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.

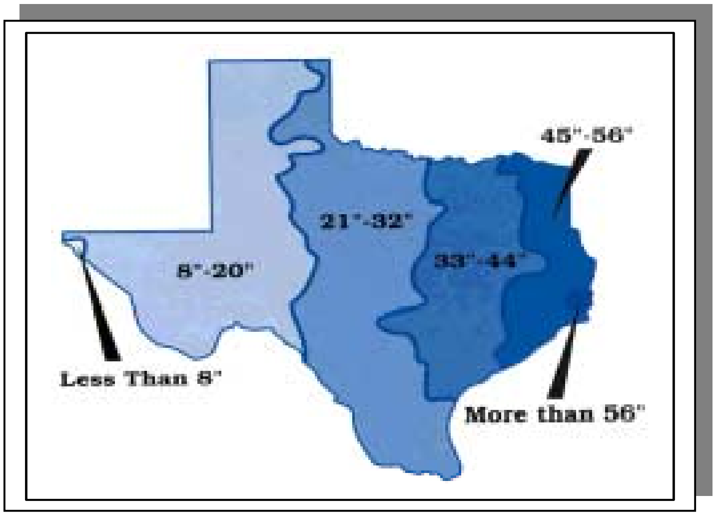
The southern two-thirds of the county is a nearly level or undulating plain sloping upward from the southeast to the northwest and rising from about 500 feet to 1,000 feet in elevation. The northern third lies directly over the Balconies Fault Line and has been dissected by streams. It is strongly sloping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

Sprawling across the county is the 8th 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 tour down the Pecos River Canyon.



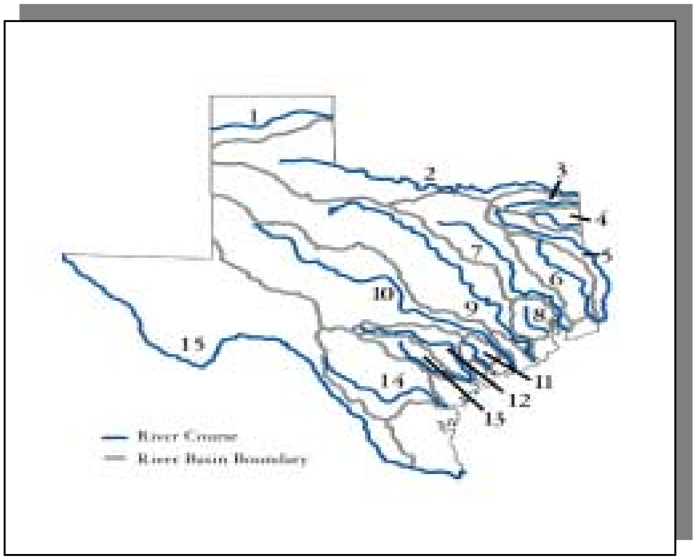
Average Annual Rainfall in Texas

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!).

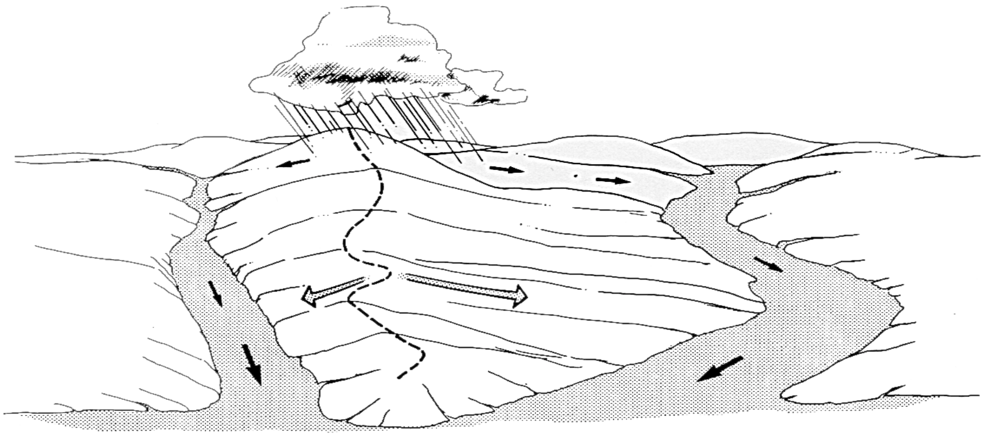
Some definitions of runoff:
(1) That part of the precipitation, snowmelt, or irrigation water that appears in uncontrolled surface streams, rivers, drains or sewers. Runoff may be classified according to speed of appearance after rainfall or melting snow as direct runoff or base runoff, and according 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.



Watershed

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

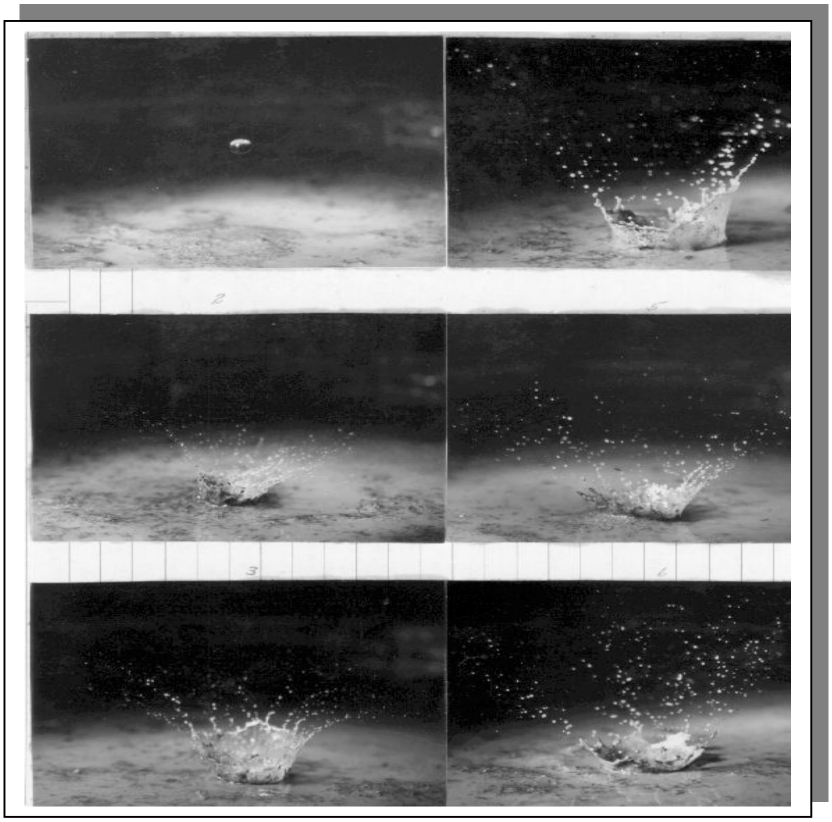
Rivers have great power to shape the land. Once rock has been broken up by weathering, the small pieces can be moved by water, ice, wind or gravity. The totality of forces that carry rocks and earth away is called erosion. In Bexar County, the erosion caused by flowing water has formed many of the area's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



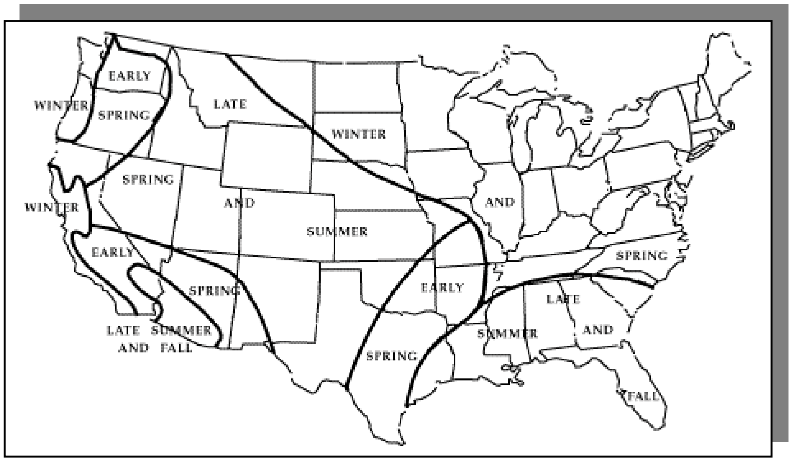
FLOODS AND FLOOD PLAINS

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

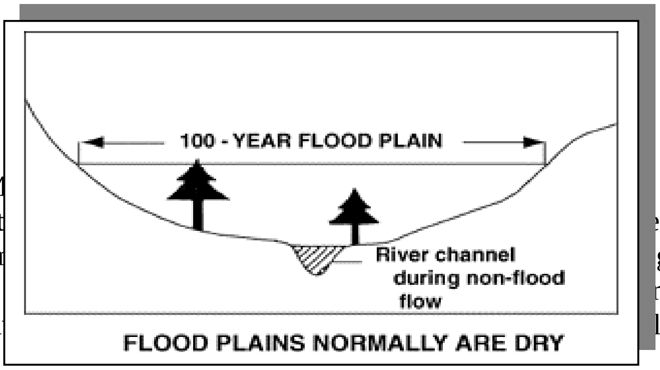
Floods can occur at any time, but weather patterns have a strong influence on when and where floods happen. Cyclones, or storms that bring moisture inland from the ocean, can cause floods in the winter and early spring in the western United States. Thunderstorms are relatively small but intense storms 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.



FLOOD PLAINS NORMALLY ARE DRY

ZONING RESTRICTIONS CAN LIM

Flood-plain zoning, which places rest the
cost of flood damage. Local governm g or
development on flood plains to limit rs in
areas that adopt local ordinances or la lood

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

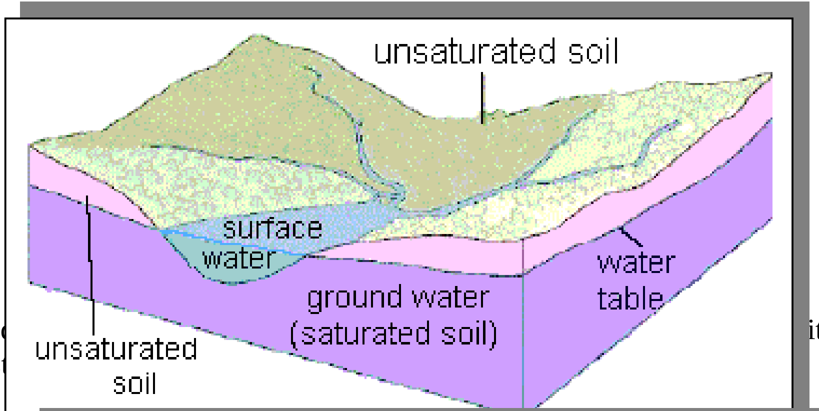
THE CONCRETE JUNGLE

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.



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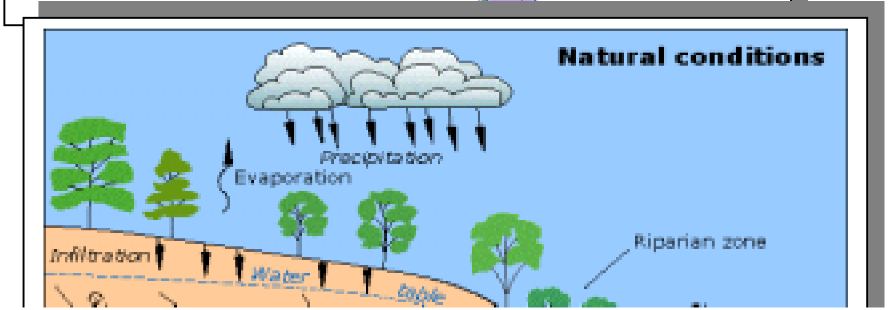
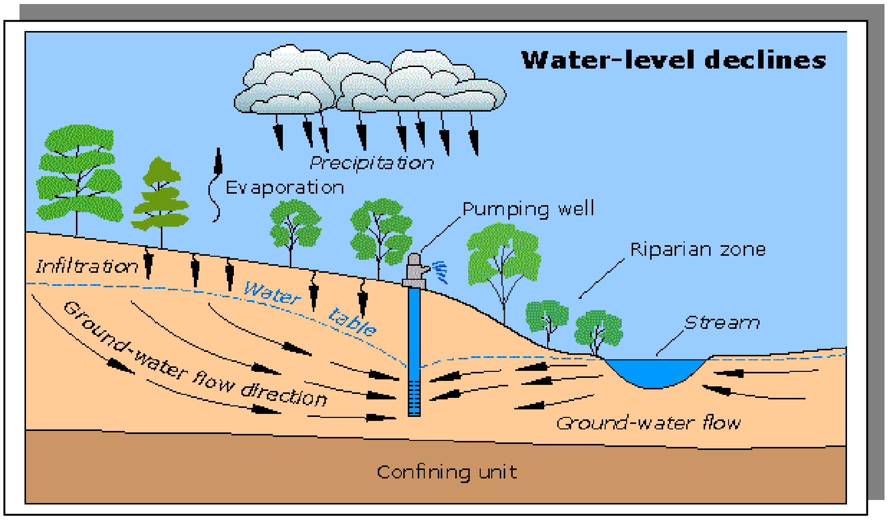
then flows to the st

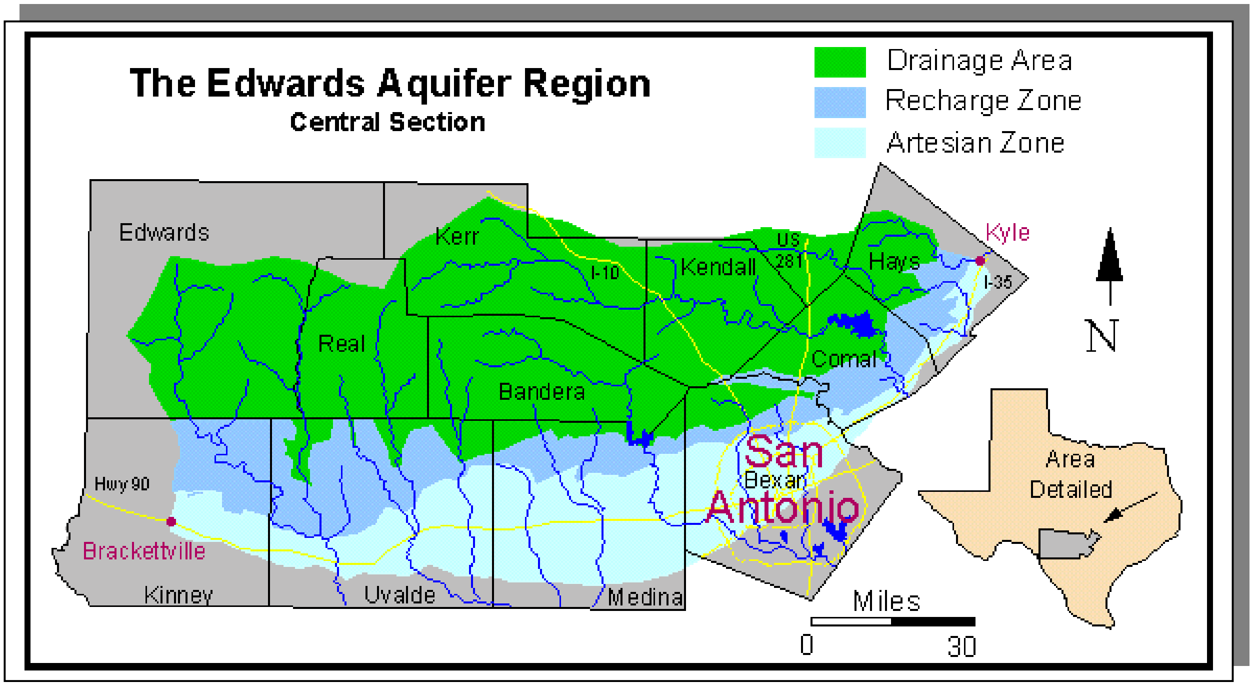


Water pumped from the ground-water system causes the water table to lower and alters the direction of ground-water movement. Some water that flowed to the stream no longer does so and some water may be drawn in from the stream into the ground-water system, thereby reducing the amount of stream flow.

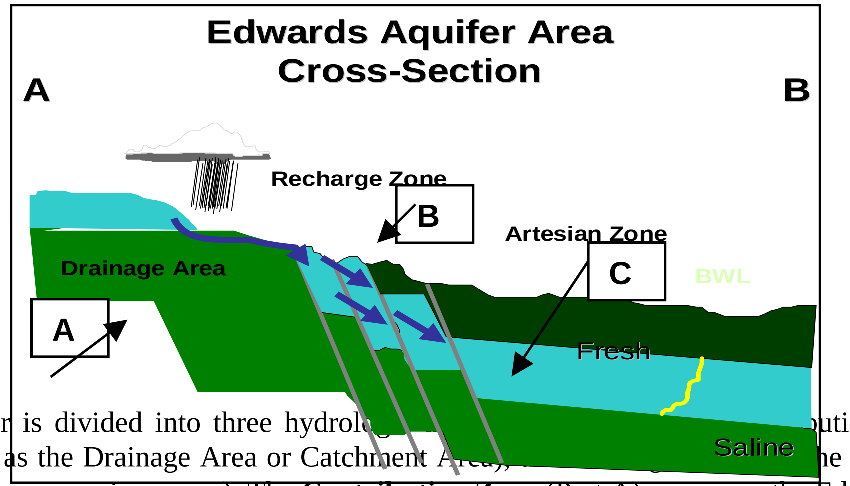


THE EDWARDS AQUIFER: OUR LOCAL GROUNDWATER STORY

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.



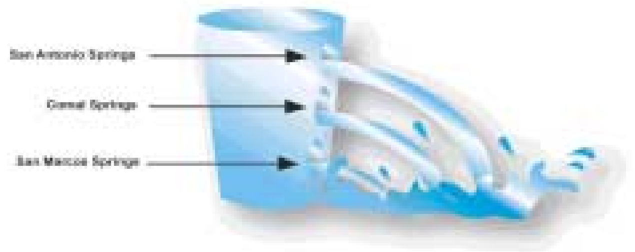
The aquifer is divided into three hydrol[illegible]uting Zone (also referred to as the Drainage Area or Catchment Area), [illegible]he Artesian Zone (see graphic on previous page). The **Contributing Zone** (Part A) occurs on the Edwards Plateau, also called the Texas Hill Country. When it rains over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

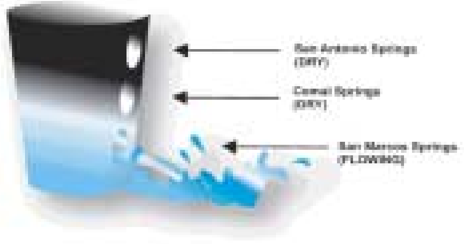
Once the rainwater reaches the **Recharge Zone** (Part B), it flows over fractured limestone forcing the water to flow underground and down into the aquifer. Approximately 80% of aquifer recharge is through a sinking stream.

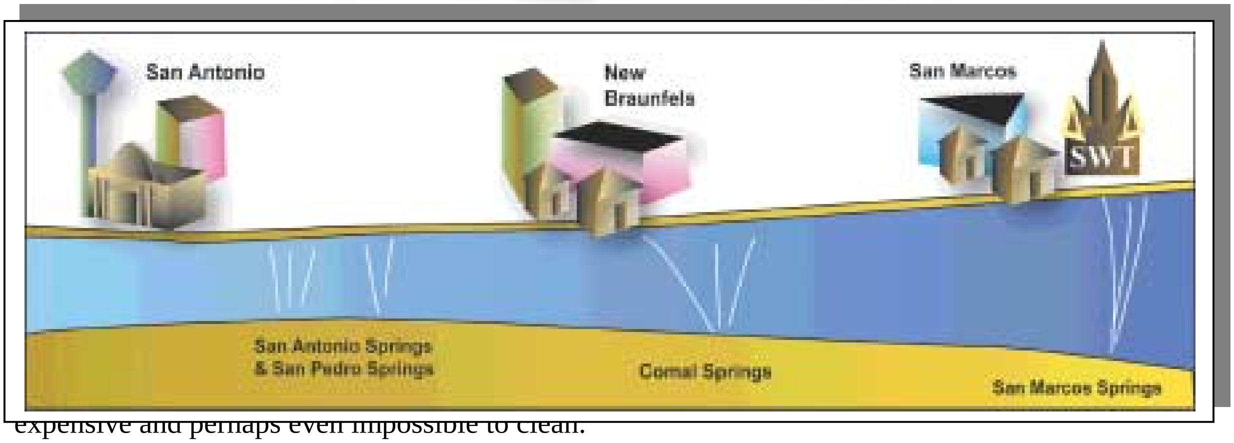
Now the water is in the **Artesian Zone** (Part C) where it is confined underground by "waterproof" layers of rock above and below the water. Because the water is confined in this zone, it is under pressure. If a well is drilled into the aquifer here, the water will rise up in the well. If the pressure 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.







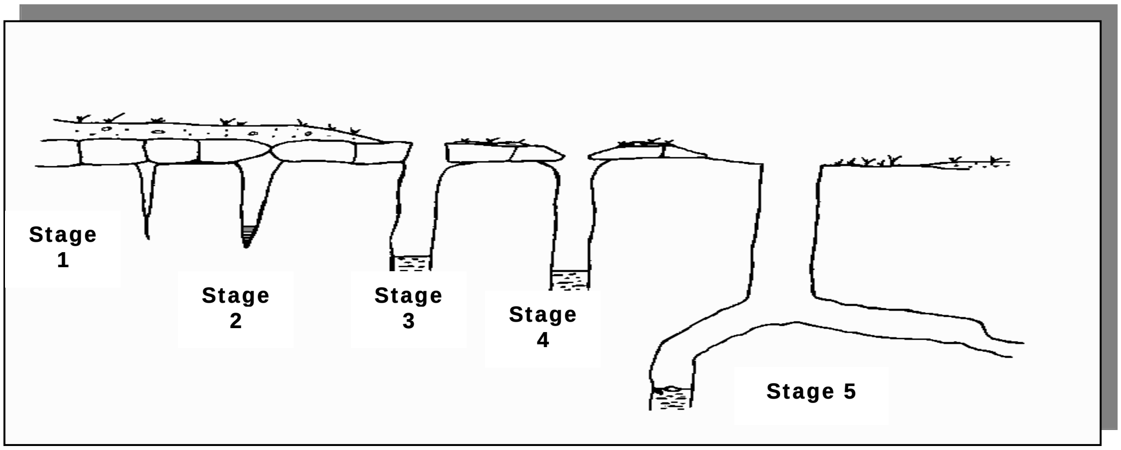
expensive and perhaps even impossible to clean.

AN EDWARDS AQUIFER CAVE

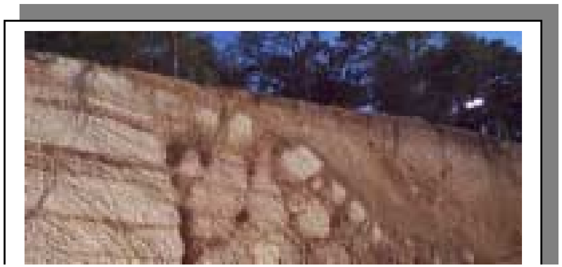
It takes water and stone to make a cave. Limestone is the prevalent rock in Edward's Aquifer caves. Caves start as cracked limestone rock exposed at the surface of the Earth. Weathering of the Earth's surface causes the cracks to widen allowing water to seep into the cracks when it rains. Small traces 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



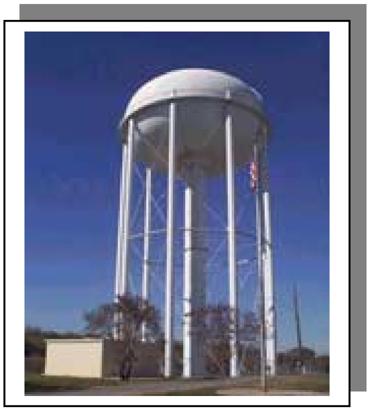
Over the Recharge Zone, water enters caves in a number of ways. In addition to directly flowing down large sinkholes, a stream or creek may cross a permeable layer of limestone and then disappear underground. This is called a sinking stream. Water also seeps down through the ground when it rains. After 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.

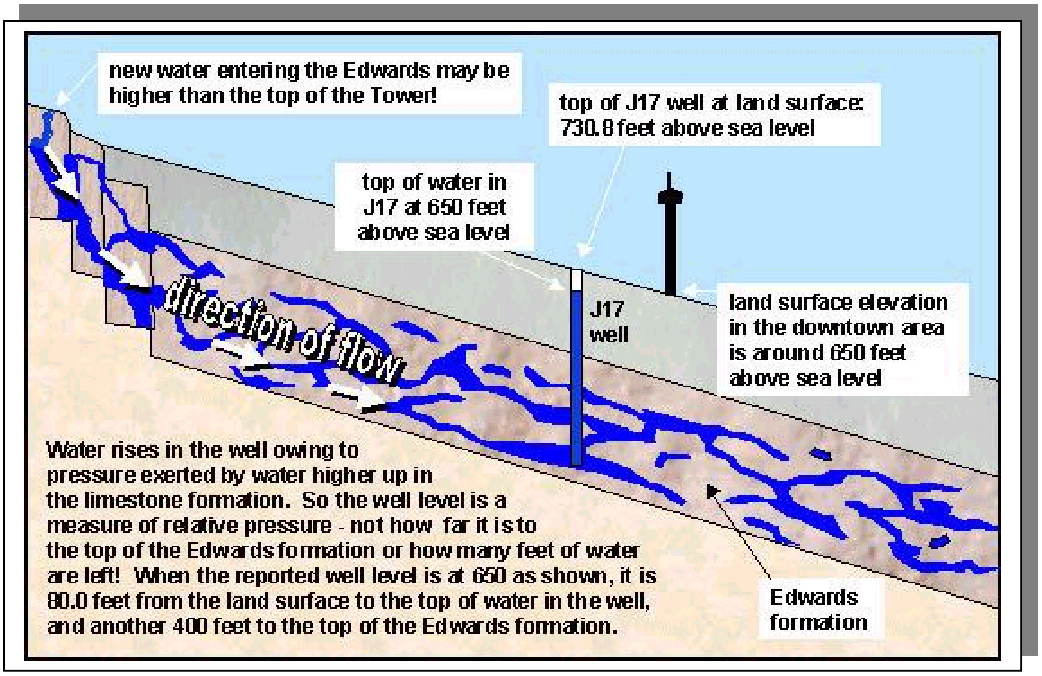
MEASURING THE EDWARDS AQUIFER

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.



Water rises in the well owing to pressure exerted by water higher up in the limestone formation. So the well level is a measure of relative pressure - not how far it is to the top of the Edwards formation or how many feet of water are left! When the reported well level is at 650 as shown, it is 80.0 feet from the land surface to the top of water in the well, and another 400 feet to the top of the Edwards 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.