series of company mains. George W. Brackenridge, a local banker and owner of land surrounding the San Antonio Springs, was confident in the new system.



But 159 years of acequia usage was difficult to change. The citizens of San Antonio were reluctant to patronize the new water works and only a handful of people used the new system once it came on line. Eleven years later in 1888, a local drilling company drilled 650 feet into the Edward's Aquifer and struck a flowing artesian well. Mr. Brackenridge knew the dependence on the San Antonio River as the primary water supply had ended. Because he feared that the spring fed source of the San Antonio River would dry up during a drought, Brackenridge immediately instructed the well company to drill a series of wells to supply his water works with a clean and abundant supply. Finally in 1891, Brackenridge struck an artesian well at 890 feet which had so much pressure that water flowed out of the pipe "15 or 20 feet high" and blew out pieces of rock "as large as a man's head" according to witnesses of its completion. The well flowed at three million gallons of water per day and soon company officials realized that the artesian aquifer would be a city water source for years to come.

## **Distribution and Treatment Come to San Antonio**

*"In the not very distant future most of Texas' springs will exist in a legend of a glorious past when mankind was one with, and reveled in, nature."*

Gunnar Brune, 1981

Change was the word in San Antonio from 1890-1900. The new water supply may have triggered a rapid population increase from 18,000 in 1890 to 53,000 in 1900. Stories appearing in the San Antonio Express in the 1890's told of the abundance of water and reported that the Edward's Aquifer supply was "unlimited". But this rapid population growth also spelled trouble for the region. By the late 1890's, George Brackenridge was so disturbed by the lack of quality and quantity of the San Antonio Springs that he agreed to dispose of all his land. "I have seen this bold, bubbling, laughing river dwindle", Brackenridge wrote, "This river is my child and it is dying and I cannot stay here to see its last gasps...I must go." But Brackenridge wasn't the only one taking notice. By 1911, others were sounding the first warnings that the Edwards Aquifer was abundant but not unlimited.

In 1905, George Brackenridge sold his interests in the water company to George Kobusch of St. Louis. At that time, the name was changed to the San Antonio Water Supply Company. Shortly thereafter, Mr. Kobusch sold the business to the Belgian syndicate. While it was under foreign ownership, the water company was known as "Compagnie des Eaux de San Antonio" and was managed by the Mississippi Valley Trust Company of St. Louis, Missouri.

Partly to recover some of their financial losses from World War I, the Belgians sold the waterworks to a group of local investors in 1920. The city finally decided to issue bonds and buy the water company outright. On June 1, 1925, the utility became known as the City Water Board and its management was placed under Board of Trustees appointed by the City Council.

By 1920, the population had grown to 161,379 citizens and Edward's wells were pumping 22,494,000 gallons of water per day. The influence of water had pushed San Antonio to become one of the largest cities in Texas and an important 20<sup>th</sup> century economic and trade center, a fact that few people realized for the next 70 years.

While struggling to develop an adequate potable water supply system, the city also attempted to address sanitary sewer needs. Mayor Bryan Callaghan II advocated an organized sewage system

in 1890, but one was not authorized until 1894. By 1900, the system was fully operational and by 1930, the new Rilling Road Sewage Treatment plant was treating 25 million gallons per day.

Throughout the 1960s, 1970's and 1980's both the water and wastewater systems continued to expand as customer demand increased. The City Water Board was involved in negotiations or court action involving attempts to secure a supplemental water supply.

In 1965, the City built the Leon Creek Treatment Plant in order to ease the burden on Rilling Road. By the 1980's the city decided to build Dos Rios Wastewater Treatment Plant and to abandon the aging Rilling Road facility. The city also purchased the Medio Creek Plant in 1991 that allowed the City to provide service to the rapidly growing northwest portion of Bexar County.

In December of 1991, the city council voted to Establish a single utility responsible for water, wastewater, stormwater and reuse. The refinancing of \$635 million in water and wastewater bonds made the merger possible. A new entity, The San Antonio Water System (SAWS) became a reality on May 19, 1992.



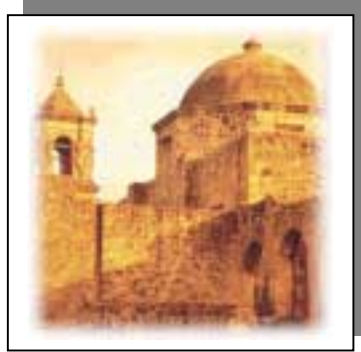
*Dos Rios Treatment Plant*

## **Conclusion**

If “an abundant supply” was the feeling in 1900-“conservation and protection” is the rallying cry today. In almost every decade since 1910, there have been warnings about the amount and quality of water in the Edwards Aquifer. The San Antonio metropolitan area now supports 1.5 million citizens and the San Antonio Water System, the largest supplier of water in the region, pumps an average of 154 million gallons per day from the Edwards Aquifer. San Pedro as well as the San Antonio Springs dry up during rainless periods and their once “impenetrable underworld” now lies at the heart of flourishing urban sprawl. An underground-pipe water system replaced most of the acequias at the end of the 19<sup>th</sup> century, but even today, the Espada Dam and its acequia continues to irrigate several small farms in South Bexar County making it the only remaining original, operational Spanish acequia system in the United States.

As for the early people of this region, the Coahuiltecs had disappeared by the time American settlers reached the area. Caught between the Spanish/Mexicans and the Apaches most of the last bands were all gone by the end of the 1800s. Their only survivors today are the many Native Texan Hispanic families in South Texas. Many families who are members of the Catholic Churches at the old missions in San Antonio can trace their families back to Coahuiltecan ancestors. The few surviving Coahuiltecs in other parts of South Texas were absorbed into the larger Hispanic/Mexican culture of South Texas. Almost any Hispanic family in South Texas who can trace their ancestors back to the early 1800s probably has Coahuiltecan blood in the family. But the culture and languages these people spoke are completely gone now.

Looking back at the history of San Antonio, it is quite clear that water has always served as a road map at the crossroads of change. Water will most probably continue to guide this region well into the next century. Water has and always will be a life giver. Not only for humans, but also for San Antonio, a city born of water.



# SAN ANTONIO WATER NATURALLY

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## Background Information

Bexar County falls into three distinct eco-zones: The Blackland Prairies, South Texas Brush Country and Edwards Limestone (Edwards Plateau).

### BLACKLAND PRAIRIES

The Blackland Prairies are found from the Dallas/ Fort Worth area, across to Bryan/College Station and down to eastern San Antonio. Throughout history, the black soil of these prairies supported tall grasses. Trees were sparse and limited only to the limestone creeks and streams.

Today, the rich soil of the Blackland prairies have been greatly beneficial to the farming community. Unfortunately, farming and over grazing have also substantially decreased the amount of prairie grasses that still remain. Since range fires are rare today, the trees are no longer just confined to the creeks and streams as they once were before settlers arrived. Invasion of woody plants on the remaining grasslands such as Ashe Juniper (cedar), Oaks and Texas Redbuds are a major influencing factor on wildlife of this region. Shrublands, in general, are better for animals like white-tailed deer, bobwhite quail, and many species of rodents. However, grassland species such as pronghorn antelope, Attwater's prairie-chicken and meadow-larks suffer as grasslands are replaced by brush.



### SOUTH TEXAS BRUSH COUNTRY

(Southern Bexar County)

Because of the low amount of rainfall, this region does not support an abundance of tall trees. When the Spanish arrived in this region in the 1600s, they found an area of almost treeless prairie grasses and tall wild flowers. Among this beauty were clumps of spiny mesquite trees and prickly pear cactus. As with the Blackland Prairies, trees were found only along creeks and rivers. With few prairie fires and intense grazing, increased cactus and mesquite took the place of the grasses and the area became a brush land.

Today the areas of the sometimes impenetrable brush country support a rich diversity of wildlife such as rattlesnakes and bobcat and plants like huisache and Texas persimmon.



## **EDWARDS PLATEAU (EDWARDS LIMESTONE)**

The Edwards Plateau is marked by a fault line (Balcones Fault) which runs from the western edge of Austin across to the northern & western edge of San Antonio/Bexar County. The Blackland Prairies are its neighbor to the south.

The rugged plateau lies just above the Edwards Aquifer which feeds clear streams such as the San Antonio, Comal and San Marcos Rivers. Historically, these spots became the focal points of settlement in this region but today, they are the focal points of tourism.

The area is rich with an abundance of deep limestone canyons and networks of underground caverns. Spanish Oaks, Mesquites and Ashe Juniper (also known as cedar), help define the characteristics of the area most people refer to as the Texas Hill Country. During springtime, the Texas Bluebonnets mix with thousands of other red, orange and pink wildflowers making the area famous for Sunday Spring drives.



## **UNIQUE FAUNA OF THE REGION**

The San Antonio/Bexar County area has an abundance of interesting and unusual wildlife found within the three eco-zones. Some of these include:

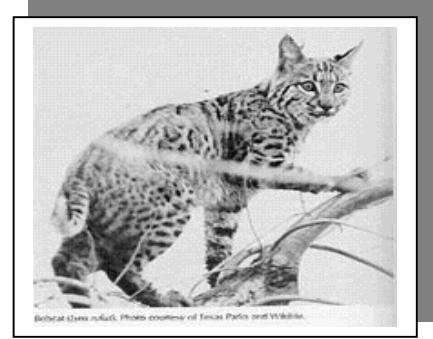
### **Nine-banded Armadillo**

This state mammal of Texas is a cat-sized, insect-eating mammal. The armadillo's bony, scaled shell protects it from predators. Many homeowners are aware of the armadillo's ability to dig. It digs many burrows as well as digs for food. Although these holes may cause a problem for human yards and gardens, many other wildlife species use these burrows once they are abandoned. The armadillo can be found in all but the western Trans-Pecos portion of Texas in a variety of habitats; brush, woods, scrub and grasslands.



### **Bobcat**

The bobcat is a medium-sized, short-tailed, reddish brown or grayish cat. Although the bobcat occupies a wide variety of habitats in Texas, they prefer rocky canyons or outcrops. In areas where such conditions don't exist (such as the South Texas Brush Country) they use dense thickets for protection and dens.



They are active largely at night although they frequently leave cover and begin hunting long before sundown.

Openings in canyon walls, rock piles or dense underbrush are favorite places for the cat to den. Occasionally, the bobcat climbs trees for refuge.

The bobcat's main diet consists of rats, ground squirrels, mice, and rabbits. Deer are occasionally killed and eaten, as are domestic sheep, goats and poultry.

### **Northern Mockingbird**

The state bird of Texas is the most widely-known songbird in America. It's singing abilities are highly regarded. In addition to its 50 call notes, it can also expertly mimic sounds such as that of a barking dog, notes from a piano and even a cackling hen.

Mockingbird nests can be found one to 50 feet above the ground in the fork of a tree or on the branch of a bush. Like many other songbirds, mockingbirds feed on fruits and insects. Mockingbirds are especially aggressive regularly attacking starlings and grackles and even cats if they feel threatened.

Mockingbirds live all year across Texas visiting lawns and gardens in urban and rural environments as well as edges of open woods, farmland, streamside thickets and brushy deserts.



### **Brazilian Free-Tailed Bats**

The Brazilian Free-Tailed Bats live in caves of the Balcones Escarpment and the adjacent Edwards Plateau. The total population of these bats that inhabit Texas caves during the summer has been estimated at 95-104 million with the largest colony being found in Bracken Cave near San Antonio. This cave is thought to hold between 20 and 40 million bats. The bats spend much of the winter in areas such as Mexico, Central America or even South America before returning to Texas when the temperatures become warmer.

The main diet of the bat consists of insects. The huge summer colonies of these bats have a great impact on nearby insect populations eating an estimated 6,000 to 18,000 metric tons of insects annually in Texas.

### **Fire Ant**

Accidentally introduced from South America in the late 1930's, the fire ant has negatively affected wildlife and overall biological diversity since it entered Texas in 1957. Young wildlife have been especially vulnerable to this aggressive pest. Numerous incidental observations of fire ants attacking and killing wildlife have been reported.

Negative interactions between people and fire ants often become more frequent as the ants move into "people places" seeking moisture. The fire ant is an aggressive pest and during a drought situation may be more likely to damage gardens, yards, homes and other structures in search of water. It is estimated that homeowners in urban areas spend around \$10.5 million a year on controlling fire ants. They spend an estimated \$7.9 million annually on medical treatments due to fire ant stings.

There are many ways to manage the fire ant problem. Pouring hot water on the mounds, using insecticide mound drenches and spreading insecticide granules approved for fire ants are just a few of the methods used to rid homes and yards of this problem in the San Antonio region.

## **UNIQUE FLORA OF THE REGION**

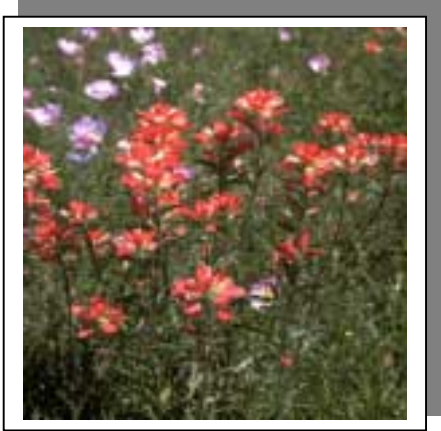
The Bexar County/San Antonio region has a variety of unusual plants. Some of the more common ones include:

### **Wildflowers**

Wildflowers have not only become a "tourist attraction" during the Spring, but they are also very popular in people's gardens. In the San Antonio region, native wildflowers benefit the local water supply. Native wildflowers require little water, no fertilizer and can be planted in areas of full sun. Once the seeds are sown, very little maintenance is required to have a healthy and beautiful yard.

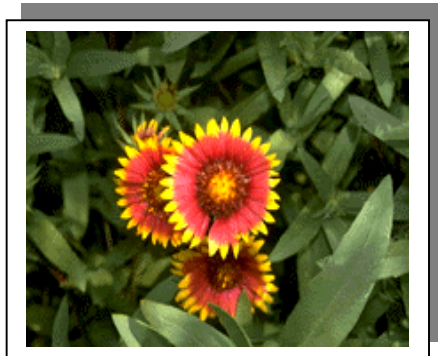
They also help to keep surface water clean. Runoff from backyards can carry excess fertilizers, pesticides and pet wastes to nearby creeks and rivers. Wildflowers act as a filter by slowing the flow of water and trapping these pollutants before they reach waterways.

**Bluebonnet-** In 1901, the Bluebonnet became the State Flower of Texas. The plant is used by the Texas Department of Transportation extensively in its roadside beautification program and as erosion control. It blooms from March to May and has a usual height of 1 foot.



**Texas Paintbrush-** The Texas Paintbrush is a member of the Figwort Family. The plant prefers well drained soil in full sun. It is widely believed that this flower feeds off the roots of grass. It's usual height is 6 - 12 inches.

**Indian Blanket, Firewheel-** This one foot tall, red and yellow flower blooms from May to September. It does well in full sun and well drained soil. Indian blanket is used for erosion control because it establishes so quickly.



**Mexican Hat**- The Mexican Hat is one of our most common flowers. The red, yellow, orange and brown flowers bloom from March to November and can grow from 1 to even 4 feet tall.



### **A “NATURAL TEXAS” LANDSCAPE: XERISCAPING/WILDSCAPING**

With water being such a hot issue in Bexar County, citizens are beginning to seriously practice landscaping around the home while thinking about conserving water. Currently, as much as 40% to 60% of water used is for maintenance of yards.

A process called Xeriscaping is also important for the outdoors. Xeriscape (“zeer uh scape”) is a word coined in 1981. “Xeros” is a Greek word that means “dry”. The word “xeriscape” means landscaping that reduces the need for water. This is important because it can cut down the amount of water needed on lawns, trees, gardens, and ornamental plants especially during the dry season.

All plants need water, but different plants have differing requirements for it. Considering that people often use utility water to water landscapes, it makes sense both practically and economically to choose plants that are adapted to our locales’ normal rainfall and temperature ranges. In those areas, it is especially important that landscapers choose native plants that thrive without a lot of watering.



Using native plants also may attract a variety of wildlife. Hummingbirds, for example, are attracted to red tubular flowers like red salvia, coral honeysuckle and cardinal flower. Food, water, shelter and space make up a Texas Wildscape. By using elements such as feeders, birdbaths, nest boxes and native vegetation, people can provide places for birds and small mammals to feed and drink, escape from predators and raise their young in the comfort of yards and gardens.

### 1. Planning and Design

How do you use your yard? For recreation? For looks? What kind of look are you going for?

### 2. Use Turf Appropriately

Choose low water requirement turf. Long, narrow strips of turf should be eliminated.

### 3. Irrigate Efficiently

Hand watering is preferable. Group plants according to water usage.

### 4. Conditioning Soil

Soil should be generally crumbly to the touch. Well conditioned soil promotes water conservation by absorbing water more efficiently. Bare soil should be covered with mulch.

### 5. Mulching

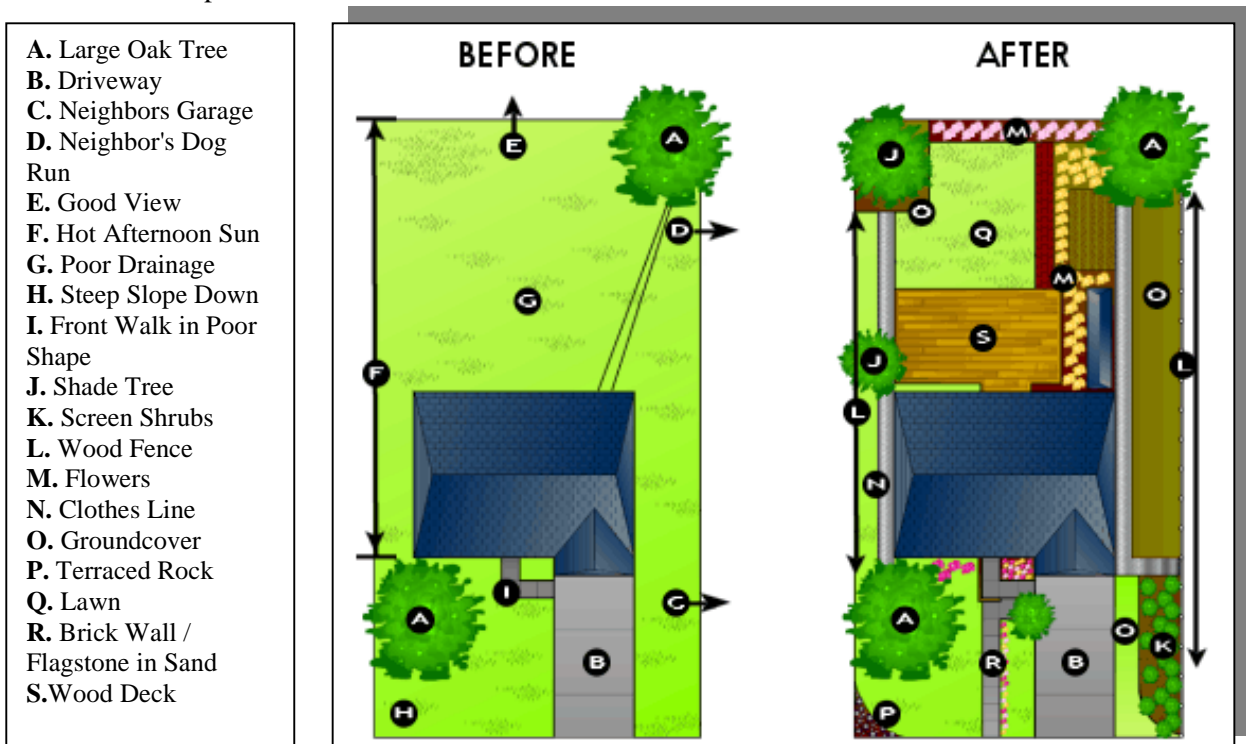
Apply 2-4 inches deep. This minimizes evaporation, reduces weed growth, and slows erosion.

### 6. Plant Selection

Choose plants suitable to the South Central Texas Climate.

### 7. Maintaining Landscapes

Proper planning and design reduces maintenance time. Using native plants reduces the need for fertilizers and pesticides.



## **MITCHELL LAKE: A LOCAL BIRDING PARADISE**

Early maps of the Camino Real, one of several highway routes used by the Spanish and other early European settlers who crossed present day Texas, clearly indicates a divergence around an impassable area where Mitchell Lake is located. These maps date from the 1690's.

In a map drawn for Captitan Don Luis Antonio Menchaca dated 1764, the area known today as Mitchell Lake is labeled as a legunilla. These lands once belonged to Mission Espada and were the site of the stables. These maps are evidence that this area was historically a natural body of still water.

In the late 1800's, the site was owned by the Mitchell family and was popular for waterfowl hunting. The marshy setting provided a quality riparian habitat. Shortly after the turn of the century the lake was purchased by the City of San Antonio and a dam was constructed to create one of the earliest centralized wastewater treatment facilities for the city.

As one of two large bodies of still water in South Central Texas, Mitchell Lake and its wetlands are seen as critical habitat for a variety of bird species which migrate along the Central Flyway.

Mitchell Lake was designated as a refuge for shore birds and waterfowl by the San Antonio City Council on February 8, 1973 at the urging of local bird enthusiasts which long knew the importance of this critical wetlands habitat.

Mitchell Lake and the associated wetlands are located along the Central Flyway where birds migrate between Canada and Central America. Maps and written accounts dating from the 1690's indicate that Mitchell Lake has historically been a place of still water where migrating flocks can feed, rest and breed.

Mitchell Lake Wetlands restoration began in earnest the Fall of 1994 when SAWS installed pump stations and began pumping water from Mitchell Lake into the series of decant basins and polders which were once receptacles for the city's waste water sludge.

Bird watching at Mitchell Lake has revealed the presence of over 300 species of birds, including endangered species. The Mitchell Lake Wetlands have long been a well kept secret among the bird watchers who come from all over the world in hopes of catching a glimpse of bird species to add to their life lists.

Birds that have been spotted include:

<b>Avocets</b>	<b>Belted Kingfishers</b>
<b>Black-neck Stilts</b>	<b>Caracaras</b>
<b>Dowitchers</b>	<b>Giant Blue Herons</b>
<b>Golden-fronted Woodpeckers</b>	<b>Great Egrets</b>
<b>Grebes</b>	<b>Hummingbirds</b>
<b>Northern Shovelers</b>	<b>Ospreys</b>
<b>Owls</b>	<b>Quail</b>
<b>Ruddy Ducks</b>	<b>Roseate Spoonbills</b>
<b>Snowy Egrets</b>	<b>Spotted Sandpipers</b>
<b>Vermilion Flycatchers</b>	<b>White-faced Ibises</b>
<b>White Pelican</b>	<b>Willetts</b>
<b>Yellow-billed Cuckoos</b>	<b>Yellowlegs</b>

## CONCLUSION

For perhaps thousands of years, man has passed through or settled in this region because of the vast and varied amount of natural resources available. From Mitchell Lake with its flocks of migrating birds, to forests of juniper and 100 year old live oaks, the San Antonio/Bexar County region's natural resources have played an important role in the development of this community's identity.

The cool, clear waters that bubbled forth from springs in the Texas Hill Country must have seemed like a dream to the tired Spanish explorers who happened upon them in the 1500's and 1600's. These same streams today are a recreational dream for the thousands of people who journey to their banks during the hot, dry periods each summer. Caves that served as shelter for early man as well as many species of wildlife are today regarded as vitally important to the well being of a water supply serving almost 2 million residents. Black fertile soil that once harbored immense fields of native grasses and wildflowers are used today for the important agriculture needs of a growing state. Finally, an unspoiled river that attracted settlers and eventually gave birth to a community called San Antonio is today the number one tourist attraction in the state and a vital source of income for the now eighth largest city in the U.S.

In 1843, Frederick Marryat said this about the San Antonio River,

*"The temperature of the water is the same throughout the year, and not a single day passes without the inhabitants indulging in their favourite and healthy exercise of swimming, which is practiced by everybody, from morning till evening; and the traveler along the shores of this beautiful river will constantly see hundreds of children, of all ages and colour, swimming and diving like so many ducks."*

Although today walking along the riverwalk is favored over swimming, the citizens of the community are still in love with this river. And although some of the natural beauty of the river has been transformed over to "urban jungle", in the future, the river will most likely still be the central focus to a city that refuses to loose it cultural and natural identity.



# SAN ANTONIO WATER PIPES, PLANNING, POLITICS AND PEOPLE

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## THE EDWARD'S AQUIFER: SAN ANTONIO'S ONLY 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.



## SAN ANTONIO'S WATER NEEDS WILL DOUBLE BY 2050

Greater San Antonio is one of the fastest growing areas in the country and its water needs are rapidly increasing. It helps that San Antonio currently has one of the most efficient and successful conservation programs in the state. But even the best conservation efforts won't completely solve all water challenges.

Most realize that the Edwards Aquifer is a limited resource. In fact, no one knows for sure exactly how much usable water it actually contains. However, 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. As a result, the Edwards region made a choice to limit the amount of water taken from the aquifer so it can be preserved for many years to come. But relying solely on the Edwards Aquifer is not the answer. That's why SAWS has been actively developing additional water resources to limit the dependence on the aquifer.

SAWS is looking at additional sources that may include the Guadalupe River, the Lower Colorado River Basin or other nearby resources. New ways to produce more water from the Edwards are still being pursued. Approximately one million dollars have been programmed annually for these studies to continue.

## **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 along 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.



## **WORKING TOGETHER TO SOLVE THE WATER SUPPLY ISSUE**

In November of 1998, the San Antonio City Council unanimously approved a long-term water plan. This plan was based on two years of input from city leaders, neighborhood groups, and citizens from all over San Antonio. Since then, SAWS has been steadily developing additional water resources, protecting the quality of aquifer water, and making the most of the water that is used.

In order to coordinate water projects across the state, the Texas Legislature has established a "from the bottom up" process. Local water projects will not be permitted by the state unless they are part of the regional and state water plan. Thus, all of the projects described here align with the regional plan and are supported throughout the planning region.

## SHORT TERM PLANNING

San Antonio's water supply requirements will be met for the short term (the next ten years) from the following sources:

### \*Water From The Edwards Aquifer

The Edwards Aquifer will always be San Antonio's primary source of water. Thus, conservation programs to use it efficiently and protect the water quality will be expanded. Additional water from the Edwards will be acquired in several ways.

### \*Recycled Water

In 2001, SAWS will complete the first phase of its system to recycle treated wastewater effluent for irrigation and industrial uses. This program will provide 35,000 acre-feet of non-drinking water per year.

### \*Oliver Ranch/BSR

Sustainability studies are being conducted to determine how much water can safely be withdrawn from a portion of the Cow Creek formation of the Trinity Aquifer in northern Bexar County. Preliminary studies suggest that 4,500 acre-feet may be sustainable from this source.

### \*Western Comal Project (Canyon Lake)

SAWS has contracted with the Guadalupe-Blanco River Authority for 3,000 acre-feet of water from Canyon Lake. An additional 6,000 acre-feet may be available on a short-term basis (through 2010) to serve the northwestern part of the SAWS service area.

### \*Aquifer Storage and Recovery (South Bexar County)

Property has been acquired in southeastern Bexar County for Aquifer Storage and Recovery (ASR) project using the Carrizo Aquifer as a storage facility. Water would be injected into this sand-based aquifer during periods of rainfall excess — and withdrawn during dry periods. This process will yield an additional 30,000 acre-feet.

### \*Regional Carrizo

SAWS is working to secure approximately 30,000 acre-feet of additional groundwater that may be available from the Carrizo Aquifer in Gonzales County.

**One acre-foot equals  
325,851 gallons.**

That's enough to fill up an acre of space with one foot of water — or enough water for two families of four for one year.

## LONG TERM PLANNING

San Antonio's long-term water needs (beyond 2010) will be met from the following sources:

### \*Guadalupe River Diversion

Negotiations are now underway for a larger supply of water from the Guadalupe River. Model runs show that approximately 60,000 to 70,000 acre-feet could be available from a large diversion in the lower part of the Guadalupe River basin near the Gulf Coast.

### \*Simsboro Project

SAWS has contracted with Alcoa to acquire groundwater from the Simsboro Aquifer in Milam and Lee Counties. SAWS has also purchased water rights owned by City Public Service on a site near-by. Sustainable yields from these two sites combined are projected to be 55,000 acre-feet.

\*LCRA Diversion

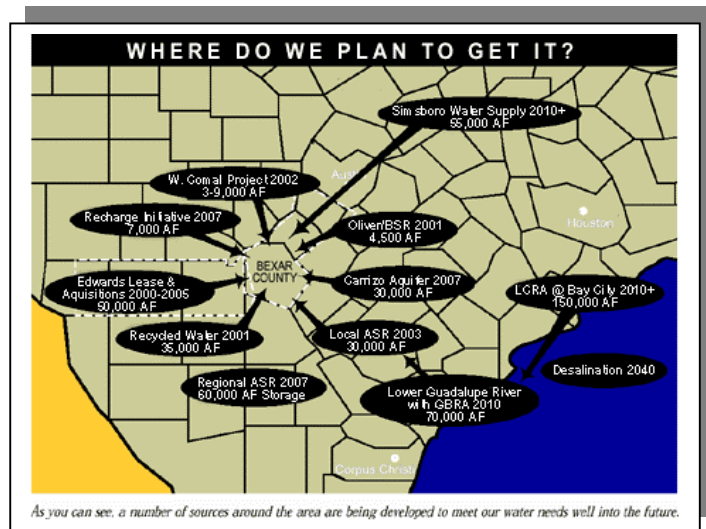
The purchase of 150,000 acre-feet may be available to SAWS and others from the Lower Colorado River Authority (LCRA) at Bay City.

\*Regional Aquifer Storage and Recovery

SAWS has agreed with the Evergreen Underground Water Conservation district to pursue a large-scale regional Aquifer Storage Recovery (ASR) program in Atascosa and Wilson Counties. This plan will not yield any additional new water supplies, but it will enable SAWS to store water underground during wet weather for use during dry periods.

\*Desalination Project

Taking salts and other minerals out of seawater may be an opportunity for San Antonio to acquire large volumes of water. Current technology makes this alternative one of the more expensive options, but it has been included in the current draft of Region L's South Central Texas Regional Water Plan (in accordance with the requirements of Senate Bill 1).



**PLANNING LAND USE**

(Information used permission by *The Water Sourcebook, Education Research and Inservice Center, University of North Alabama, Florence, Alabama*).

In communities throughout the U.S., land use is usually determined by immediate economic considerations. However, in recent years, more and more communities are planning their growth more carefully. Part of the reason for this is that people have recognized that environmental quality and aesthetic value- clean, healthful and attractive characteristics- are important considerations along with economics.

Since natural areas do yield economic benefit to the community, land use planners are taking these less immediate concerns into account when developing new land areas.

Natural areas such as parks, tracts of forest or grasslands, streams and ponds are usually desirable features in any community. They have been proven to increase an area's livability and to increase property values. Water bodies are highly desirable to most people.

Urban and regional planners often leave strips of natural area along these watercourses. These strips help protect water quality by filtering pollutants out of the runoff entering the water; it also provides habitat for many plants and animals.

## **AGRICULTURAL LAND USE**

*(Information used permission by The Water Sourcebook, Education Research and Inservice Center, University of North Alabama, Florence, Alabama).*

The increasing world population has placed a huge stress on agricultural systems to produce food. While food distribution remains a problem, new advances in agriculture are encouraging.

In 1940, the average farmer in the U.S. could produce enough food for 19 people. Today, an American farmer can produce enough food to feed 129 people—101 in the U.S. and 28 abroad. Technological advances have increased the productivity of farmers, particularly by improving their ability to provide water to their crops through irrigation. Irrigation is defined as the managed application of water to soil for the purpose of increasing crop production.

Irrigated agriculture has helped American farmers produce the most abundant and diverse supply of food, fiber and foliage products in the world. Irrigation plays an especially important role in the Western United States where growing seasons are longer but there is not enough rainfall to supply an optimum amount of water to commercial crops.

Most countries use a large amount of water resources for agricultural purposes. In the U.S., agriculture accounts for 42 percent of water consumption. For crop irrigation, most of the areas of high production depend on water from underground sources-groundwater. In recent years, scientists have measured drastic falls in the water tables of important aquifers like the Edwards. These aquifers are almost impossible to replenish.

The by-products of agriculture also are affecting the groundwater. While pesticides and fertilizers are greatly responsible for production increases, residues from these products can filter down through the soil and into groundwater. Animal waste, or manure, has also contributed to groundwater contamination. Nitrates from both the manure and agricultural chemicals, can contaminate drinking water supplies.

On the positive side, many of these threats can be diminished through efficient farming methods and creative problem solving. By using manure instead of commercial fertilizer to enrich land, farms and the environment can both profit. Reducing the amount of pesticides and applying them only in critical times can also save money and lower the risk of contamination. Other alternative uses for manure range from enriching landfill cover soil to producing an alternative energy source (methane gas). Recent surveys involving farmers in the



Midwestern U.S. indicate that many farmers would welcome more efficient techniques and that the use of such techniques has increased.

## **WASTEWATER**

We consider wastewater treatment as a water use because it is so interconnected with the other uses of water. Much of the water used by homes, industries, and businesses must be treated before it is released back to the environment.

If the term "wastewater treatment" is confusing to you, you might think of it as "sewage treatment." Nature has an amazing ability to cope with small amounts of water wastes and pollution, but it would be overwhelmed if we didn't treat the billions of gallons of wastewater and sewage produced every day before releasing it back to the environment. Treatment plants reduce pollutants in wastewater to a level nature can handle.

Wastewater is used water. It includes substances such as human waste, food scraps, oils, soaps and chemicals. In homes, this includes water from sinks, showers, bathtubs, toilets, washing machines and dishwashers. Businesses and industries also contribute their share of used water that must be cleaned.

Wastewater also includes storm runoff. Although some people assume that the rain that runs down the street during a storm is fairly clean, it isn't. Harmful substances that wash off roads, parking lots, and rooftops can harm our rivers and lakes.

### **WHY TREAT WASTEWATER?**

#### Fisheries

Clean water is critical to plants and animals that live in water. This is important to the fishing industry, sport fishing enthusiasts, and future generations.

#### Wildlife Habitats

Our rivers and ocean waters teem with life that depends on shoreline, beaches and marshes. They are critical habitats for hundreds of species of fish and other aquatic life. Migratory water birds use the areas for resting and feeding.

#### Recreation

Water is a great playground for us all. The scenic and recreational values of our waters are reasons many people choose to live where they do. Visitors are drawn to water activities such as swimming, fishing, boating and picnicking.

#### Health

If it is not properly cleaned, water can carry disease. Since we live, work and play so close to water, harmful bacteria have to be removed to make water safe.

The major aim of wastewater treatment is to remove as much of the suspended solids as possible before the remaining water, called effluent, is discharged back to the environment. As solid material decays, it uses up oxygen, which is needed by the plants and animals living in the water. "Primary treatment" removes about 60 percent of suspended solids from wastewater. This treatment also involves aerating (stirring up) the wastewater, to put oxygen back in. Secondary treatment removes more than 90 percent of suspended solids.

*(Information courtesy of USGS)*

## SAWS WASTEWATER SYSTEM

The San Antonio Water System has three major Water Recycling Centers that supply water to the SAWS Reuse Program and to the City Public Service cooling lakes. All are located on the city's south side, and together they presently (1996) produce about 120 millions gallons of water per day. Another smaller plant, the Medio Creek WRC, is located on the city's west side and produces about 4 million gallons per day. SAWS also owns and operates several small "package" facilities that serve individual high schools and neighborhoods.



- \*In the 1930's San Antonio's Rilling Road plant was one of the first water recycling systems in the state of Texas. It was replaced by the state-of-the-art Dos Rios facility in 1987.
- \*In the 1950's and 60's, San Antonio and City Public Service were pioneers in the large-scale use of recycled water for cooling electrical power plants. Over 6.5 billion gallons of recycled water are used each year.
- \*SAWS Water Recycling Centers treat wastewater from over one million persons in Bexar County.
- \*The area served by SAWS in Bexar County is over 400 square miles.
- \*There are over 4,300 miles of sewer lines in the collection system.
- \*Average discharge from the Recycling Centers is presently about 120 million gallons per day.
- \*Recycled water is discharged to the Medina and San Antonio Rivers

## HOW DOES WATER RECYCLING WORK?

The water recycling process utilizes very basic physical, biological, and chemical principles to remove contaminants from water. Use of mechanical or physical systems to treat wastewater is generally referred to as *primary treatment*. Use of biological processes to provide further treatment is referred to as *secondary treatment*. Additional purification is called *tertiary* or *advanced treatment*.

### PRIMARY TREATMENT

Primary treatment uses simple mechanical and physical processes to remove approximately half of the contaminants from wastewater.

1. Bar screens: Screening removes large floating objects such as sticks and rags from the incoming wastewater stream. Unless they are removed, they could cause problems later in the treatment process. Most of these materials are sent to a landfill.
2. Grit chamber : Water flows into large tanks designed to slow it just enough so that sand and grit drop to the bottom.
3. Primary clarification: Water is slowed further so that settleable organic materials drop to the bottom while fats, oils, and greases float to the top. Biosolids removed at this point are digested, dewatered, and used for beneficial purposes like conditioning soil or composting.

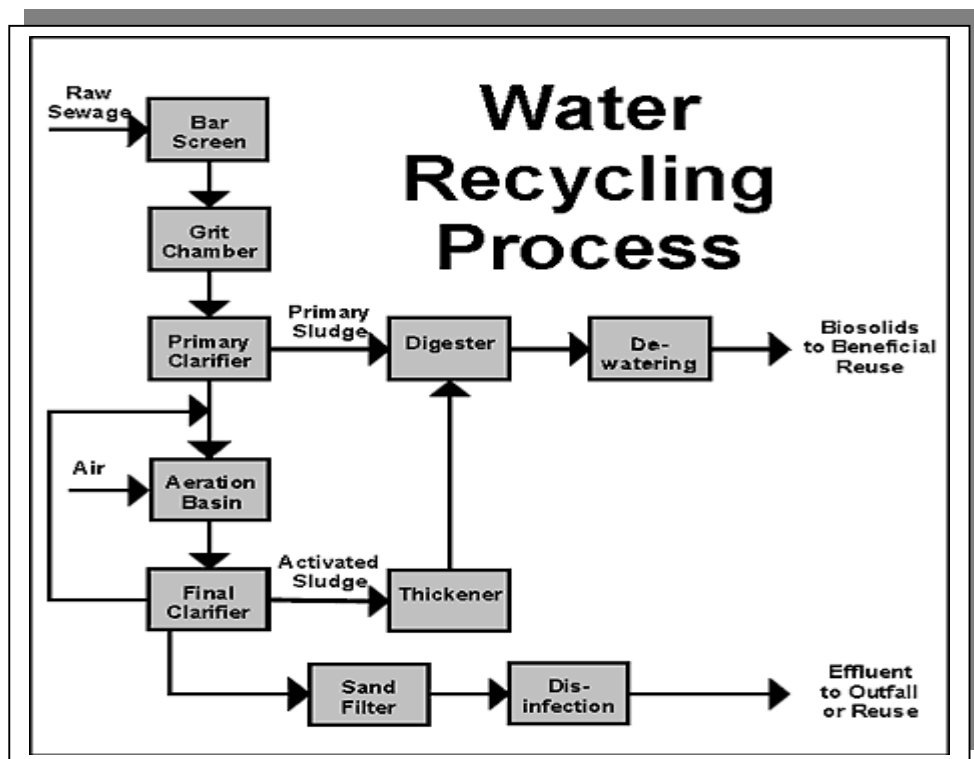
## SECONDARY TREATMENT or "Bug Farming For Clean Water"

Secondary treatment uses biological processes to remove most of the remaining contaminants.

1. Aeration and Clarification : Water flows into aeration basins where oxygen is mixed with the water. Bacterial microorganisms consume the organic material as food. They convert non-settleable solids to settleable solids and are later themselves captured in final clarifiers, ending up in wastewater biosolids. Most of the solids that settle out in final clarifiers are thickened and digested, but some are returned to the aeration tank to reseed incoming water with microorganisms. Many operators of WRC's consider themselves "bug farmers" since they are in the business of growing and harvesting a healthy population of microorganisms.

## ADVANCED TREATMENT and DISINFECTION

After the bugs do their work, water is filtered through sand and then chemical disinfection in chlorine contact chambers is used to kill any remaining microorganisms. It is not desirable to have residual chlorine in the rivers and lakes, so chlorine is then removed using sulfur dioxide. This protects the aquatic life in the receiving stream. The point where recycled water is discharged to a stream or body of water is called the *outfall*.



## WASTEWATER RESIDUALS

Another part of treating wastewater is dealing with the solid-waste material. These solids are kept for 20 to 30 days in large, heated and enclosed tanks called 'digesters.' Here, bacteria break down (digest) the material, reducing its volume, odors, and getting rid of organisms that can cause disease. The finished product is mainly sent to landfills, but sometimes can be used as fertilizer.

## RECYCLED WASTEWATER

With the scarcity of water in some parts of the U.S. and with water conservation being so important nowadays, the reuse of treated wastewater is becoming more important. No, you don't have to worry about your drinking water at home coming right from a sewage-treatment plant (although a successful test of this has been done!!), but treated wastewater is being used for certain purposes throughout Bexar County.



The use of recycled wastewater helps us in two ways:

1. Recycled water can supply needed water for some purposes
2. Recycled wastewater frees up fresh water that can be used somewhere else, such as for drinking water

So, what exactly is recycled wastewater used for? A lot of it goes toward watering golf courses and landscaping alongside public roads, etc. Some industries, such as power-generation plants can use recycled wastewater. A lot of water is needed to cool power-generation equipment, and using wastewater for this purposes means that the facility won't have to use higher-quality water that is best used somewhere else.

In 1996 the SAWS Board approved a Water Recycling plan that will deliver 35,000 acre feet of this highly treated effluent to commercial and industrial users throughout the city. Today the program consists of a planned 64-mile pipeline going around the entire city delivering recycled water to customers for **non-drinking** water purposes.

# SAN ANTONIO WATER QUALITY

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## WATER QUALITY IN THE WATERSHED

Each time we use water, we change its quality by adding substances to it. These materials are such things as municipal sewage, toxic chemicals, automotive oils, fertilizers, detergents and pesticides. Some materials, even in small quantities, can damage water quality to the point that it is unusable. A single quart of motor oil, for example, could pollute as much as 250,000 gallons of water.



When it comes to water pollution, what comes around goes around the watershed. By definition, a watershed is a multi-dimensional (varying sizes) area used to define a region in which all land drains to a particular body of water or common low point. A watershed could be as small as your backyard or as large as any major river basin. Regardless of the size, we now know that water quality and uses can be impacted by land use activities anywhere in the watershed. San Antonio has three main categories of land-users: Urban, Industrial & Agricultural.

Because of these users, agencies in Texas have started a watershed management approach which helps solve the problems cost-effectively, fairly and scientifically. Watershed management is a holistic or complete experience. Instead of focusing attention and resources on one particular water quality problem, managers take a holistic approach. One agency in Texas leading the way in watershed management is the Texas Natural Resource Conservation Commission or TNRCC.

Regulations on animal waste for hog and poultry farms is just one way the TNRCC regulates agriculture land users from potentially damaging the watershed. Agriculture can create serious demands on a water supply and cause several types of pollution. Besides animal wastes, sediment pollution due to excessive tillage and crop fertilizers can enter streams, ponds or lakes after a rainfall.



Densely populated urban areas, which are covered by impervious surfaces like streets, sidewalks, rooftops and buildings, increase the amount and decrease the quality of storm water run-off. The high concentrations of people in these areas tend to produce greater quantities and varieties of pollutants, including nutrients, bacteria and toxic chemicals.

Think about your neighborhood for example. Have you ever considered what happens to the fertilizers and insecticides that wash off your yard during a thunderstorm? When it rains, these types of pollutants are washed into neighborhood gutters and storm drains which are not connected to any wastewater treatment plant and therefore not treated. These urban pollutants flow through the storm drain system and empty directly into our local rivers, creeks and lakes. All rivers and creeks in Bexar County drain to the San Antonio River and eventually drain into the Gulf of Mexico. These pollutants could therefore harm wildlife and fisheries and ruin recreational areas from here to the Texas coast.

## **POLLUTION**

Water pollution is identified in two categories: Point Source and Non-point Source. Point Source Pollution is contamination that comes from a single, clearly identifiable source, such as a pipe which discharges material from a factory into a lake, stream, river, bay or other body of water. Point source pollution could also include storm water runoff that is channeled from a drain directly into a waterway. Point source pollution is relatively easy to identify.

Non-point Source Pollution is more difficult to identify. This is pollution which originates over a broad area resulting from a variety of causes. Examples of non-point source pollution include improper application of pesticides and fertilizers, sediment from construction and petroleum-based products from streets and parking lots. Non-point source pollution usually originates from storm water runoff.

There are six major types of water pollutants that watershed managers recognize:

- \*Biodegradable wastes
- \*Plant nutrients
- \*Heat
- \*Sediments
- \*Hazardous and toxic chemicals
- \*Radioactive wastes

## **STREAM HEALTH**

In addition to water measurement characteristics such as temperature, pH, conductivity, turbidity, dissolved oxygen and hardness (see Chemical section in this book), scientists look at four other areas to gauge overall stream health. They include:

**BACTERIA**-Bacteria is a good indicator of drinking and recreational water quality. Total bacteria and fecal coliform bacteria are the most widely used “indicator bacteria.” High levels of bacteria are not desirable.

**ALGAE**-Algae are good water quality indicators. High quality lakes and streams contain sparse to moderate amounts of algae assuring an adequate food supply for fish communities.

**PHOSPHATES**- Phosphates are chemical compounds that are made from the element phosphorus and are sometimes used in detergents and fertilizers. Urban activities such as washing cars and applying fertilizers can greatly increase phosphate levels.

**NUTRIENTS**-Urban runoff can also carry nutrients in streams and creeks. With the right quantity and proportion, these nutrients can contribute to an overabundance of plant growth which could “choke” the waterway.

## **HAZARDOUS WASTE**

As mentioned previously, hazardous waste is one of the most common pollutants found in rivers and streams. Have you ever thought about what you pour down the drain? What about your old motor oil or your household chemicals and cleaners? Think about it. What you put down the storm drains could eventually re-enter the water cycle. You could be a source of hazardous pollution. Ways to avoid this are to recycle oil and other petroleum-based chemicals at service stations or recycling centers. Avoid using hazardous chemicals when possible and substitute more environmentally friendly materials. The city of San Antonio schedules four Household Hazardous Waste Collection Days so that individuals can take hazardous wastes to a site for proper disposal.

Why is it so important to keep these hazardous wastes from entering our streams and creeks? They might end up in our drinking water. The San Antonio Water System has a “Wellhead Protection” program that inventories any potential wastes that could affect our production wells and these wells are direct conduits or pathways to the Edward’s Aquifer.

## **WATER QUALITY AND YOU**

Public water systems, like San Antonio Water System, are required by law to report every year on the type and quantity of substances that are in the water. This law - the Safe Drinking Water Act (SDWA) - has specific guidelines about what types of substances are tested for in drinking water, as well as methods of testing, and how often testing is conducted.

The Environmental Protection Agency (EPA) administers the SDWA to make sure tap water is safe to drink. Bottled water, on the other hand, is regulated by the Food and Drug Administration (FDA) which limits contaminants for similar protection of public health.

## **WHAT'S IN OUR POTABLE WATER**

The technical term for anything other than water in the water is “contaminant.” In this line of thinking, you could consider orange juice as water which has been “contaminated” by the orange pulp, the oil, and the flavorings in the orange-all the things that make orange juice taste so good! The important thing when reading this is not to be alarmed by this use of the word “contaminant.”

It's natural for drinking water to contain contaminants. San Antonio's water is well within allowable limits. Drinking water, including bottled water, may reasonably be expected to contain at least small amounts of some contaminants. The presence of contaminants does not necessarily indicate that water poses a health risk.

Sources for drinking water (both tap water and bottled water) include rivers, lakes, streams, ponds, reservoirs, springs and wells. As water travels over the surface of the land or through the ground, it dissolves naturally-occurring minerals and, in some cases, radioactive material and can pick up substances resulting from the presence of animals or from human activity.



Contaminants that may be present in source water include:

- microbiological contaminants, such as viruses and bacteria which may come from sewage treatment plants, septic systems, agricultural livestock operations and wildlife
- inorganic contaminants, such as salts and metals which can be naturally-occurring or result from urban stormwater runoff, industrial or domestic wastewater discharges, oil and gas production, mining or farming
- pesticides and herbicides, which may have a variety of sources such as agriculture, urban stormwater runoff and residential uses
- organic chemical contaminants which are by-products of industrial processes and petroleum production and can also come from gas stations, urban stormwater runoff and septic systems and
- radioactive contaminants, which can be naturally-occurring or the result of oil and gas production and mining activities.

Contaminants may be found in drinking water that may cause taste, color or odor problems. These types of problems are not necessarily causes for health concerns.

## **WELL HEAD PROTECTION**

A major consequence of rapid urbanization through the San Antonio area, specifically over the sensitive Edwards Aquifer recharge and transition zone, has been the abandonment of many water wells. Abandoned water wells remain at the top of the list of potential groundwater contaminant sources, which can be identified and eliminated. Around the wellhead (or the area draining to a wellhead), uncapped or uncased wells provide a direct conduit to groundwater from activities at the surface. The San Antonio Water System (SAWS) Water Quality Division's abandoned well program aggressively pursues the identification and closure of approximately 70 abandoned wells each year. But a number of these wells are identified and not closed due to the lack of funds from the well owner. Complying with the plugging provisions in Chapter 32 of the Water Code and City Ordinances represents a demonstrable financial burden to these landowners.

SAWS routinely identifies abandoned wells as having the potential to impact public water supplies. In the past decade, SAWS has committed more resources in identifying and pursuing the closure of abandoned wells in the San Antonio region. Additionally, in the past three years the utility has taken a proactive approach in developing and implementing programs designed to protect and understand the water sources in the area.

Many of the abandoned wells that need closing are shallow wells (50-200 feet), near creeks or rivers. They are typically dug only into the gravel layer, and often not properly cased. When refuse collects in them, they pose a contamination hazard to the nearby surface water. Waste material can leach out and flow underground into the stream bed, or be carried there when the creek's water flow exceeds its normal boundaries and enters the well. Five such hand-dug wells were found near the San Antonio River this past year. These wells were being used as septic systems for nearby residents. While proper septic systems have since been established, those wells have yet to be cleaned out or plugged to prevent further misuse. The best way to rectify this ongoing problem is to develop a unique innovative approach that will prevent further degradation and ultimately improve water quality. To accomplish this, SAWS will need to identify a number of parameters such as the condition of the casing in the abandoned well, the lithology of the well bore and the water quality of the well. These vital characteristics can only be identified through a geophysical log survey and the collection of water quality samples. In addition to closing abandoned wells, SAWS will be able to develop a valuable database that will be beneficial to other agencies and the public.

# SAN ANTONIO WATER and YOU

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## **WATER IS LIFE**

Water is of major importance to all living things. In some organisms, up to 90 percent of their body weight comes from water. Up to 60 percent of the human body is water: the brain is composed of 70 percent water, blood is 82 percent water, and the lungs are nearly 90 percent water.

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.



## **TEXAS WATER USE**

Water is essential to life. However, many times people take this important resource for granted. Humans expect it to be clean and abundant, but they 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 number of people will most likely put a strain on the state's existing ground and surface water. Bexar county alone has 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.

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.

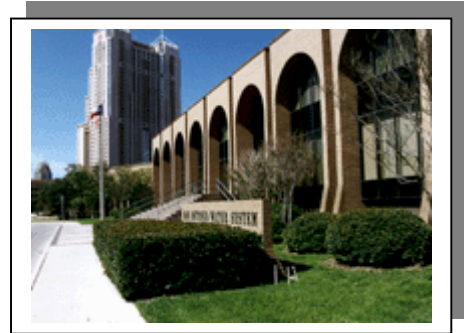
## **WATER FACTS ABOUT SOUTH/CENTRAL TEXAS**

- ◆ 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.

## **SAN ANTONIO'S WATER SYSTEM**

SAWS is a public utility owned by the city of San Antonio. It was created in May 1992 through the consolidation of three predecessor agencies:

- City Water Board (the previous city-owned water supply utility)
- City Wastewater Department (the city government department responsible for sewage collection and treatment)
- Alamo Water Conservation and Reuse District (an independent city agency created to develop a system for reuse of treated wastewater)



In 1995, the San Antonio Water System served approximately 1 million people in the urbanized part of Bexar County. This population included approximately 260,000 separate customers. SAWS' population is projected to increase to 2.2 million by 2050, and its water demand will roughly double over that period.

SAWS' service areas are established by its permits from state regulatory authorities. The service area for water supply includes most (but not all) of the City of San Antonio, several suburban municipalities, and adjacent parts of Bexar County. In addition to serving its own retail customers, SAWS also provides wholesale water supplies to several smaller utility systems within this area boundary.

A larger and somewhat different area, following natural watersheds, is defined for wastewater collection and treatment. SAWS is the only sewage treatment agency in this area, and it charges a fee to the military bases and suburban cities which maintain their own wastewater collection systems. SAWS also provides collection and treatment services by contract to developments outside its defined service area, to avoid unnecessary proliferation of state wastewater discharge permits.

## **WATER CONSERVATION**

On the average, every American uses about 100 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. Our 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 we're 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 we 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. This gets the job done just as well, but with less water.

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.



We should all put voluntary restrictions on our water usage around the house. But in times of drought, additional water restrictions are 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. During an especially hot and dry period, it doesn't take long for these measures to be implemented.

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

### **STAGE 1**

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

### **STAGE 2**

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

### **STAGE 3**

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](http://www.SAWS.org).)

## HOW TO CONSERVE

For approximately \$10 to \$20, the average homeowner can install two low-flow showerheads, place dams or bottles in the toilet tanks, install low-flow aerators on the faucets, and repair dripping faucets and leaking toilets. This could save 10,000 to more than 25,000 gallons per year for a family of four, and would pay for itself in less than a year! Even more could be saved if good outdoor water conservation is practiced for the lawn and garden.

Here are some more great watersaving tips to help you conserve water and lower your water bill:

### In The Bathroom...

1. Install a low-flow shower head that limits the flow from the shower to less than three gallons per minute.
2. Take short showers and install a cutoff valve, or turn the water off while washing and back on again only to rinse.
3. Take a shower instead of taking a bath. Showers with low-flow shower heads often use less water than taking a bath.
4. Reduce the level of the water being used in a bathtub by one or two inches if a shower is not available.
5. Shampoo hair in the shower. Shampooing in the shower takes only a little more water than is used to shampoo hair during a bath and much less than shampooing and bathing separately.
6. When building a new home or remodeling a bathroom, install a new low-volume flush toilet that uses only 1.6 gallons per flush.
7. Test toilets for leaks. Add a few drops of food coloring or a dye tablet to the water in the tank, but do not flush the toilet. Watch to see if the coloring appears in the bowl with a few minutes. If it does, the toilet has a silent leak that needs to be repaired.
8. Use a toilet tank displacement device such as a toilet dam or bag. Also, a plastic bottle can be filled with stones or water, recapped, and placed in the toilet tank. These devices will reduce the volume of water in the tank but will still provide enough for flushing. (Bricks are not recommended since they eventually crumble and could damage the working mechanism.) Displacement devices are not recommended with new low-volume flush toilet.
9. Never use the toilet to dispose of cleansing tissues, cigarette butts, or other trash. This wastes a great deal of water and also places an unnecessary load on the sewage treatment plant or septic tank.
10. Do not use hot water when cold will do. Water and energy can be saved by washing hands with soap and cold water. Hot water should be added only when hands are especially dirty.



11. When brushing teeth, turn the water off until it is time to rinse.
12. Do not let the water run when washing hands. Water should be turned off while washing and scrubbing and be turned on again to rinse. A cutoff valve may be installed on the faucet.
13. When shaving, fill the lavatory basin with hot water instead of letting the water run continuously.
14. Install faucet aerators to reduce water consumption.

### **In The Kitchen...**

15. Scrape the dishes clean instead of rinsing them before washing. There is no need to rinse unless they are heavily soiled.
16. Use a pan of water (or place a stopper in the sink) for washing and rinsing pots, pans, dishes, and cooking implements, rather than turning on the water faucet each time a rinse is needed.
17. Never run the dishwasher without a full load. This practice will save water, energy, detergent, and money.
18. Use the garbage disposal sparingly or start a compost pile.
19. Keep a container of drinking water in the refrigerator. Running water from the tap until it is cool is wasteful. Better still, both water and energy can be saved by keeping cold water in a picnic jug on a kitchen counter to avoid opening the refrigerator door frequently.
20. Use a small pan of cold water when cleaning vegetables, rather than letting the water run over them.
21. Use only a little water in the pot and put a lid on it for cooking most food. Not only does this method save water, but food is more nutritious since vitamins and minerals are not poured down the drain with the extra cooking water.
22. Always keep water conservation in mind, and think of other ways to save in the kitchen. Small kitchen savings from not making too much coffee or letting ice cubes melt in a sink can add up in a year's time.



### **For Outdoor Use...**

1. Water only when needed. Look at the grass, feel the soil, or use a soil moisture meter to determine when to water.
2. Do not over-water. Soil can absorb only so much moisture and the rest simply runs off. A timer will help, and either a kitchen timer or an alarm clock will do. One and a half inches of water applied once a week in the summer will keep most Texas grasses alive and healthy.

3. Water lawns early in the morning during the hotter summer months. Otherwise, much of the water used on the lawn can simply evaporate between the sprinkler and the grass.
4. To avoid excessive evaporation, use a sprinkler that produces large drops of water, rather than a fine mist. Sprinklers that send droplets out on a low angle also help control evaporation.
5. Set automatic sprinkler systems to provide thorough, but infrequent watering. Pressure-regulating devices should be set to design specifications. Rain shutoff devices can prevent watering in the rain.
6. Use drip irrigation systems for bedded plants, trees, or shrubs, or turn soaker hoses upside-down so the holes are on the bottom. This will help avoid evaporation.
7. Forget about watering the streets or walks or driveways. They will never grow a thing.



### **RAINWATER HARVESTING**

Why waste tap water watering plants when rainwater works better? All you have to do is harvest it! Rainwater harvesting is capturing and storing rainfall to irrigate plants and animals. All you need for harvesting is a good rainstorm and something to collect it in. Your system can be simple, using contoured areas so that water flows directly to plants; or sophisticated, featuring storage systems that can contain captured water for later use, such as rain barrels.

## ADDITIONAL RESOURCES

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### Addresses:

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

◆ Children's Alliance for Protection of the Environment  
P.O. Box 307  
Austin, Texas 78767

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

◆ Environmental Action Foundation  
6930 Carroll Avenue  
Takoma Park, MD 20912  
(301)891-1100

◆ 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](http://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 Natural Resource Conservation Commission (TNRCC)  
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>

◆ Texas State Soil & Water Conservation Board  
311 North 5<sup>th</sup> 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

**Web Pages:**

◆ Educating Young People About Water  
<http://www.uwex.edu/erc/ywc/>

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

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

◆ Groundwater Education  
<http://gwrp.cciw.ca/education/index.html>

◆ Nature Conservancy  
<http://www.tnc.org/>

◆ San Antonio Water System  
<http://www.saws.org/>

◆ Surf Your Watershed (EPA)  
<http://www.epa.gov/surf/>

◆ 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/>

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