CAWCC REPORT

ADDRESSES DRAWDOWN AND SUBSIDANCE ISSUES FOR 10 WELL FIELD DRILLING PROGRAM IN Austin and Waller County

BY

Hubert Yoist

March 22, 2013

Table of contents

List of Illustrations

Executive Summary/Concerns

Electro Purification LLC filed an application for authorization for the completion of ten (10) new wells for production of groundwater with the Bluebonnet Groundwater Conversation District (BGCD). The wells will be a maximum of twenty-million gallons per day or approximately 22,500 acre-feet per annum. The produced water is to be used within the District and transported out-of-district transport to Fort Bend County, Texas. The metropolitan areas of Richmond-Rosenberg are to be the principle users of the water.

The wells, twenty (20) inches in diameter and drilled to a depth of approximately 1500 feet with casing to a least 700 feet. The wells completed in the Evangeline aquifer.

The approximately 300 landowners and 11 landowners with wells have been or are beings noticed by certified mail, in accordance with BGCD Rules 8.5 (A)(1)(K) and 8.5(D)(!).

Notice of application was published February 14, 2013 in the Brookshire and Sealy newspapers. From the date of publication, affected parties have twenty (20) day to request a hearing. BGCD Rule 14.14D. Refer to the BGCD Austin County public Briefing 19023_wrh.pdf for the complete time line for approval of the Electro Purification LLC application.

Electro Purification LLC indicates that there will be not effect the Aquifers in the areas of the wells and there is no measurable reduction in pressure and levels. The project will provide BGCD with resources to monitor the aquifer and Electro Purification LLC water project will always be subject to the rules and regulations of the BGCD.

The Electro Purification LLC study did not note increases in population in the presentation of February 25, 2013. Walker County has experienced a 10 % increase in population as of the 2010 census. The census for 1990 and 2000 the increase was over 20 %. Grimes County has experienced a 13 % increase in population as of the 2010 census. The census for 1990 and 2000 saw an increase over 25 %. Waller County has experienced a 32 % increase in population as of the 2010 census. The census for 1990 report an increase of 18 % and the census of 2000 saw an increase over 39 %. Austin County saw a 20% increase in population as of the 2010 census. The census for 1990 and 2000 reported an increase of 12 % and 19% respectively. Fort Bend County has experienced a 65% increase in population as of the 2010 census. The census for 1990 report an increase of 72 % and the census of 2000 saw an increase over 65 %.

As of 2010, the total population of Richmond is 11,679, which is 5.40% more than it was in 2000. The population growth rate is much lower than the state average rate of 20.59% and is lower than the national average rate of 9.71%. The total population of Rosenberg is 30,618, which is 27.35% more than it was in 2000. The population growth rate is much higher than the state average rate of 20.59% and is much higher than the national average rate of 9.71%.

Total groundwater pumpage Sub-Area R/R (Richmond/Rosenberg) was 10.5mgd for 2011; a 41% increase from 2010.

State Climatologist John-Nielsen Gammon has warned that Texas could be in the midst of a drought worse than the drought of record. In 2011, the months from March through May, and then June through August all set records for low rainfall. The high temperatures over the summer months increased evaporation, further lowering river, and lake levels.

2011 was the driest year ever for Texas, with an average of only 14.8 inches of rain. The only comparable drought occurred during the drought of record during the 1950s, but no single year during that drought was as dry as 2011.

The drought began in October 2010 and continued through 2011. However, conditions had improved in the winter and spring of 2012, by the fall of 2012 dry conditions had returned too much of the state.

As of January 29, 2013, 90 percent of Texas is in some form of drought conditions, and the state's reservoirs are only 66 percent full. Nearly 7 percent of the state is in "exceptional" drought, the worst stage. Compare that to the peak of the drought, when 88 percent of Texas was in the "exceptional" stage.

The year 2011 was the worst one-year drought on record. Texas normally receives an average of 29 inches of rainfall in twelve months. The first twelve months of the drought, from October 2010 through September 2011, featured an average of 11.36 inches, a record low. The year 2012 was better by comparison but still about five inches below normal. Over the combined past two years, the state received only 68% of its normal precipitation. The data from the Texas Water Development Board indicates that total reservoir storage statewide is at its lowest for this time of year since at least 1990 when the current suite of reservoirs was largely in place, and probably earlier. In addition to the lack of rainfall, both of the past two years featured exceptionally high temperatures, among the three warmest years on record. The warm temperatures contribute to drought severity by enhancing evaporation from soil, from streams, and from reservoirs.

Currently, the drought has left the Brazos River Authority reservoir system at about 79 percent of its capacity and under "Drought Watch" status. The seasonal Drought predictions for the May 31 2013 indicate a continuing drought with a potential to intensify.

The USGS report of 2012 indicates widespread water level declines over the 1 year and 5 year study period. The water level changes in the aquifers are attributed to the increased groundwater withdrawals due to drought conditions. Some 1-year water levels decline between 20 and 50 feet.

In the Chicot, aquifer has seen more declines than rises at the monitored wells sites. Declines in this aquifer are for the most part limited to the east of Grimes and Waller counties. The declines at monitored well in these counties are in the ranges 1 to 10 feet for periods from 1977 to 2012.

The Evangeline Aquifer has seen more declines than rises at the monitored wells sites. Declines in this aquifer are in the east of Grimes and Waller counties. One point indicated a more that 50 foot decline and other reporting a decline of 11 to 20 feet.

The Jasper Aquifer has seen more declines than rises at the monitored wells sites. Declines in this aquifer are in the western and central Grimes County and southern Walker County. Several points in Grimes indicate a 21 to 50 foot decline and other reported declines of 11 to 20 feet. Water levels reported from 2000 to 2012 in the southeastern Grimes and northeastern Waller Counties have shown to 20 to 80 feet.

.

Introduction

In November of 2012, Electro Purification LLC filed an application for authorization to drill, operate, and aggregate ten (10) new wells for production of groundwater with the Bluebonnet Groundwater Conversation District (BGCD). Production from the wells will be a maximum of twenty-million gallons per day or approximately 22,500 acre-feet per annum the applicant intends to apply the produced water to beneficial use for municipal and industrial purposes within the District.

The application included authorization for out-of-district transport of groundwater for beneficial municipal use in Fort Bend County, Texas. The metropolitan areas of Richmond-Rosenberg are to be the principle users of the water.

Each of the wells would be twenty (20) inches in diameter and drilled to a depth of approximately 1500 feet below the surface with casing to a least 700 feet from the surface down hole. The wells would be completed in the Evangeline aquifer.

Within the half-mile radius of the proposed well sites, there are approximately 300 landowners and 11 landowners with wells. At this time it is undetermined if all of the effected parties have be noticed by certified mail and proof of notification have been received by BGCD in accordance with Rules 8.5 (A)(1)(K) and 8.5(D)(!).

February 14, 2013 was the proposed publication of Notice of application in the Brookshire and Sealy newspapers. From that date affected parties have twenty (20) day to request a hearing. Rule 14.14D

March 6, 2013 was the close of the comments and request for hearing by the public. As the public hearing in Austin County was held on February 25, 2013, that gave just six (6) working days for those of us who are not directly affected to request a hearing. Rule 14.14F(1) &(2) and the Presiding Officer determine who is or is not directly affected.

March 18, 2013, soonest weekday for scheduling of hearing, after the twenty (20) day comment period and to provide for the 10-day notice requirement.

Refer to the BGCD Austin County public Briefing 19023_wrh.pdf for the complete time line for approval of the Electro Purification LLC application

Electro Purification LLC presentation the Austin and Waller Counties on February 25, 2013 indicates that there will be not effect the Aquifers in the areas of the well and there is no measurable reduction in pressure and levels. The project will provide BGCD with resources to monitor the aquifer and Electro Purification LLC water project will always be subject to the rules and regulations of the BGCD.

Bluebonnet Groundwater Conversation District

Bluebonnet GCD encompasses Austin, Waller, Grimes, and Walker Counties. The district is fee-based; operating on production fees from approved permit applications, and does not collect a tax.

Special Laws of Texas
<u>Boundaries</u>: All of Austin, Grimes, Walker, and Waller Counties
<u>Aquifers</u>: *Primary Aquifer*: Gulf Coast; *Northern Parts of Grimes and Walker Counties*: Carrizo-Wilcox, Yegua-Jackson, Queen City, and Sparta Aquifers, and five river alluviums: Brazos, Navasota, San Bernard, San Jacinto, and Trinity
<u>Board members</u>: 16 appointed board members; one representing municipal, agriculture, industrial, and rural water supply interests from each county
<u>Meetings</u>: Quarterly on the 3rd Wednesday of January, April, July, and October at 6:00 PM in the district's board room at 303 E. Washington Ave., Suite B & C in Navasota, Texas
<u>Largest water users</u>: Public and rural water supplies and agriculture
<u>Regulation Methods</u>: Fee-based, permitted regulation
<u>Permitting</u>: The district registers all wells within the district. Beneficial use that is not domestic, agriculture, or related to Railroad Commission drilling or mining are considered to be non-exempt. Non-exempt wells must be permitted and require submission of monthly production reports. Large wells (capable of producing more than 7,000,000 gallons/year) are required to complete a hydro-geologic study. This study serves to advance the district's science-based knowledge of the aquifer and resources and demonstrates the influence of the well on its surroundings and availability of water.

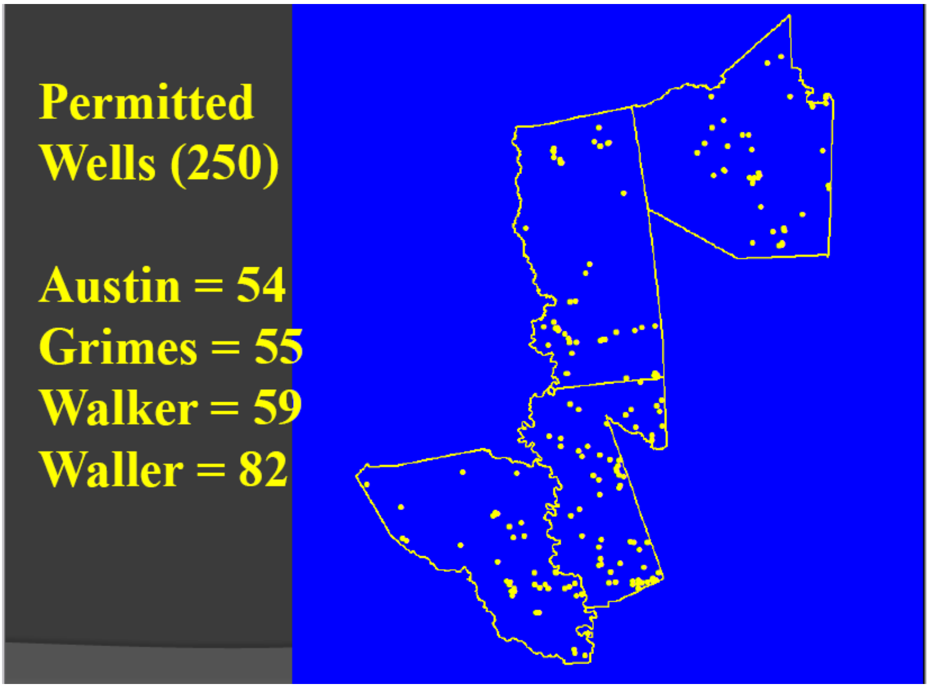
Board Meetings

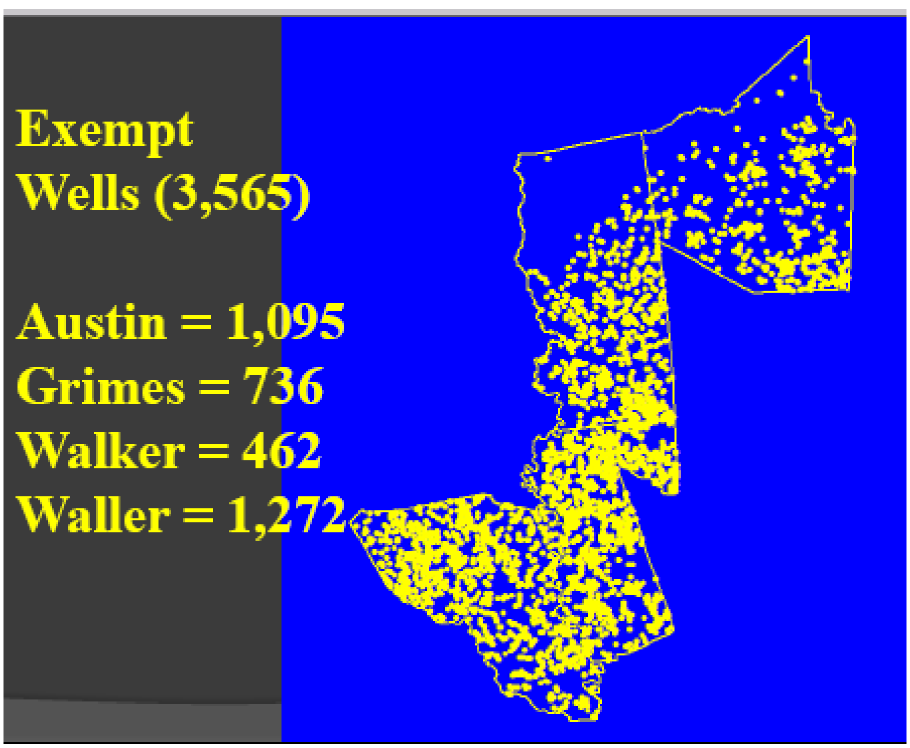
The District Board of Directors holds regular meetings quarterly in January, April, July, and October. The board holds special meetings as necessary at the call of the President or by request of three Directors. Regular meetings are held on the third Wednesday of the month at 6:00 PM. Regular meetings are currently held in the District Board Room, Suites B & C, 303 East Washington Ave., Navasota, TX. Special meetings may be held at a time and place designated in the call for the meeting.

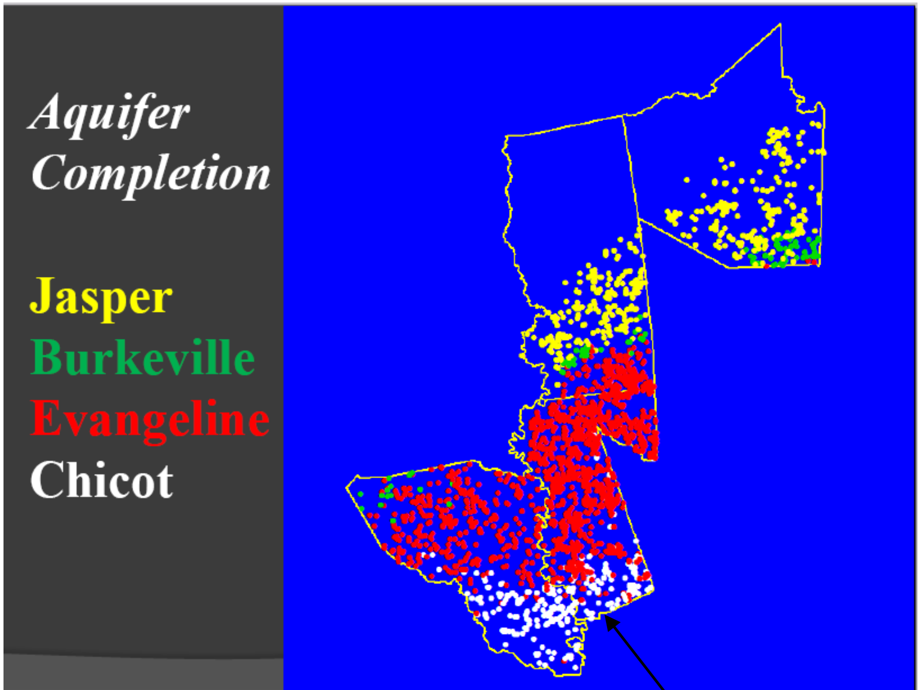
Board of Directors

Name	District Position	Representing Interests
Directors Representing Austin County		
Milton Beckendorff	Vice President	Agricultural Interests
Michael Blezinger	Director	Rural Water Interests
Current Term Expires January, 2014		
Sharon Brandes	Director	Industrial Interests
Glenn Huebner	Director	Municipal Interests
Directors Representing Grimes County		
J. Jared Patout	President	Industrial Interests
William P Thomas	Director	Agricultural Interests
Jim Ward	Director	Municipal Interests
Bobby Brown	Director	Rural Water Interests
Current Term Expires January, 2016		
Directors Representing Walker County		
Carol Reed	Director	Municipal Interests
James Morrison	Director	Rural Water Interests
Current Term Expires January, 2014		
Joe B Sandel	Secretary	Agricultural Interests
Jack Olsta	Director	Industrial Interests
Directors Representing Waller County		
David Minze	Vice President	Municipal Interests
David Groschke	Director	Agricultural Interests
Current Term Expires January, 2016		
Jim Vaughn	Director	Industrial Interests
Brent Davis	Director	Rural Water Interests
Current Term Expires January, 2016		

Permitted and Exempt well locations in Bluebonnet Water Conversation District







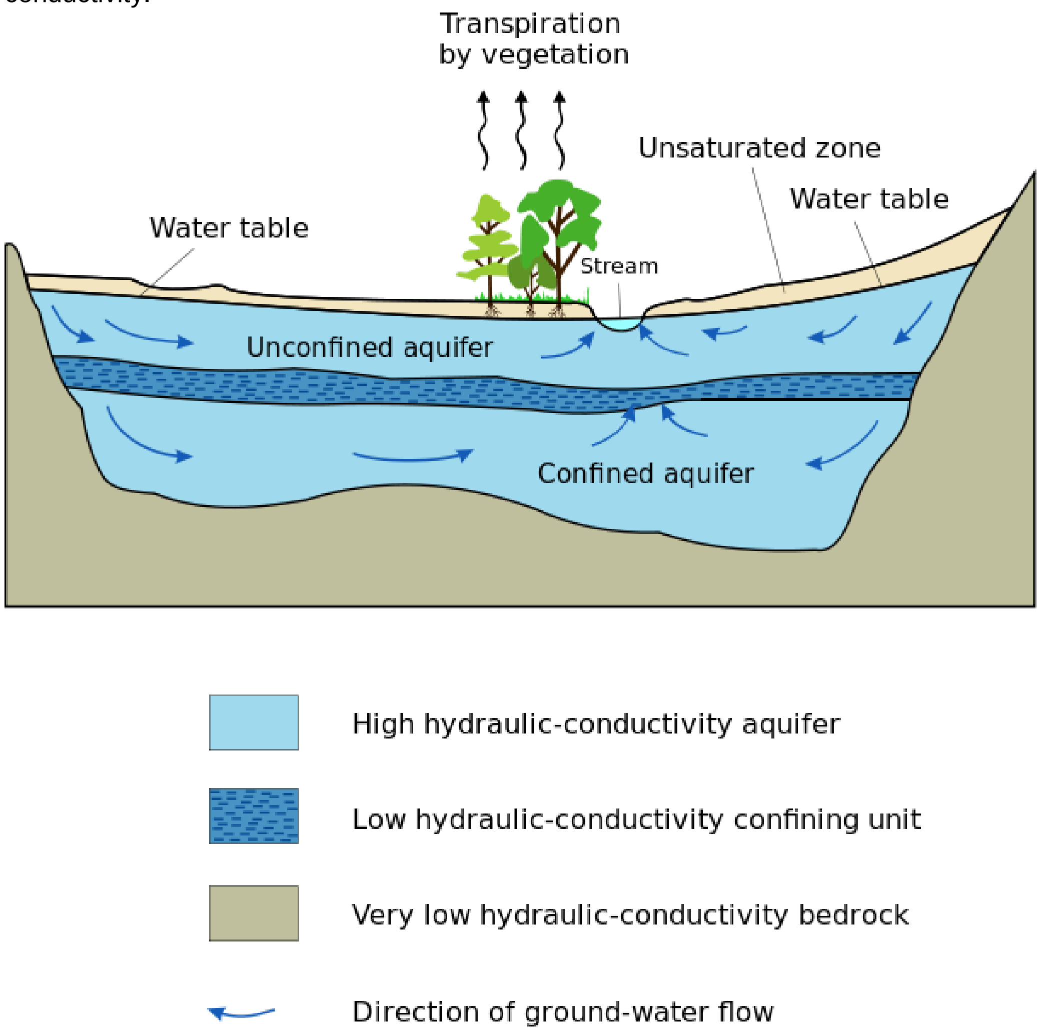
AQUIFER

An **aquifer** is an underground layer of water-bearing permeable rock or unconsolidated materials (gravel, sand, or silt) from which groundwater can be extracted using a water well. The study of water flow in aquifers and the characterization of aquifers are called hydrogeology. Related terms include **aquitard**, which is a bed of low permeability along an aquifer, and **aquiclude** (or aquifuge), which is a solid, impermeable area underlying or overlying an aquifer. If the impermeable area overlies the aquifer, pressure could cause it to become a confined aquifer.

Aquifers may occur at various depths. Those closer to the surface are not only more likely to be used for water supply and irrigation, but are also more likely to be topped up by the local rainfall.

Classification

The below diagram indicates typical flow directions in a cross-sectional view of a simple confined or unconfined aquifer system. The system shows two aquifers with one aquitard (a confining or impermeable layer) between them, surrounded by the bedrock aquiclude, which is in contact with a gaining stream (typical in humid regions). The water table and unsaturated zone are also illustrated. An aquitard is a zone within the earth that restricts the flow of groundwater from one aquifer to another. An aquitard can sometimes, if impermeable, be called an aquiclude or aquifuge. Aquitards are composed of layers of either clay or non-porous rock with low hydraulic conductivity.



.

Saturated versus unsaturated

Groundwater can be found at nearly every point in the Earth's shallow subsurface, to some degree; although aquifers do not necessarily contain fresh water. The Earth's crust can be divided into two regions: the *saturated zone* or *phreatic zone* (e.g., aquifers, aquitards, etc.), where all available spaces are filled with water, and the *unsaturated zone* (also called the vadose zone), where there are still pockets of air with some water, but can be filled with more water.

Saturated means the pressure head of the water is greater than atmospheric pressure (it has a gauge pressure > 0). The definition of the water table is surface where the pressure head is equal to atmospheric pressure (where gauge pressure = 0).

Unsaturated conditions occur above the water table where the pressure head is negative (absolute pressure can never be negative, but gauge pressure can) and the water that incompletely fills the pores of the aquifer material is under suction. The water content in the unsaturated zone is held in place by surface adhesive forces and it rises above the water table (the zero gauge pressure isobar[disambiguation needed]) by capillary action to saturate a small zone above the phreatic surface (the capillary fringe) at less than atmospheric pressure. This is termed tension saturation and is not the same as saturation on a water content basis. Water content in a capillary fringe decreases with increasing distance from the phreatic surface. The capillary head depends on soil pore size. In sandy soils with larger pores, the head will be less than in clay soils with very small pores. The normal capillary rise in a clayey soil is less than 1.80 m (six feet) but can range between 0.3 and 10 m (1 and 30 ft).[2]

The capillary rise of water in a small diameter tube is this same physical process. The water table is the level to which water will rise in a large-diameter pipe (e.g., a well) that goes down into the aquifer and is open to the atmosphere.

Confined versus unconfined

There are two end members in the spectrum of types of aquifers; *confined* and *unconfined* (with semi-confined being in between). **Unconfined** aquifers are sometimes also called *water table* or *phreatic* aquifers, because their upper boundary is the water table or phreatic surface. (See Biscayne Aquifer.) Typically (but not always) the shallowest aquifer at a given location is unconfined, meaning it does not have a confining layer (an aquitard or aquiclude) between it and the surface. The term "perched" refers to ground water accumulating above a low-permeability unit or strata, such as a clay layer. This term is generally used to refer to a small local area of ground water that occurs at an elevation higher than a regionally extensive aquifer. The difference between perched and unconfined aquifers is their size (perched is smaller).

If the distinction between confined and unconfined is not clear geologically (i.e., if it is not known if a clear confining layer exists, or if the geology is more complex, e.g., a fractured bedrock aquifer), the value of storativity returned from an aquifer test can be used to determine it (although aquifer tests in unconfined aquifers should be interpreted differently than confined ones). Confined aquifers have very low storativity values (much less than 0.01, and as little as 10^{-5}), which means that the aquifer is storing water using the mechanisms of aquifer matrix expansion and the compressibility of water, which typically are both quite small quantities. Unconfined aquifers have storativities (typically then called specific yield) greater than 0.01 (1% of bulk volume); they release water from storage by the mechanism of actually draining the pores of the aquifer, releasing relatively large amounts of water (up to the drainable porosity of the aquifer material, or the minimum volumetric water content).

Isotropic versus anisotropic

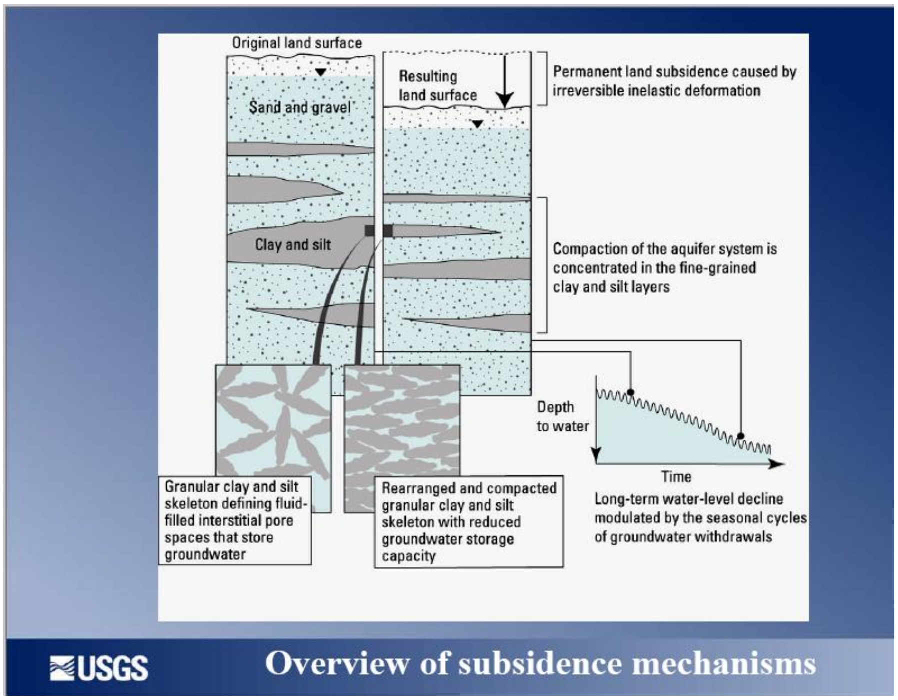
In isotropic aquifers or aquifer layers the hydraulic conductivity (K) is equal for flow in all directions, while in anisotropic conditions it differs, notably in horizontal (Kh) and vertical (Kv) sense.

Semi-confined aquifers with one or more aquitards work as an anisotropic system, even when the separate layers are isotropic, because the compound Kh and Kv values are different (see hydraulic transmissivity and hydraulic resistance).

When calculating flow to drains [3] or flow to wells [4] in an aquifer, the anisotropy is to be taken into account lest the resulting design of the drainage system may be faulty.

Subsidence

In unconsolidated aquifers, groundwater is produced from pore spaces between particles of gravel, sand, and silt. If the aquifer is confined by low-permeability layers, the reduced water pressure in the sand and gravel causes slow drainage of water from the adjoining confining layers. If these confining layers are composed of compressible silt or clay, the loss of water to the aquifer reduces the water pressure in the confining layer, causing it to compress from the weight of overlying geologic materials. In severe cases, this compression can be observed on the ground surface as subsidence. Unfortunately, much of the subsidence from groundwater extraction is permanent (elastic rebound is small). Thus, the subsidence is not only permanent, but the compressed aquifer has a permanently reduced capacity to hold water.



Examples

The Ogallala Aquifer of the central United States is one of the world's great aquifers, but in places it is being rapidly depleted by growing municipal use, and continuing agricultural use. This huge aquifer, which underlies portions of eight states, contains primarily fossil water from the time of the last glaciation. Annual recharge, in the more arid parts of the aquifer, is estimated to total only about 10 percent of annual withdrawals.

An example of a significant and sustainable carbonate aquifer is the Edwards Aquifer[10] in central Texas. This carbonate aquifer has historically been providing high quality water for nearly 2 million people, and even today, is full because of tremendous recharge from a number of area streams, rivers and lakes. The primary risk to this resource is human development over the recharge areas.

GULF COAST AQUIFER

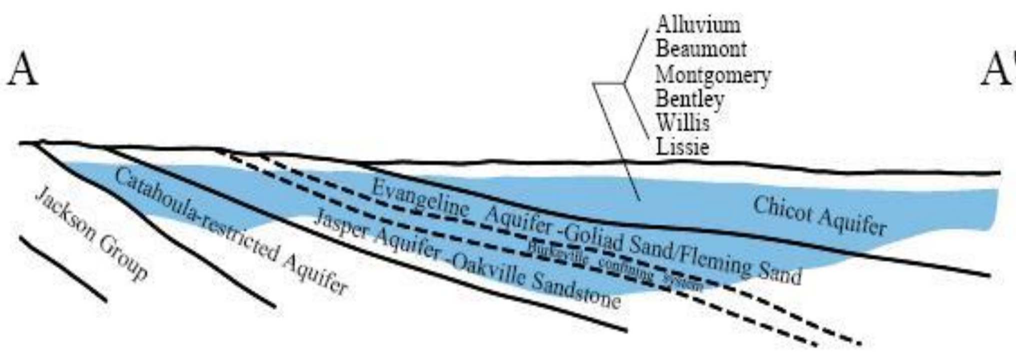
The Gulf Coast aquifer forms a wide belt along the Gulf of Mexico from Florida to Mexico. In Texas, the aquifer provides water to all or parts of 54 counties and extends from the Rio Grande northeastward to the Louisiana-Texas border. Municipal and irrigation uses account for 90 percent of the total pumpage from the aquifer. The Greater Houston metropolitan area is the largest municipal user, where well yields average about 1,600 gal/min.

The Gulf Coast region tapped surface and groundwater sources for 2,352,592 acre-feet of water in 2006, as estimated by the Texas Water Development Board (TWDB) using the most recent data available. (An acre-foot is the amount needed to cover an acre of land with a foot of water, or 325,851 gallons, about the annual consumption of two to three Texas households.

The aquifer consists of complex interbedded clays, silts, sands, and gravels of Cenozoic age, which are hydrologically connected to form a large, leaky artesian aquifer system. This system comprises four major components consisting of the following generally recognized water-producing formations. The deepest is the Catahoula, which contains ground water near the outcrop in relatively restricted sand layers. Above the Catahoula is the Jasper aquifer, primarily contained within the Oakville Sandstone. The Burkeville confining layer separates the Jasper from the overlying Evangeline aquifer, which is contained within the Fleming and Goliad sands. The Chicot aquifer, or upper component of the Gulf Coast aquifer system consists of the Lissie, Willis, Bentley, Montgomery, and Beaumont formations, and overlying alluvial deposits. Not all formations are present throughout the system, and nomenclature often differs from one end of the system to the other. Maximum total sand thickness ranges from 700 feet in the south to 1,300 feet in the northern extent.

Water quality is generally good in the shallower portion of the aquifer. Ground water containing less than 500 mg/l dissolved solids is usually encountered to a maximum depth of 3,200 feet in the aquifer from the San Antonio River Basin northeastward to Louisiana. From the San Antonio River Basin southwestward to Mexico, quality deterioration is evident in the form of increased chloride concentration and saltwater encroachment along the coast. Little of this ground water is suitable for prolonged irrigation due to either high salinity or alkalinity, or both. In several areas at or near the coast, including Galveston Island and the central and southern parts of Orange County, heavy municipal or industrial pumpage had previously caused an updip migration, or saltwater intrusion, of poor-quality water into the aquifer. Recent reductions in pumpage here have resulted in a stabilization and, in some cases, even improvement of ground-water quality.

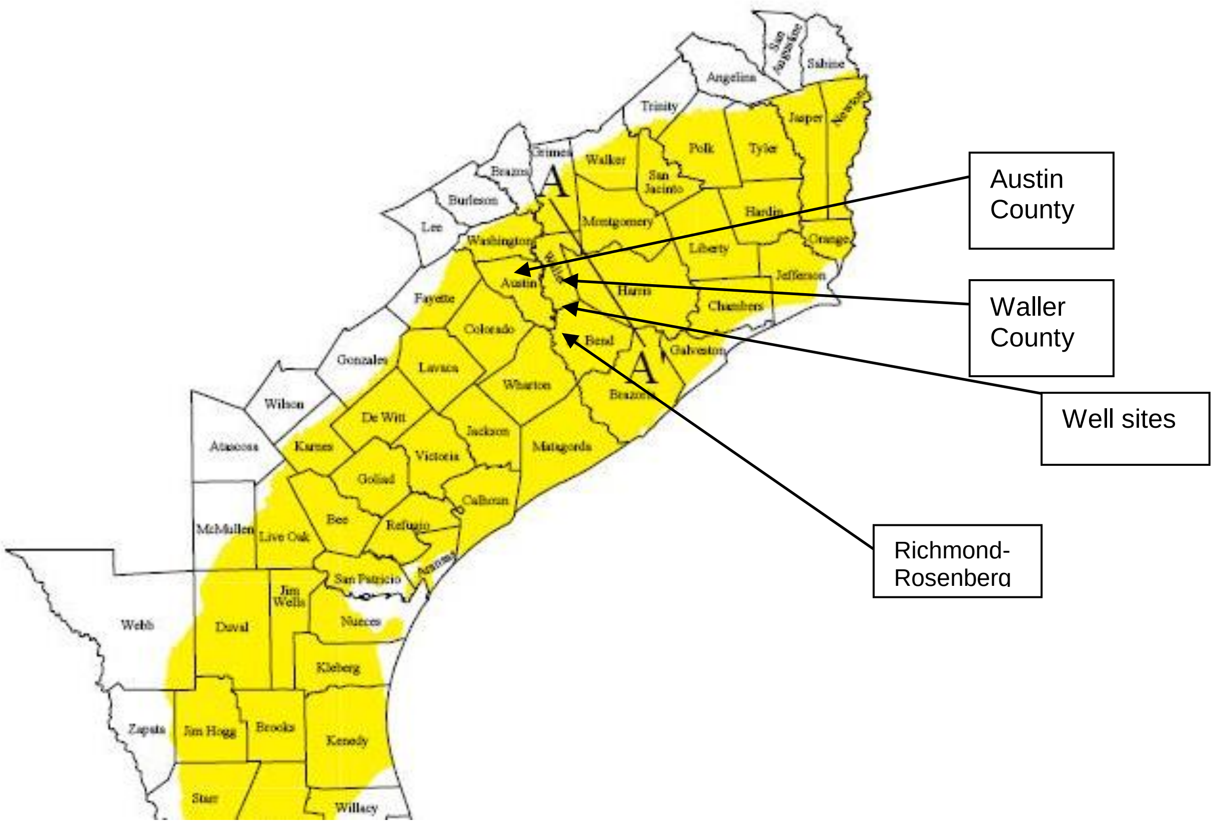
Years of heavy pumpage for municipal and manufacturing use in portions of the aquifer have resulted in areas of significant water-level decline. Declines of 200 feet to 300 feet have been measured in some areas of eastern and southeastern Harris and northern Galveston counties. Other areas of significant water-level declines include the Kingsville area in Kleberg County and portions of Jefferson, Orange, and Wharton counties. Some of these declines have resulted in compaction of dewatered clays and significant land surface subsidence. Subsidence is generally less than 0.5 foot over most of the Texas coast, but has been as much as nine feet in Harris and surrounding counties. As a result, structural damage and flooding have occurred in many low-lying areas along Galveston Bay in Baytown, Texas City, and Houston. Conversion to surface-water use in many of the problem areas has reversed the decline trend.



Major components of the Gulf Coast Aquifer (Ashworth, 1995).

Geologic Setting

The aquifer is a large, leaky artesian aquifer system. The system is a complex of interbedded clays, silts, sands, and gravels. It is subdivided into four major components. The uppermost and easternmost component, the Chicot Aquifer, consists of alluvial deposits and low permeable clay layers with some interbedding sands. The next component is the Evangeline Aquifer. This layer includes two prominent sand formations, making it more permeable than the Chicot. The Burkeville confining system separates the Evangeline from the next component, the Jasper Aquifer. This formation is mostly impermeable due to the presence of the Oakville Sandstone. Below the Jasper is the Catahoula, a layer containing restricted sand layers. The maximum total sand thickness reaches 700 feet in the south and 1,300 feet in the northeast (Ashworth, 1995).



Groundwater

Most of the groundwater for the aquifer is used for irrigation and municipal purposes. The chart on the right illustrates the high usage. The demand is even higher a decade later with over 90% used for irrigation and city water supplies (Ashworth, 1995). The continuous growth of the Houston area keeps the need for municipal water on the rise. The predominate crops in the region are the water intensive crops of cotton and rice.
Typical groundwater composition samples contain more than 95% percent calcium, sodium, potassium, magnesium, bicarbonate, chloride, and sulfate. Total dissolved solids were generally less than 1000 mg/l. Three locations in the Chicot Aquifer contained values higher than 3000 mg/l. These locations had high salinity concentrations (Mace, 2006).

Hydraulic Properties

The geometric average for hydraulic conductivity ranged from 11-98 feet per day for each county in a nine county study of the central coast. The overall average hydraulic conductivity was 19 feet per day. Harris County, the most populous county and home to Houston had a hydraulic conductivity of 27 feet per day. The majority of the pumping tests in this study produced specific capacity values in the range of 6-10 feet per day with a few being higher or lower (Young, 2006). The table below shows values from the Brazos Alluvium in the upper most part of the aquifer (Mace, 2006).

Hydraulic Property	Values Range	Average Value
Transmissivity	50,000-300,000 gallons per day per foot	
Hydraulic conductivity	<1 - 2,400 feet per day	about 290 feet per day
Specific yield	4-35%	about 24%
Well yields	250-500 gallons per minute	
Total dissolved solids	<500 - >3,000 milligrams per liter	

Storativity values between the Chicot Aquifer and the Evangeline Aquifer displayed little variation. The storativity range for Chicot was 10^-4 - 0.2 compared to 4 x 10^-5 -0.2 for the Evangeline (Mace, 2006).

DEFINITIONS

Transmissivity, the rate which groundwater flows horizontally through an aquifer.

Hydraulic conductivity, symbolically represented as K, is a property of vascular plants, soil or rock, that describes the ease with which a fluid (usually water) can move through pore spaces or fractures. It depends on the intrinsic permeability of the material and on the degree of saturation, and on the density and viscosity of the fluid. Saturated hydraulic conductivity, K_{sat}, describes water movement through saturated media.

Specific yield, In an aquifer with a water table (unconfined aquifer), the volume of water released from groundwater storage per unit surface area of aquifer per unit decline in the water table is known as the specific yield, Sy. also known as the drainable porosity. Hydrologists divide water in storage in the ground into the part that will drain under the influence of gravity (called specific yield) and the part that is retained as a film on rock surfaces and in very small openings (called specific retention). The physical forces that control specific retention are the same forces involved in the thickness and moisture content of the capillary, fringe.

Storativity or the **storage coefficient** is the volume of water released from storage per unit decline in hydraulic head in the aquifer, per unit area of the aquifer. Storativity is a dimensionless quantity, and ranges between zero and the effective porosity of the aquifer; although for confined aquifers, this number is usually much less than 0.01. The storativity or storage coefficient of an unconfined aquifer is approximately equal to the specific yield,

Well yield, The volume of water discharged from a well in gallons per minute or cubic meters per day.

Well Recovery Rate, the rate at which water runs into the well from the rock fissures and openings into the lower portion of the well below the steel casing, while pumping water out of the well.

CHICOT AQUIFER

The Chicot aquifer is the uppermost formation and has a greater sand to clay ratio than the Evangeline. Transmissivities range from 90,000 to 500,000 gpd/ft, which are the greatest of the four formations. The Chicot consists of discontinuous layers of sand and clay of about equal thickness,. In addition, in some of the area the system can be separated into upper and a lower unit. The transmissivity of the upper unit is less that that of the lower unit and the upper unit acts as a confining layer to the lower unit. The Chicot has a thickness of about 650 feet.

EVANGELINE AQUIFER

The Evangeline aquifer is composed of the Goliad Sand and the uppermost part of the Fleming Formation above the Burkeville confining layer. In the northern portion of the Evangeline aquifer includes parts of the Willis Sand and younger formations. The aquifer consists mostly of discontinuous layers of sand and clay of about equal total thickness. The Goliad Sand is composed of interbedded layers of clay, sand, sandstone, marl, caliche, and limestone. The uppermost part of the Fleming Formation is composed of calcareous clay and sandstone interspersed with quartz and pebble-sized chert (Popkin 1971).

The Evangeline aquifer sometimes can be differentiated from the overlying and geologically similar Chicot aquifer on the basis of resistivity curves on geophysical logs and the color of the stratum. However, delineating a definitive boundary between the Chicot aquifer and the Evangeline aquifer can be difficult in some areas. The sediments of the Chicot aquifer are generally ferrous in composition with a red hue (Popkin 1971). A weak hydraulic connection between the land surface and the Chicot aquifer and between the Chicot and Evangeline aquifers allows vertical movement of water into and between the two aquifers; consequently, the aquifer system is characterized as “leaky.”

BURKEVILLE CONFINING LAYER

The Burkeville confining layer or zone is a portion of the upper Fleming Formation. It is an aquitard or confining layer that consists mainly of very thick clay. This hydrogeologic unit lies beneath the Evangeline aquifer and above the Upper Jasper aquifer. It restricts the vertical flow of water between the two aquifers (Popkin 1971).

JASPER AQUIFER

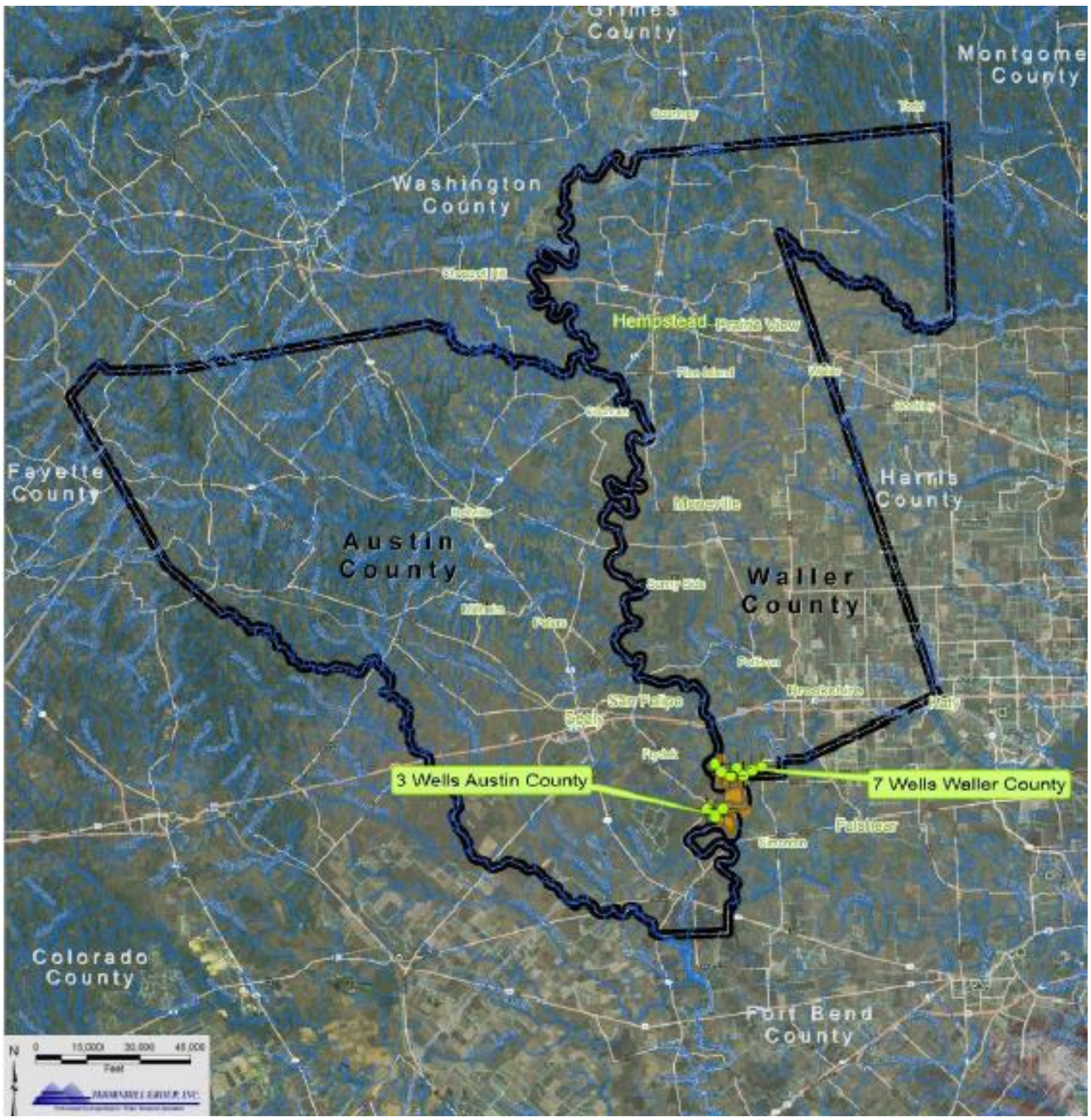
The Jasper aquifer (in sediments of Miocene age) is the lowermost of the three primary aquifers of the Gulf Coast aquifer system. The Jasper aquifer is overlain by the Burkeville confining unit (in sediments of Miocene age), which in turn is overlain by the Evangeline aquifer (in sediments of Miocene and Pliocene age) and the Chicot aquifer (in sediments of Pleistocene and Holocene age). The hydrogeologic units dip from land surface southeastward at slight angles toward the Gulf of Mexico. The units thus crop out in bands approximately parallel to the coast. The Jasper aquifer outcrop, which comprises the oldest sediments, is the farthest inland of the aquifer outcrops. The Jasper aquifer in the greater Houston area thickens toward the coast from about 600 feet in the outcrop to about 1,000 feet at the base of fresh (less than 1,000 milligrams per liter dissolved solids) to slightly saline (1,000–3,000 milligrams per liter dissolved solids) water (Baker, 1979). The Jasper aquifer can be separated into two parts on the basis of lithology (Popkin, 1971). The upper part, which composes 50 to 80 percent of the aquifer, consists of a massive sand; the lower part consists mostly of interbedded sand and clay. In the natural system, water recharges the Jasper aquifer in its outcrop, gradually moves downdip and discharges upward through the Burkeville confining unit.

CATAHOULA AQUIFER

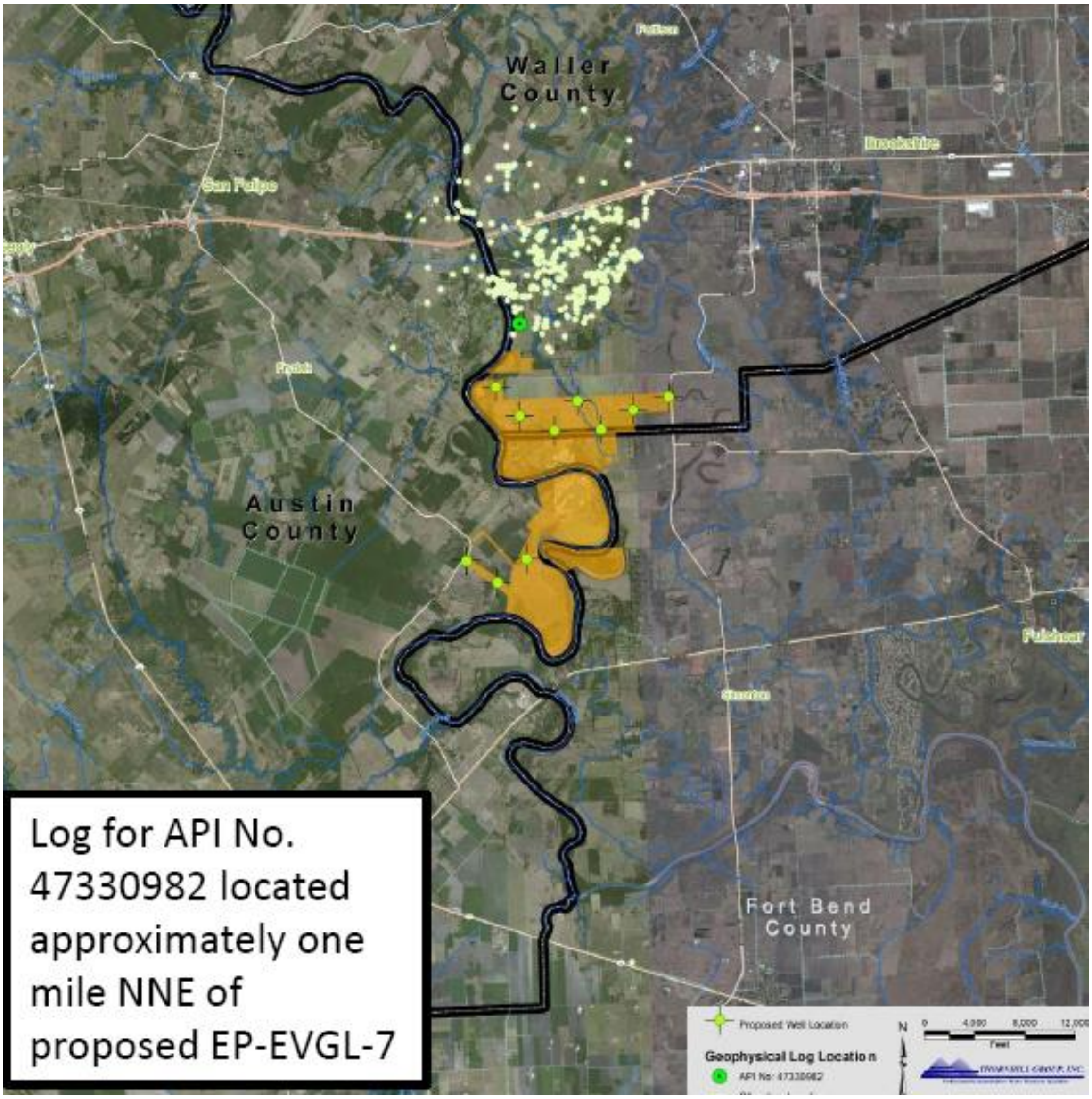
The Catahoula Aquifer lies beneath the Lower Jasper Aquifer, Upper Jasper Aquifer, Burkeville Aquiclude, Evangeline Aquifer, and Chicot Aquifer in southeast Texas and slopes in depth from some 2,500 feet to 4,000 feet, more or less, within Montgomery County (reference Figure 1). The vertical thickness of the Catahoula in Montgomery County is not known precisely but is believed to be of less thickness than the Lower Jasper. The nature of the sands comprising the Catahoula is presumed to be less predictable than the Lower Jasper based on limited available information. Catahoula water is generally higher in total dissolved solids, salinity, and temperature than water in the upper aquifers, depending upon location and depth. There has been no long-term, concentrated pumpage of the Catahoula in Montgomery County at high rates of withdrawal to provide any reliable data as to how, if at all, the aquifer is recharged or how, if at all, the quantity and quality characteristics of Catahoula water may be affected.

ELECTRO PURIFICATION, LLC WATER SUPPLY PROJECT

WELL LOCATION



GEOPHYSICAL LOG LOCATION

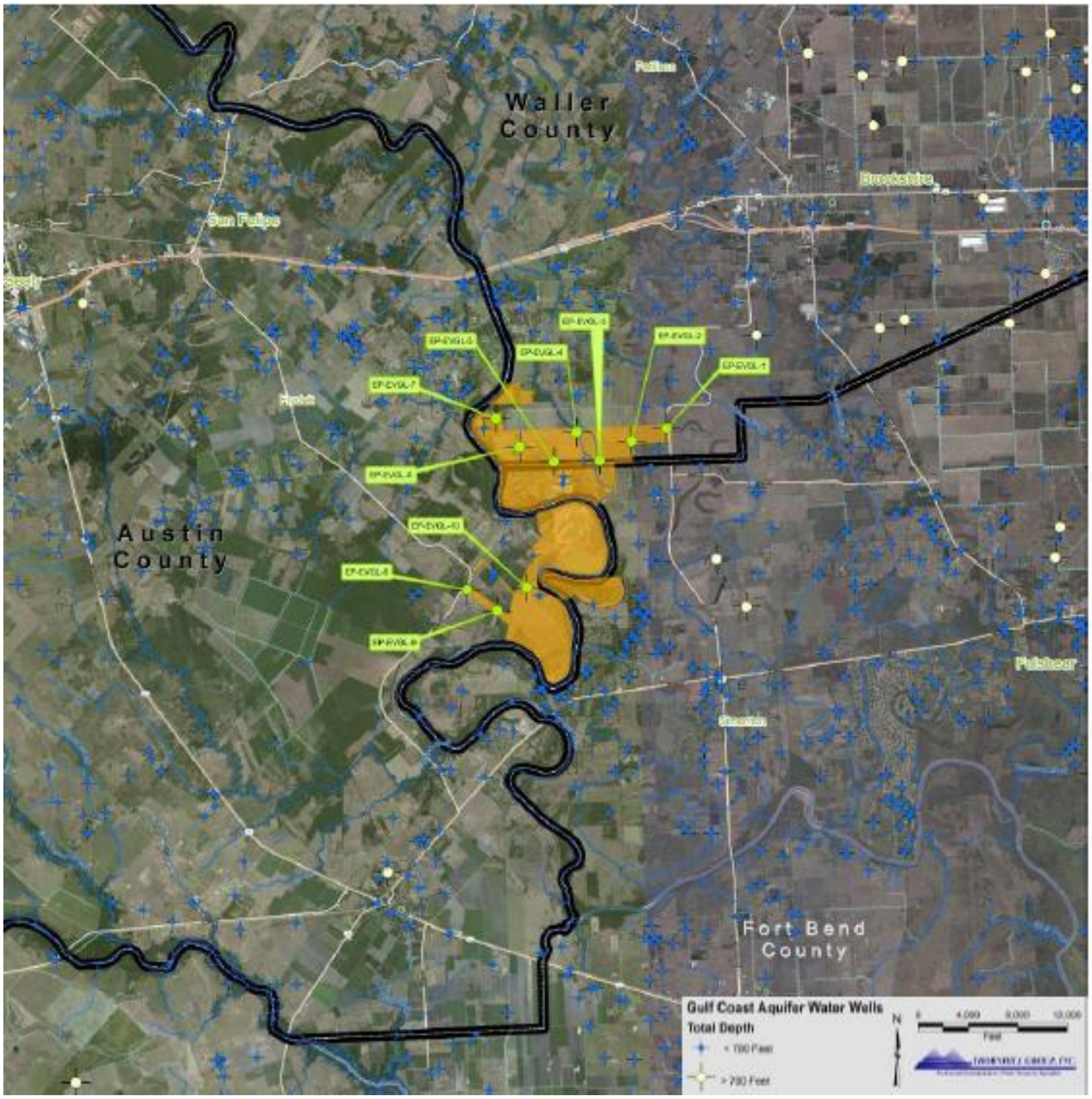


QUESTIONS

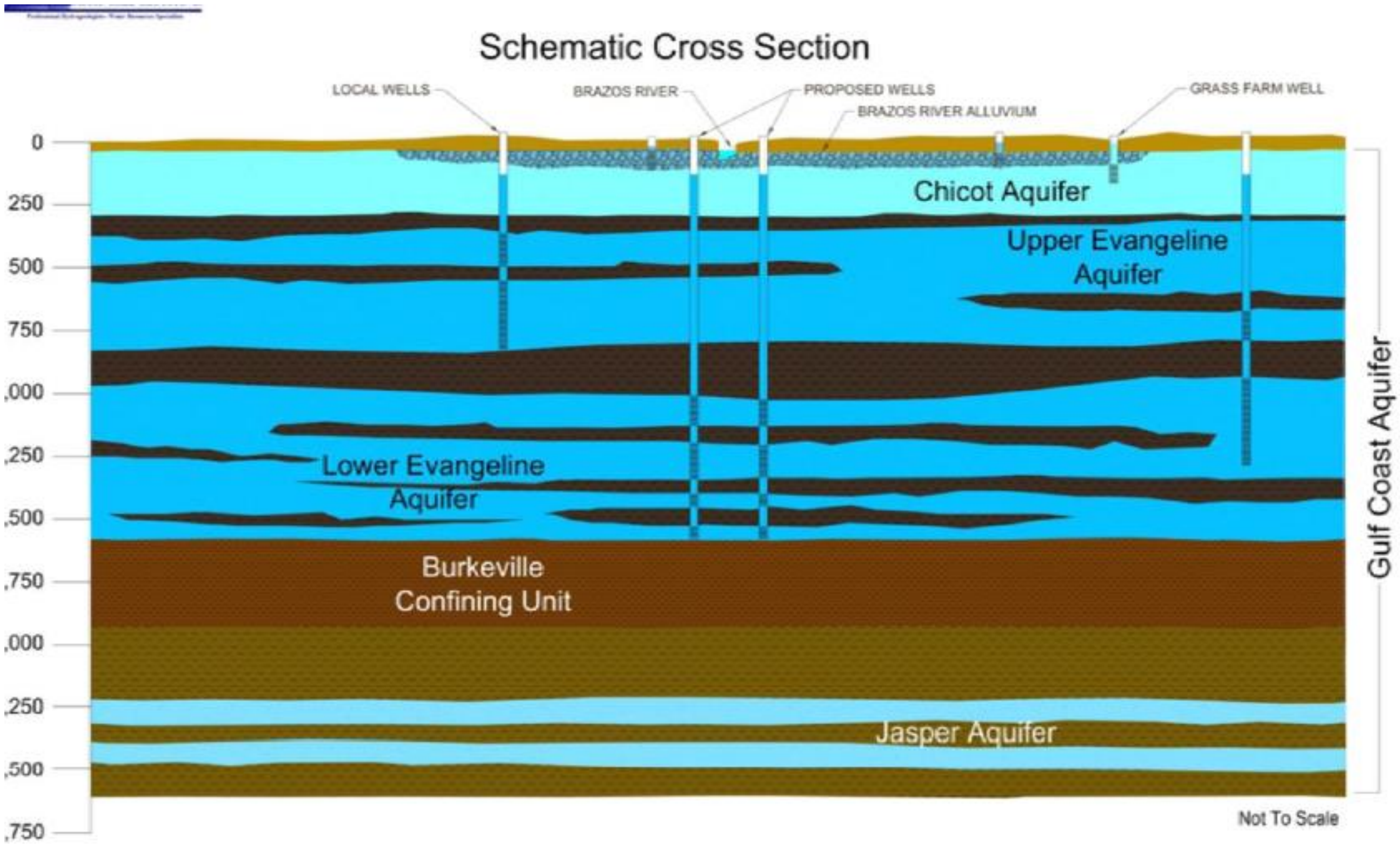
What are the white dotes above the Geophysical log location?

What is the split for the galleons used in Austin, Waller and Fort Bend Counties and the Richmond Rosenberg cities.

EXISTING WELLS IN PROPOSED WELL AREA



BLUE DOTES - WELLS LESS THAN 700 FEET
WHITE DOTES - WELLS MORE THAN 700 FEET

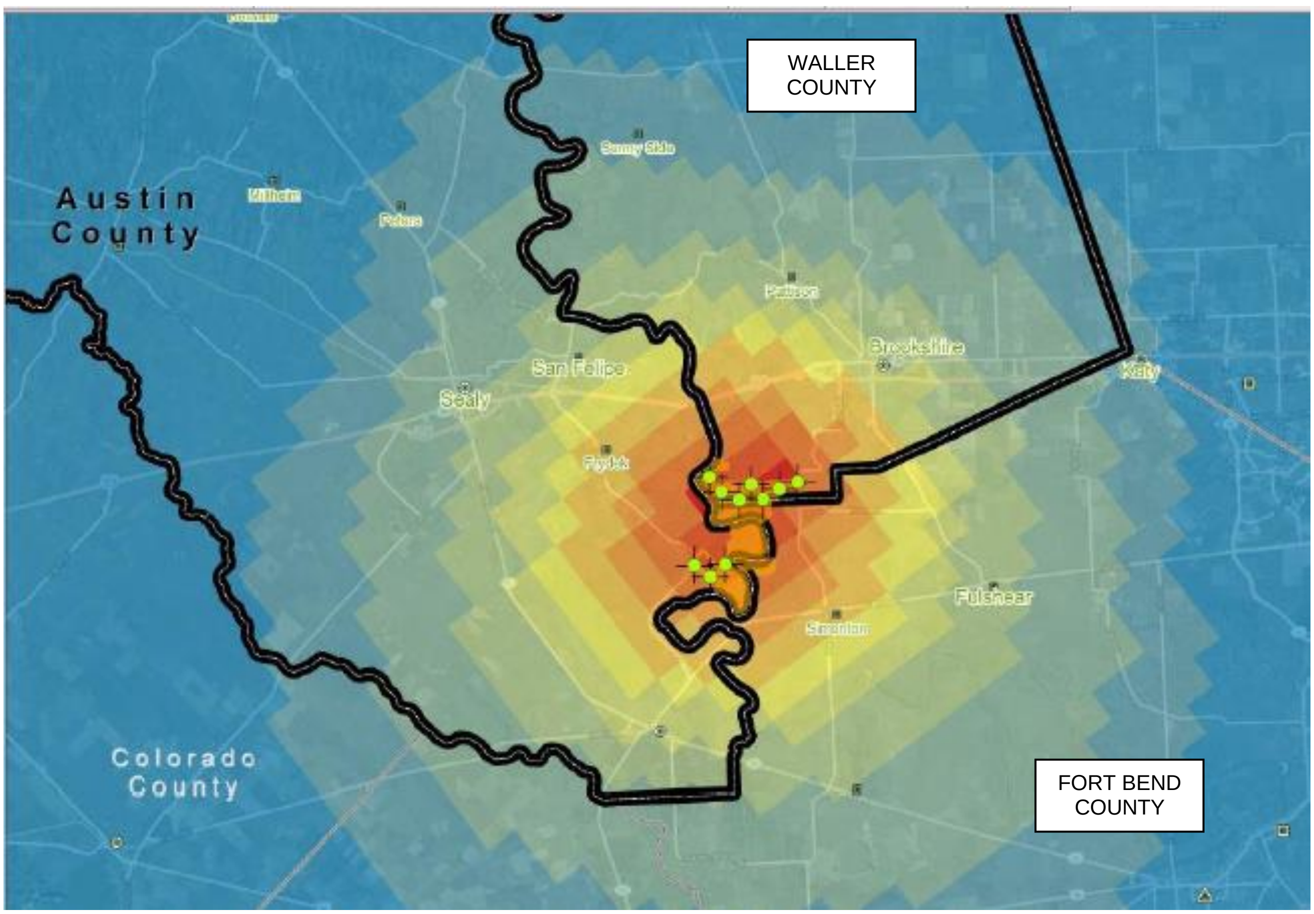


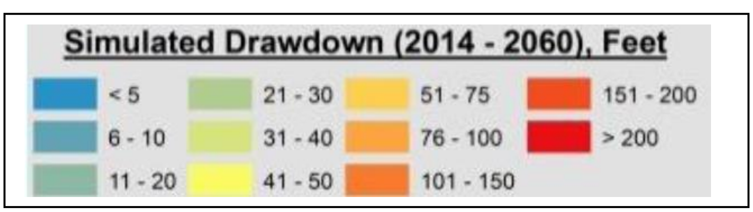
LOCAL AND PROPOSED WELL DEPTHS IN GULF COAST AQUIFER

PROJECTED PUMPNG OVER THE NEXT 46 YEARS

County	Water in Storage in Evangeline*	Reduction Due to EP Pumping 2014 – 2060
Austin	45,400,000 acre-feet	0.06 percent
Waller	49,000,000 acre-feet	0.06 percent
Fort Bend	147,130,000 acre-feet	0.001 percent
TOTAL	**241,530,000 acre-feet**	**0.023 percent**

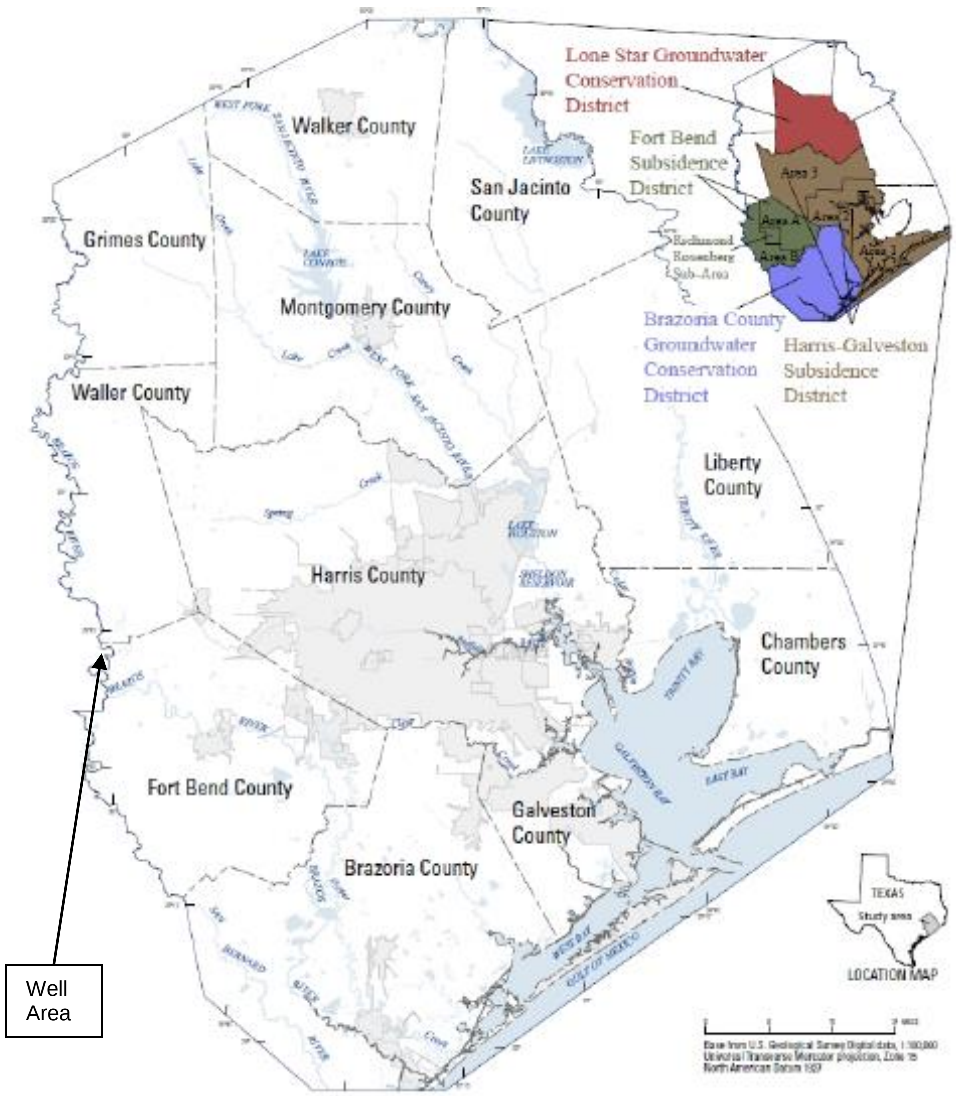
PROJECT DRAWDOWN (2014-2060)



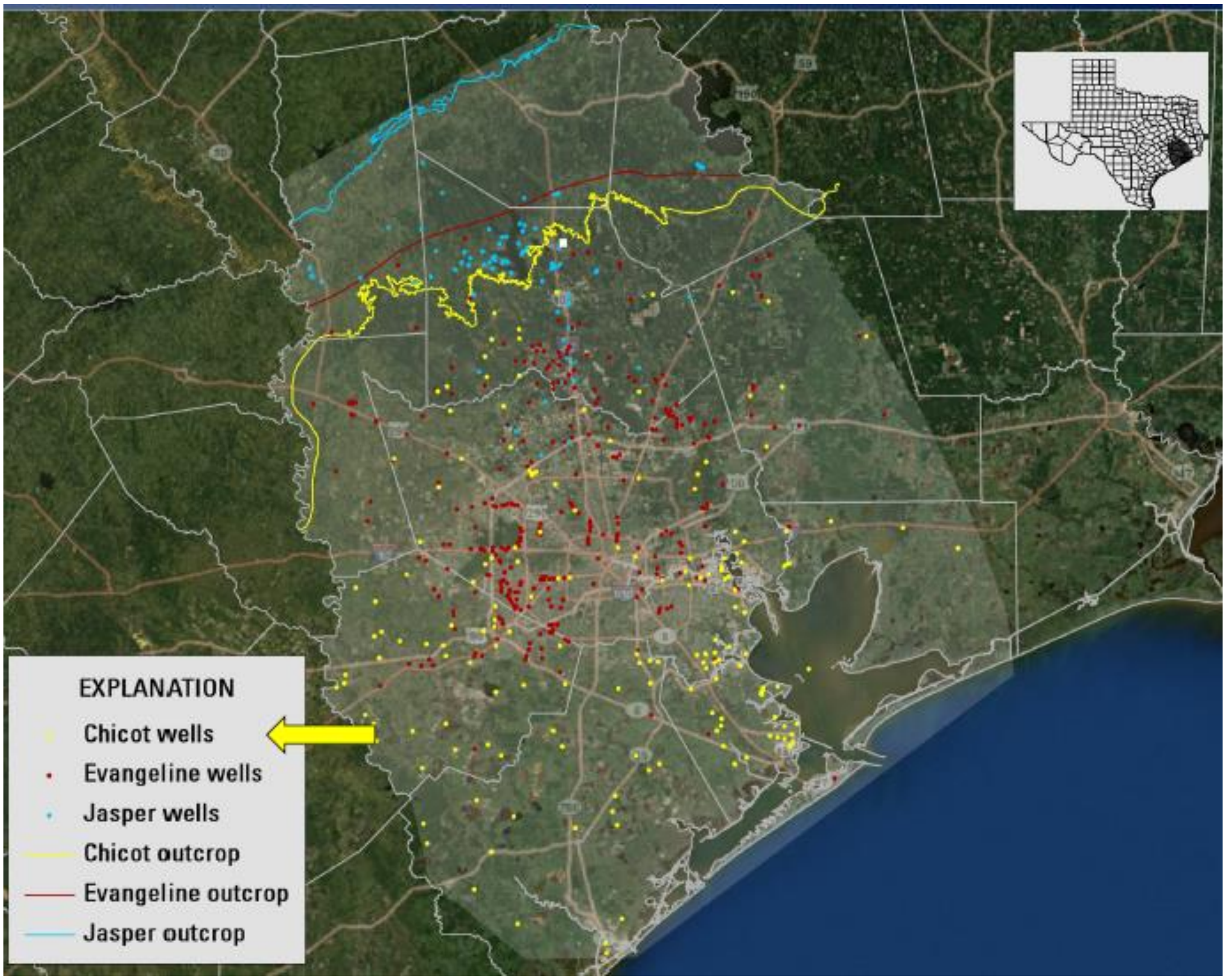


USGS REPORTS

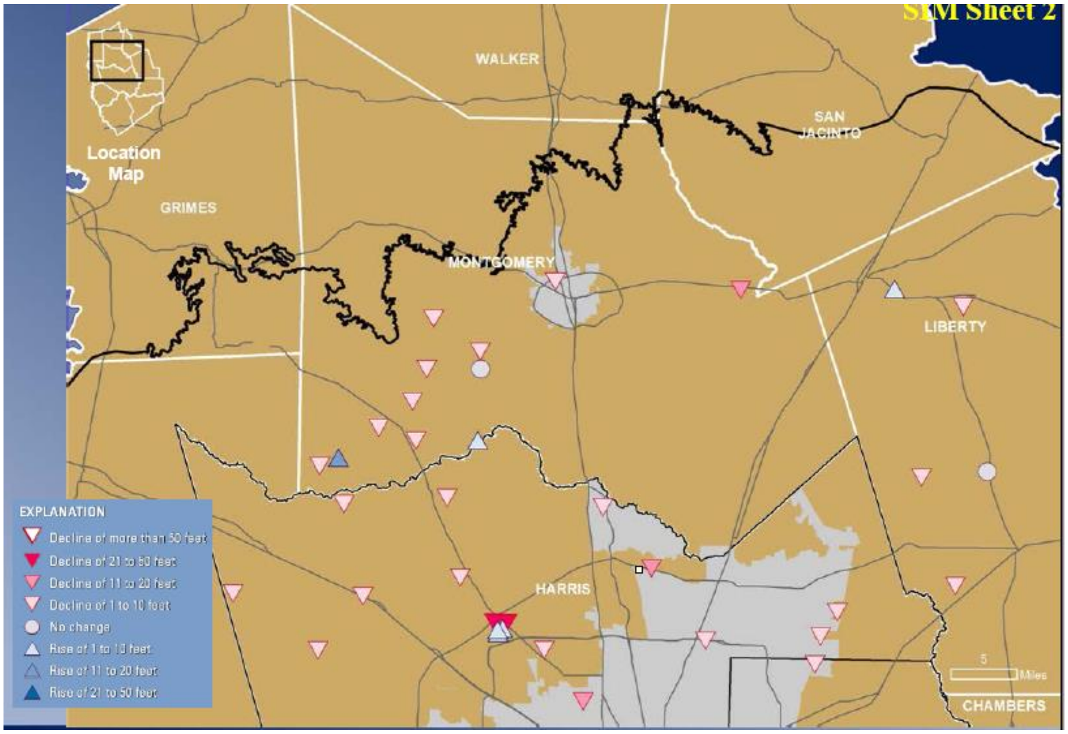
Water-Level Altitudes and Level Changes for Chicot, Evangeline, and Jasper Aquifers 2012



USGS Scientific Investigation Map Study Area

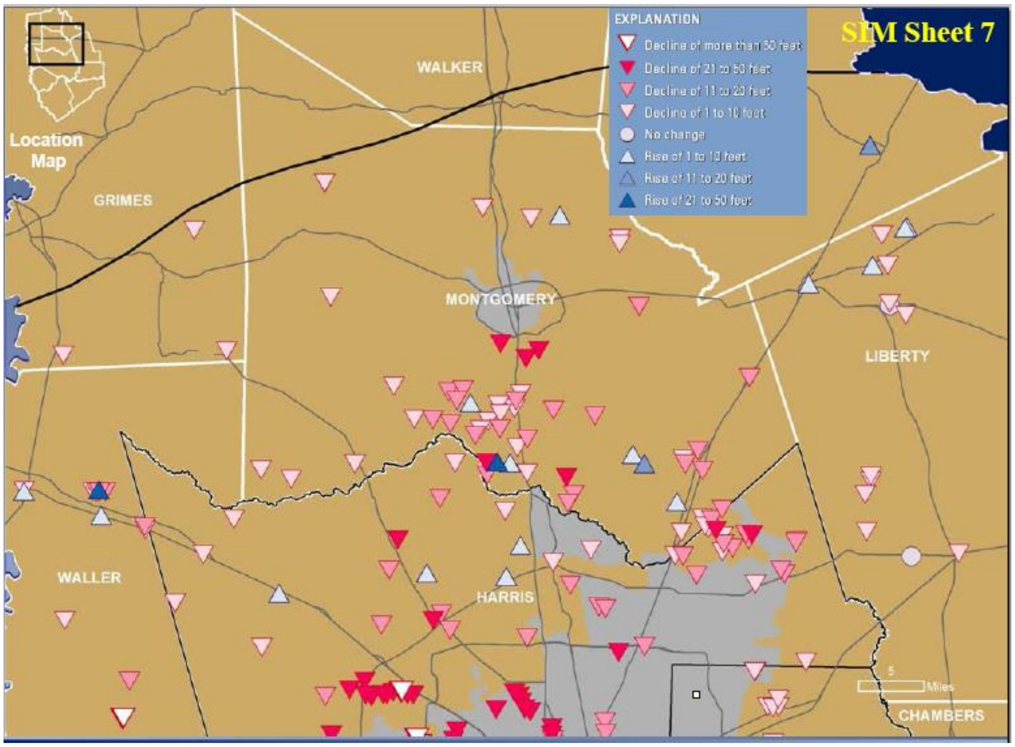


2012 Aquifer Monitoring well network



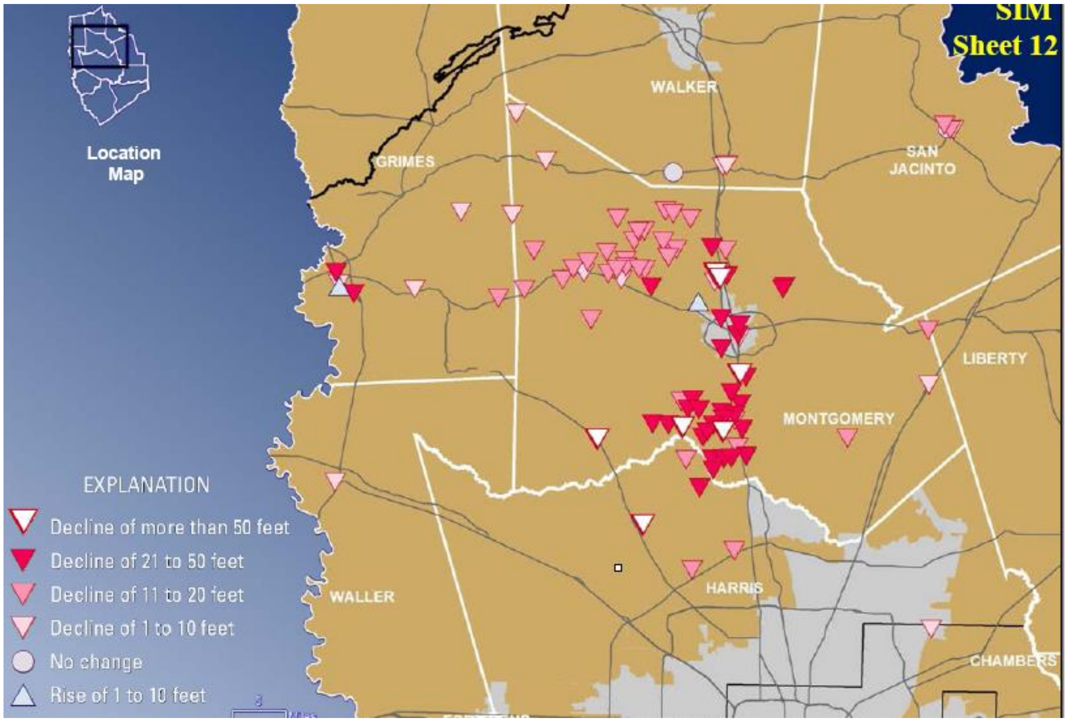
CHANGE INTERVALS	NUMBER OF WELLS	% OF WELLS
Decline of 21 to 50 feet	10	~5.9
Decline of 11 to 20 feet	11	~6.5
Decline of 1 to 10 feet	120	~71.0
No Change	14	~8.3
Rise of 1 to 10 feet	11	~6.5
Rise of 11 to 20 feet	3	~1.8

2011-2012 Chicot Aquifer level changes



CHANGE INTERVALS	NUMBER OF WELLS	% OF WELLS
Decline of more than 50 feet	25	~7.8
Decline of 21 to 50 feet	89	~27.7
Decline of 11 to 20 feet	84	~26.2
Decline of 1 to 10 feet	96	~29.9
No Change	4	~1.2
Rise of 1 to 10 feet	18	~5.6
Rise of 11 to 20 feet	2	~0.6
Rise of 21 to 50 feet	3	~0.9

2011-2012 Evangeline Aquifer level changes



CHANGE INTERVALS	NUMBER OF WELLS	% OF WELLS
Decline of more than 50 feet	7	~7.1
Decline of 21 to 50 feet	33	~33.3
Decline of 11 to 20 feet	38	~38.4
Decline of 1 to 10 feet	17	~17.2
No Change	2	~2.0
Rise of 1 to 10 feet	2	~2.0

2011-2012 Jasper Aquifer level changes

FORT BEND SUBSIDENCE DISTRICT 2012 ANNUAL GROUND WATER REPORT

There are three regulatory areas in Fort Bend County (see map). The FBSD regulatory plan calls for all regulated entities (non-agriculture entities with a 4-inch well or greater that uses more than 10,000,000 gallons per year) to file a Groundwater Reduction Plan (GRP) demonstrating how water conversion requirements will be met. Those in 'Area A' are required to convert 30 percent of their groundwater to surface water by 2013 and 60 percent by 2025. Those in the 'R/R Area' (Richmond/Rosenberg) are required to convert 30 percent of their groundwater by 2015 and 60 percent by 2025. 'Area B' currently has no conversion requirements. All GRPs must be certified by the Subsidence District. In an effort to encourage early conversion to alternative water sources and water conservation education, the FBSD adopted policies to issue groundwater credits that can be used by a GRP to offset future demands or requirements. GRP entities in 'Area A' can earn groundwater credits for early conversion and over conversion at a rate of 1:1. If a GRP converts to using wastewater effluent, groundwater credits accrue at a rate of 1.5:1. Over conversion credits must be redeemed before January 1, 2030.

Richmond and Rosenberg have requested an additional two-year extension that would push their initial conversion requirement to 2017.

Fort Bend subsidence District Regulatory Map

In 2003, the FBSD adopted the 2003 Regulatory Plan, which established two Regulatory Areas and the Richmond/Rosenberg Sub-Area of Area A. Regulatory Area A encompasses the greatest density of population of Fort Bend County, generally the northern and eastern portions of Fort Bend County. The Richmond/Rosenberg Sub-Area of Area A encompasses the majority of the population in central Fort Bend County. Regulatory Area B encompasses the remainder of Fort Bend County generally the far western and southern portions of the County. Of the 131.9mgd total groundwater pumpage for Fort Bend County, Regulatory Area A, excluding the R/R Sub-Area accounted for 80% (105.1mgd) for 2011. Regulatory Area B users pumped 12% (16.3mgd) of the total while the small Sub-Area RR accounted for 8% (10.5mgd).

Total groundwater pumpage from Regulatory Area A was 105.1mgd for 2011; a 27% increase from the 2010. Irrigation pumpage is given as a total and as a breakout of Agricultural (includes traditional farm crops plus nurseries, sod farms, tree farms, etc.) and Other (includes uses for irrigation of parks, cemeteries, golf courses, common areas, and amenity lakes) irrigation.

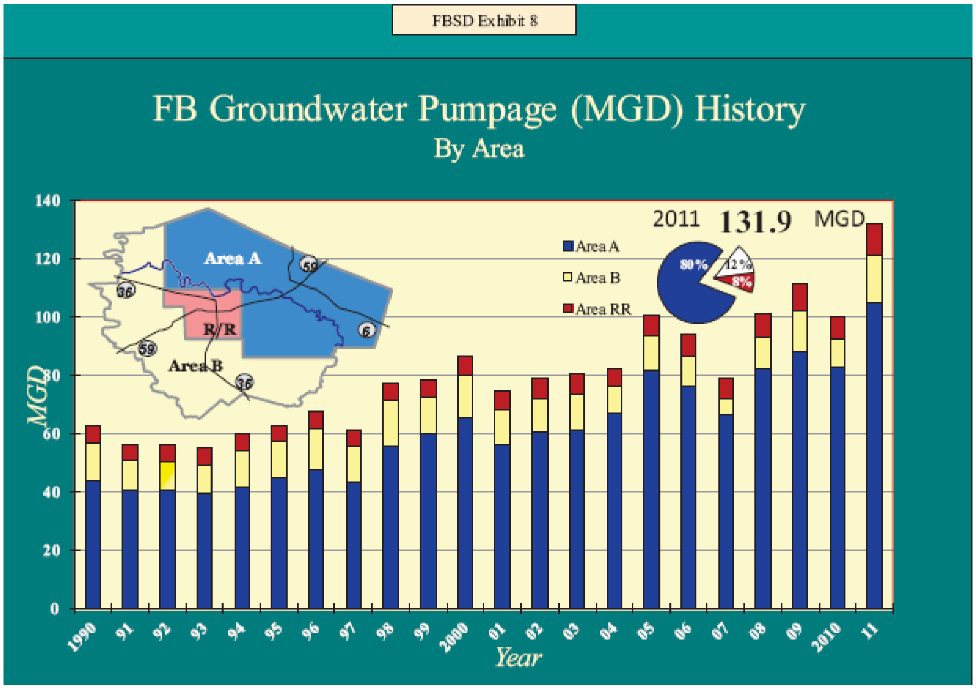
81% (85.1mgd) of the total groundwater pumped (105.1mgd) was for public supply. The next largest portion (12%, 13.1mgd) went to other irrigation (lake make-up, nonagricultural irrigation, etc.) followed by industrial use (4%, 4.2mgd). Agricultural irrigation was the smallest category, accounting for 3% (2.8mgd) of the groundwater pumped within Regulatory Area A.

Total groundwater pumpage from Regulatory Area B was 16.3mgd for 2011; a 65% increase from 2010.

82% (13.32mgd) of the groundwater pumped was for agricultural irrigation while 14% (2.19mgd) went to public supply. The remaining groundwater was used for other irrigation (4%, 0.71mgd) and industrial use (0.2%, 0.03mgd).

Total groundwater pumpage Sub-Area R/R (Richmond/Rosenberg) was 10.5mgd for 2011; a 41% increase from 2010.

Public Supply remained the largest category of use accounting for 82% (8.64mgd) of the pumping, while Industrial use accounted for 8% (0.82mgd) of the total. Agricultural Irrigation and Other Irrigation each accounted for approximately 5% (0.57mgd Agricultural, 0.46mgd Other).

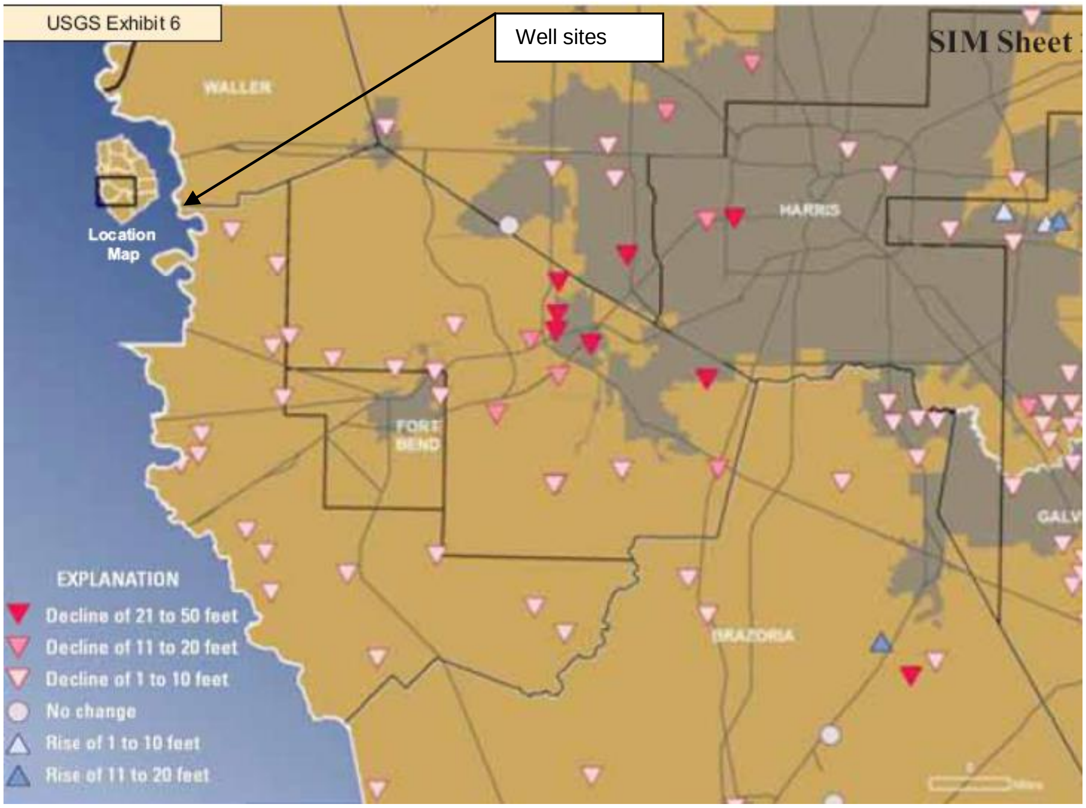


Fort Bend Groundwater Pumpage (1990-2011)

Water-Level Change Map & Table Chicot Aquifer, 2011-2012

In the 2011-12 time period there were 141 wells (83.4%) that had water level declines, 14 (8.2%) with rises and 14 (8.2%) that had no change.

Of the 32 wells measured in Fort Bend, all 32 showed declines (23 were 1'-10', four were 11'-20', and five were 21'-50' declines).



USGS Exhibit 7

CHANGE INTERVALS	NUMBER OF WELLS	% OF WELLS
Decline of 21 to 50 feet	10	~5.9
Decline of 11 to 20 feet	11	~6.5
Decline of 1 to 10 feet	120	~71.0
No Change	14	~8.3
Rise of 1 to 10 feet	11	~6.5
Rise of 11 to 20 feet	3	~1.8

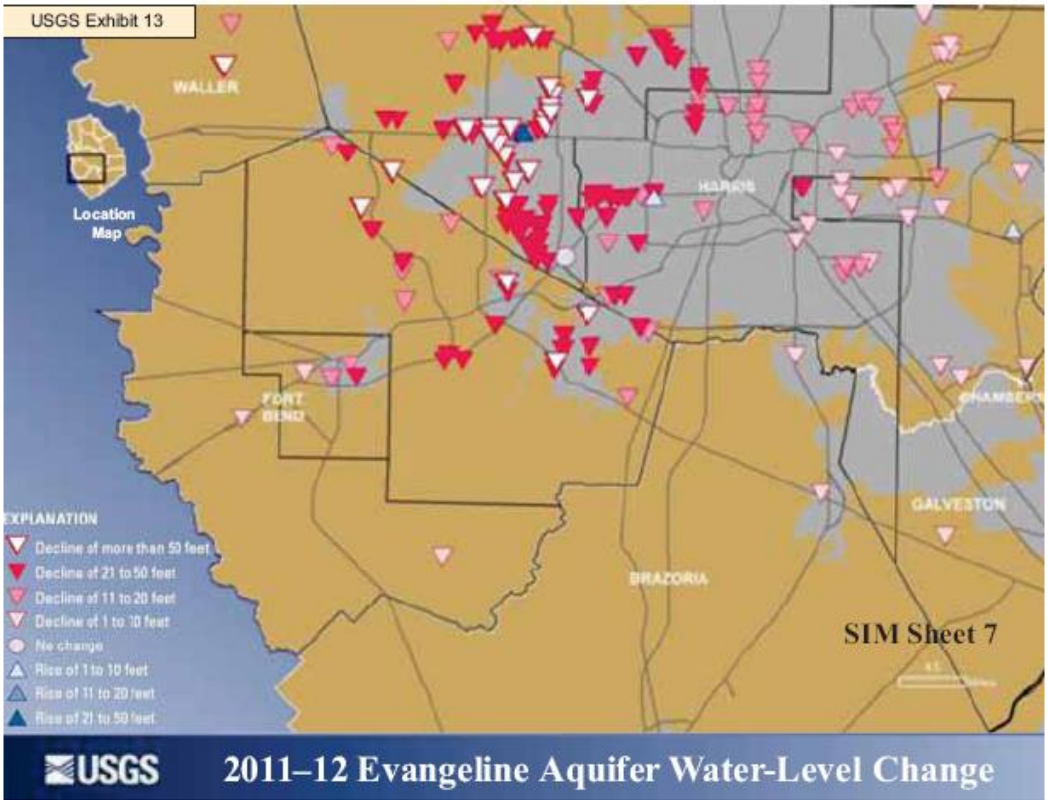
USGS 2011–12 Chicot Aquifer Water-Level Change

USGS EXHIBIT NOS. 6&7: WATER-LEVEL CHANGE MAP & WATER-LEVEL CHANGE TABLE CHICOT AQUIFER, 2011-2012

Water-Level Change Map & Table Evangeline Aquifer, 2011-2012

In the Evangeline well network, 294 wells (91.6%) showed declines while only 23 wells (7.2%) showed rises. Four wells (1.2%) showed no change.

31 of the measurements were taken in Fort Bend County. All of those showed declines; three were 1’ to 10’ declines, eight were 11’ to 20’ , 15 were 21’ to 50’, and five declines more than 50’.



USGS Exhibit 14

CHANGE INTERVALS	NUMBER OF WELLS	% OF WELLS
Decline of more than 50 feet	25	~7.8
Decline of 21 to 50 feet	89	~27.7
Decline of 11 to 20 feet	84	~26.2
Decline of 1 to 10 feet	96	~29.9
No Change	4	~1.2
Rise of 1 to 10 feet	18	~5.6
Rise of 11 to 20 feet	2	~0.6
Rise of 21 to 50 feet	3	~0.9

USGS 2011–12 Evangeline Aquifer Water-Level Change

USGS EXHIBIT NOS. 13 & 14: 2011-12 EVANGELINE AQUIFER WATER-LEVEL CHANGE MAP & WATER-LEVEL CHANGE TABLE

References

Refer to the following documents in this folder for further information

Chicot/Evangeline Aquifer of the Texas Gulf Coast, Groundwater Age and Pathways for Saltwater Contamination

Water-Level Altitudes 2011 and Water- Level Changes in the Chicot, Evangeline, and Jasper Aquifers and Compaction 1973– 2010 in the Chicot and Evangeline Aquifers, Houston–Galveston Region, Texas

Groundwater Models of the Gulf Coast Aquifer of Texas

Water-Level Altitudes 2012 and Water-Level Changes in the Chicot, Evangeline, and Jasper Aquifers and Compaction 1973–2011 in the Chicot and Evangeline Aquifers, Houston-Galveston Region, Texas

Sugarland City council 1-24-12 Agenda

Sugarland City council 2-7-12 Agenda

TGI Presentation –EP Water Supply Project – 02252013.PDF

Austin County Public Hearing 19023_WRH.PDF

Fort Bend Subsidence District 2012 annual ground water report

Fort Bend subsidence District Regulatory Map

Fort Bend subsidence District Regulatory Plan 2003

Chicot/Evangeline Aquifer of the Texas Gulf Coast, Groundwater Age and Pathways for Saltwater Contamination

U.S. SEASONAL DROUGHT MAP

EP – proposed notice and property-well owner info.

Groundwater Models of the Gulf Coast Aquifer of Texas - Chapter 10

Drought – StateImpact. Npr.org