OKLAHOMA ROCKS! GROUNDWATER

2012

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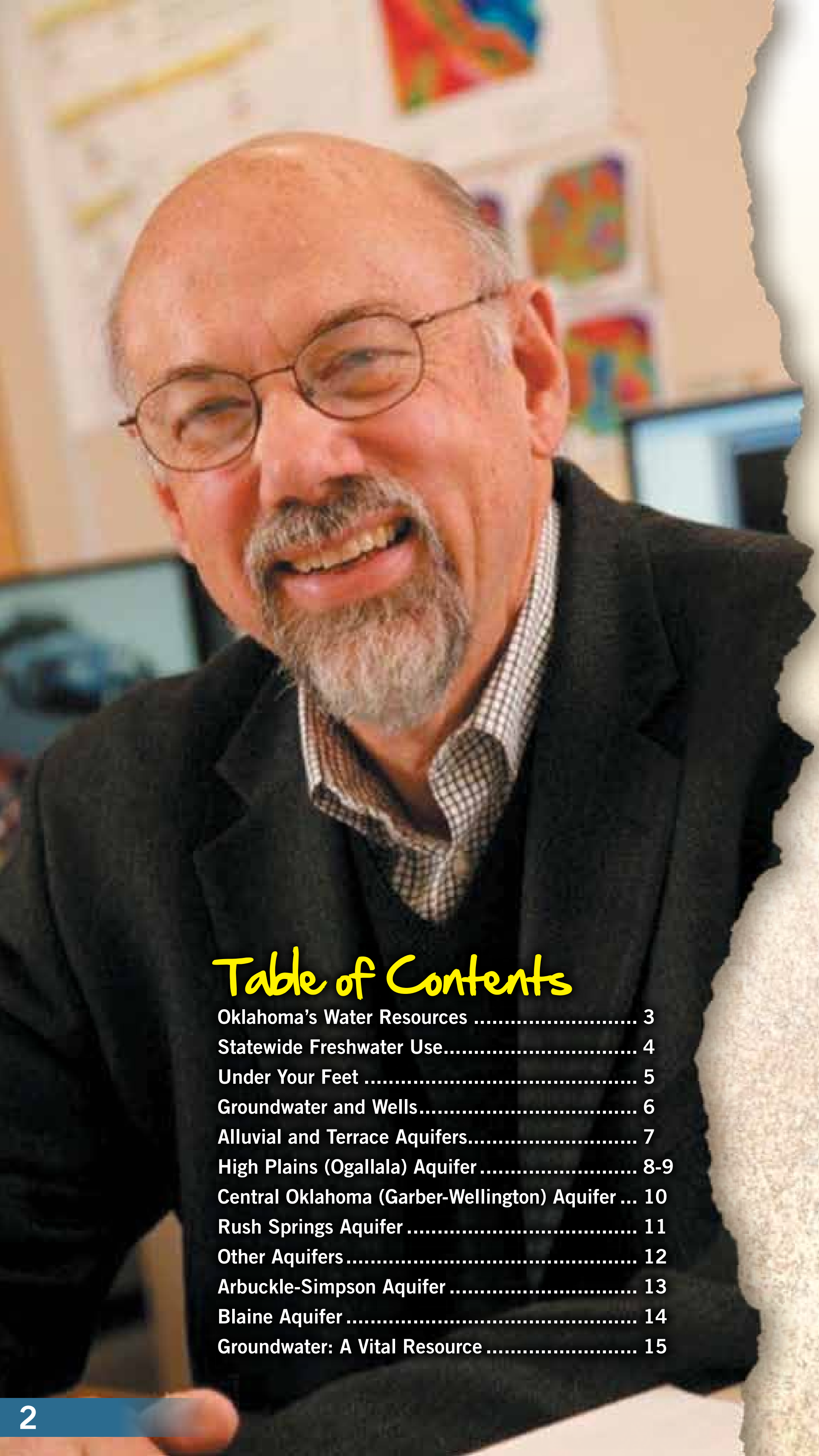

Preface from the Director of the Oklahoma Geological Survey:

Needless to say, water is our most important natural resource because it makes Earth a place that can sustain life compared to say Mars, where we are currently exploring via the National Aeronautics and Space Administration (NASA) rover CURIOSITY. Thus, all Oklahomans are probably even more aware of our water resources than they are of our petroleum, mineral or rock resources. Even so, it is important to recognize that all these resources are required to preserve and protect life.

A number of Oklahoma and federal agencies play a role in managing and protecting our water resources. These include, but are not limited to, the U.S. Geological Survey (USGS), U.S. Environmental Protection Agency (EPA), Oklahoma Water Resources Board (OWRB), Oklahoma Geological Survey (OGS), Oklahoma Water Survey (OWS), and the Oklahoma Department of Environmental Quality (OKDEQ).

Many other local organizations and jurisdictions play a role in managing, distributing, and protecting water resources. We ALL have an important, shared stake in understanding and preserving our water for future generations and need to be as informed as possible about these resources. The OGS brings this issue of ***Oklahoma Rocks! Groundwater*** to you to provide an overview of groundwater resources of the state, and point you to more information on water-related issues.

Dr. G. Randy Keller

Director, Oklahoma Geological Survey

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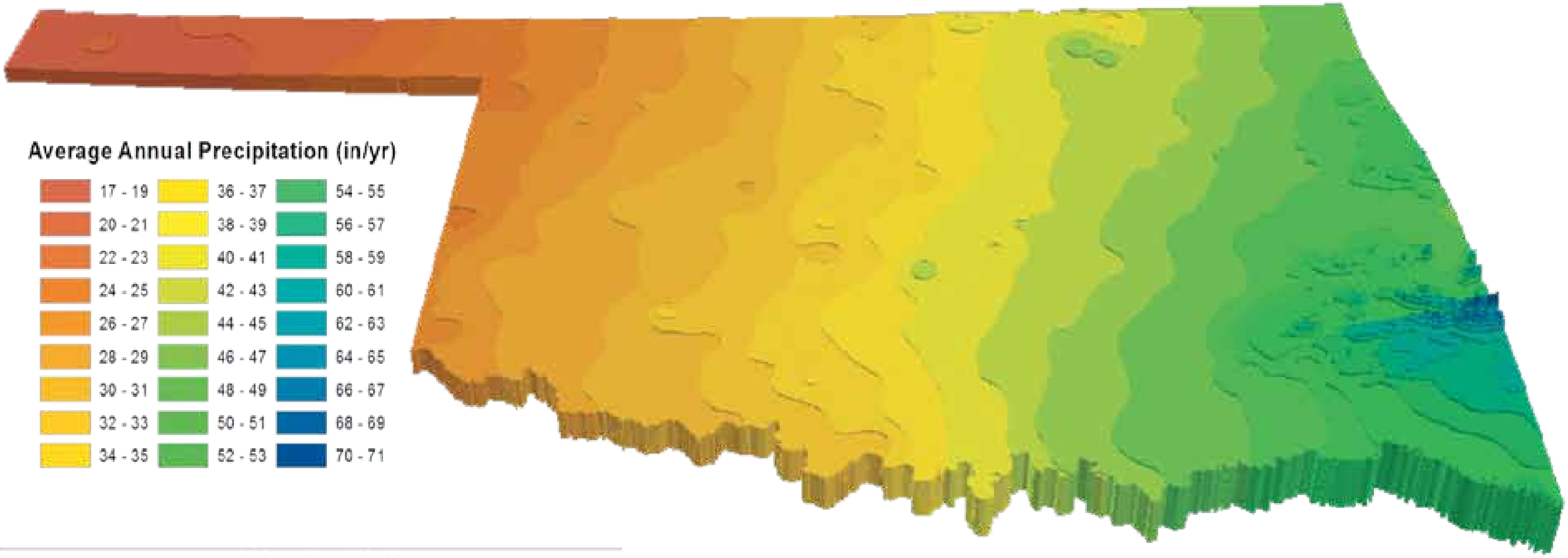
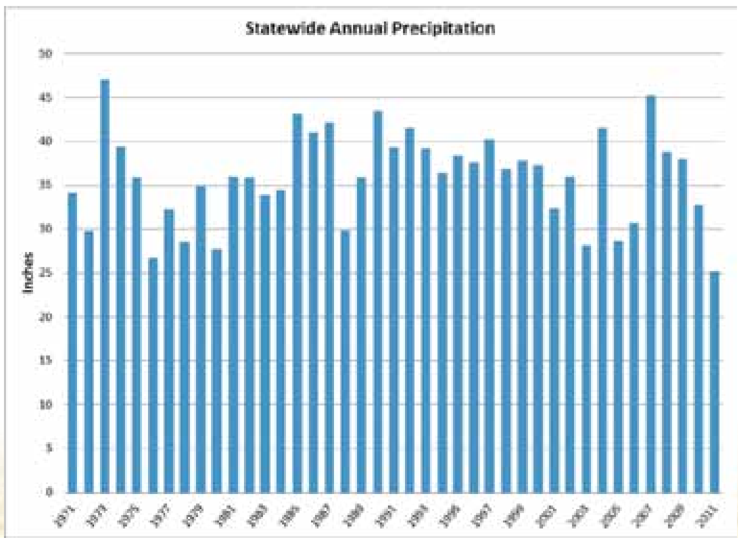
By: Dr. Kyle E. Murray, OGS Hydrogeologist

Water is one of the primary necessities of life. Beyond an individual's need for water, a community's ability to develop, utilize and protect water resources affects long-term prosperity of the region. Water resources are generally found in one of two places: on the surface of the Earth as streams, lakes & reservoirs (i.e., surface water), or below the surface of the Earth (i.e., groundwater). As shown in the diagram below, the average annual precipitation rate in Oklahoma varies from about 17 inches per year (in/yr) in the far western part of the panhandle to about 71 in/yr near the southeast-central border with Arkansas. A large majority of precipitation can be captured and stored in surface water bodies, while a smaller fraction (about 10% of precipitation) will recharge groundwater systems.





Questions to Ponder/Activities:

1. Parts of Oklahoma experienced drought conditions during the years 2011 and 2012. Look at the drought monitor to see where we stand now: http://climate.ok.gov/index.php/drought/last_365_days/drought_wildfire# or relative to the rest of the country http://droughtmonitor.unl.edu/monitor.html
2. How would you define a drought?

Statewide Freshwater Use

By: Dr. Kyle E. Murray, OGS Hydrogeologist

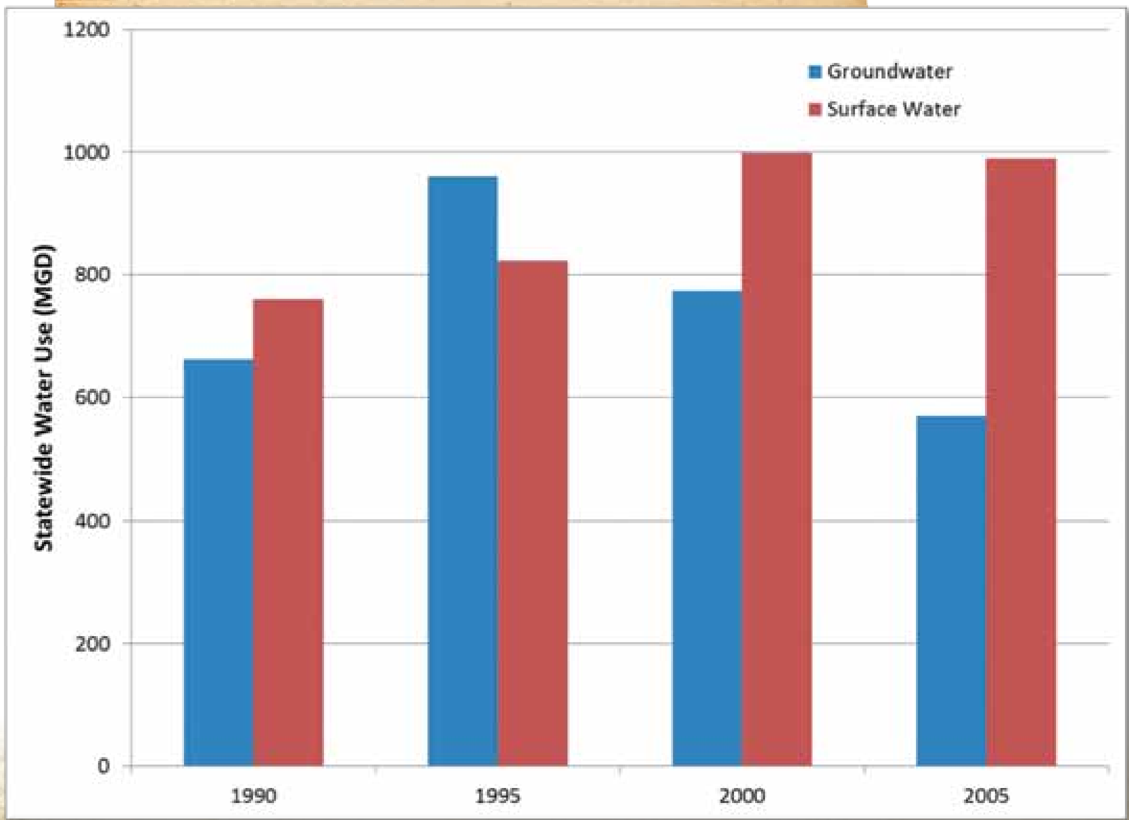
Volume of water withdrawn will vary from year-to-year depending on many factors including the amount of precipitation. In recent years, the volume of water withdrawn from Oklahoma's surface water systems exceeded the volume of water withdrawn from groundwater systems. However, it is difficult to differentiate between surface water and groundwater in some areas because water may be readily exchanged between the two systems. Particularly where rivers (i.e., alluvial systems) overlie shallow bedrock aquifers or in karst terrain where seeps, springs, caves, and recharge features may be common. Principal aquifers and minor aquifers in Oklahoma are used as sources of water by many sectors of the Oklahoma socioeconomic system. In the data given below, the term "water use" is synonymous with the term "withdrawn". In most sectors a large fraction of the water that is "used" actually returns back to the surface water or groundwater system from which it was withdrawn. This fraction of water may be more accurately described as non-consumptive water use. Consumptive water use then refers to the fraction of water that is transported off-site or "lost" via evapotranspiration.

Activities:

The US Census Bureau reported Oklahoma's population as 3,450,654 in the year 2000.

How many gallons of freshwater were withdrawn per person per day in 2000?

$$\frac{1775\,\text{Mill gal}}{\text{day}} \div 3.45\,\text{Mill people} = \frac{\text{gal}}{\text{person day}}$$



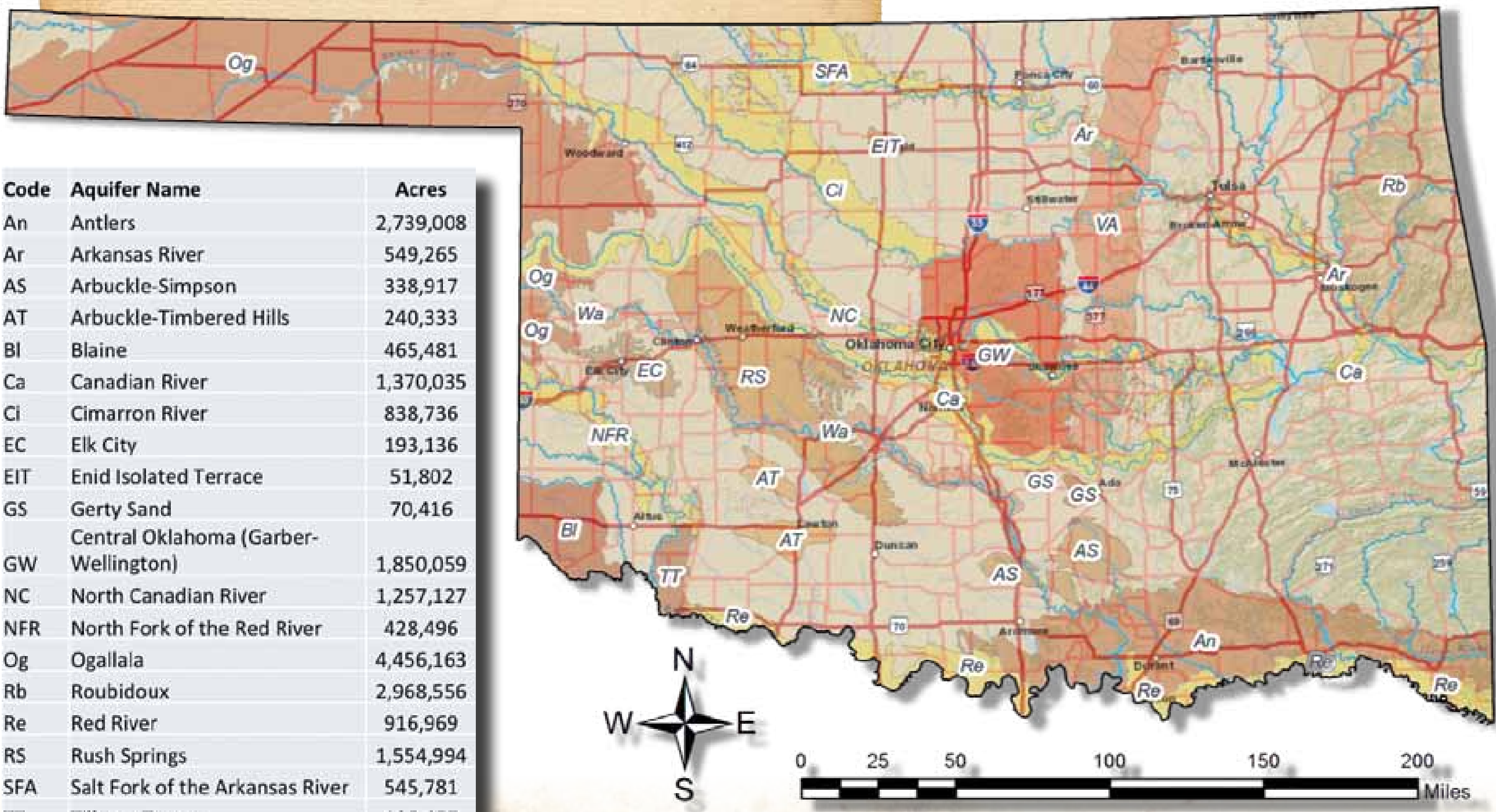
Water use is highly variable throughout the state, as a rule of thumb: more than 50% of the water used in the eastern part of the state is derived from surface water sources and more than 50% of the water used in the western part of the state is derived from groundwater sources.

In 2005, nearly 600 million gallons per day (MGD) of groundwater were withdrawn from Oklahoma aquifers and used for various purposes.

By: Dr. Kyle E. Murray, OGS Hydrogeologist

Questions to Ponder/Activities:

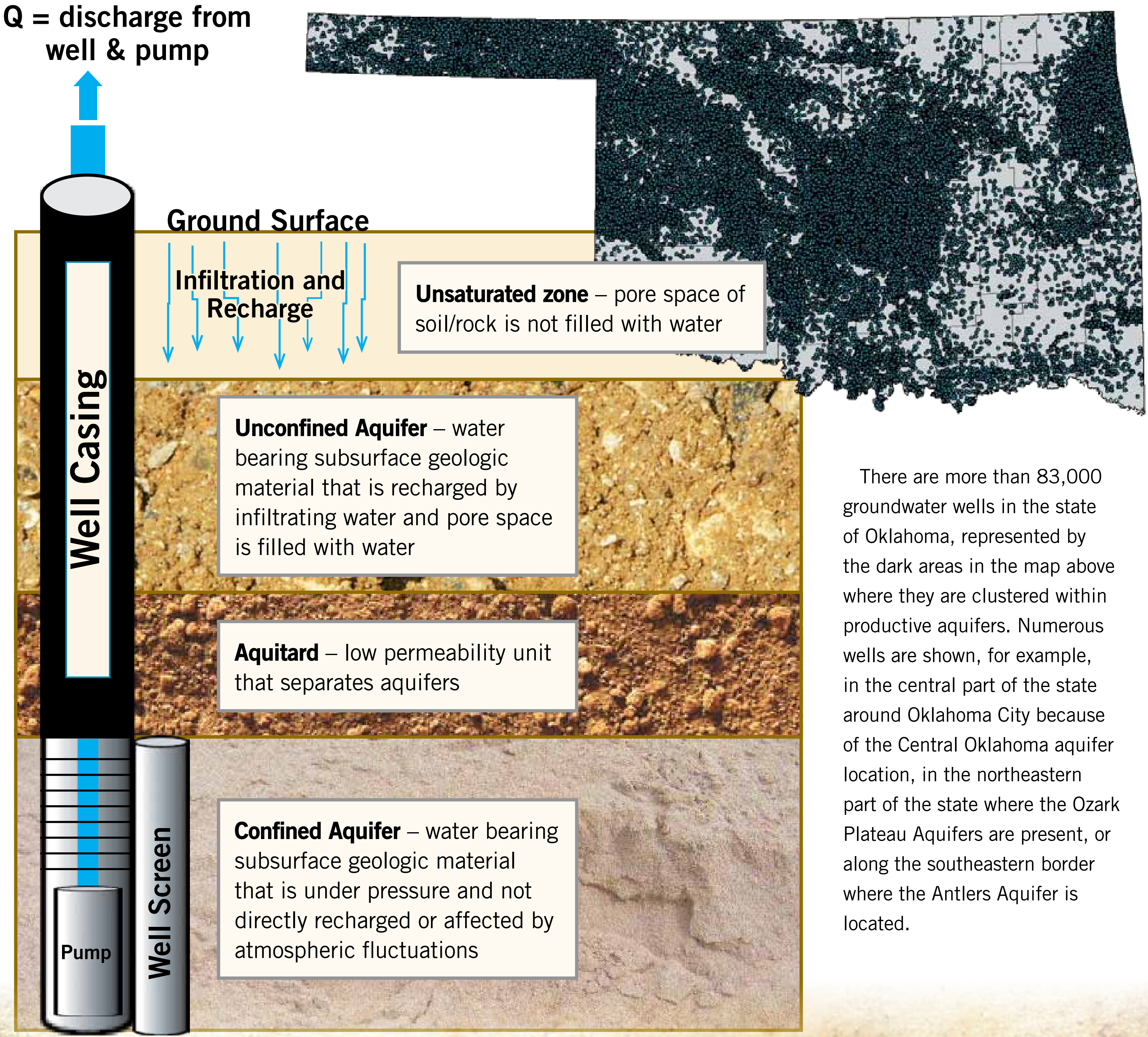
1. Plot your location on the map below.
2. Which, if any, major aquifer is below your feet?
3. Is a minor aquifer available where you are located? To find out, use the Oklahoma Water Resources Board's (OWRB's) map here: http://www.owrb.ok.gov/maps/pdf_map/GW%20Bedrock%20and%20Alluvial%20Aquifers.pdf



Code	Aquifer Name	Acres
An	Antlers	2,739,008
Ar	Arkansas River	549,265
AS	Arbuckle-Simpson	338,917
AT	Arbuckle-Timbered Hills	240,333
BI	Blaine	465,481
Ca	Canadian River	1,370,035
Ci	Cimarron River	838,736
EC	Elk City	193,136
EIT	Enid Isolated Terrace	51,802
GS	Gerty Sand	70,416
GW	Central Oklahoma (Garber-Wellington)	1,850,059
NC	North Canadian River	1,257,127
NFR	North Fork of the Red River	428,496
Og	Ogallala	4,456,163
Rb	Roubidoux	2,968,556
Re	Red River	916,969
RS	Rush Springs	1,554,994
SFA	Salt Fork of the Arkansas River	545,781
TT	Tillman Terrace	185,657
VA	Vamoosa-Ada	1,658,857
Wa	Washita River	697,176

Groundwater & Wells

By: Dr. Kyle E. Murray, OGS Hydrogeologist



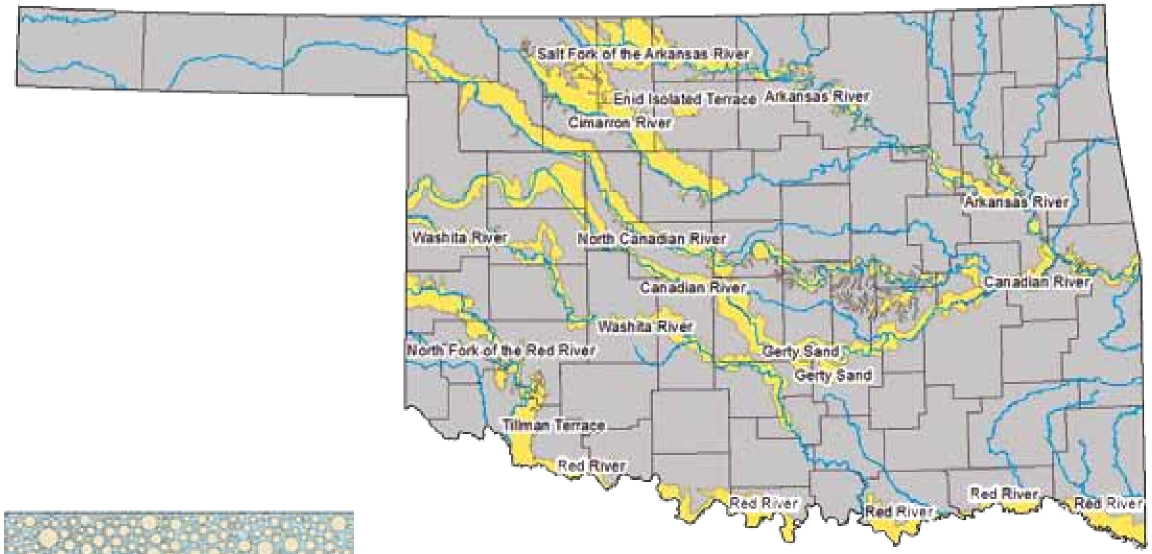
There are more than 83,000 groundwater wells in the state of Oklahoma, represented by the dark areas in the map above where they are clustered within productive aquifers. Numerous wells are shown, for example, in the central part of the state around Oklahoma City because of the Central Oklahoma aquifer location, in the northeastern part of the state where the Ozark Plateau Aquifers are present, or along the southeastern border where the Antlers Aquifer is located.

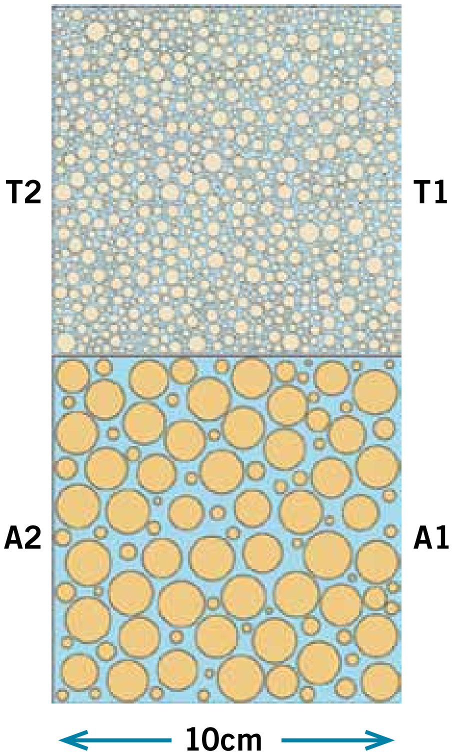
By: Dr. Kyle E. Murray, OGS Hydrogeologist

"Alluvial and Terrace Aquifers" of Oklahoma are a collection of more than 15 geologically and geographically separate units. The term alluvial is used to describe material that is deposited by a stream or running water. Aquifers in this group were formed in the recent geologic past (Quaternary age) along present day streams such as the Arkansas, Canadian, Cimarron, Red, and Washita Rivers. Alluvial aquifers are comprised of clastic, unconsolidated silt, sand, and gravel. Because of the relatively large grain-size and resulting large pore spaces, alluvial aquifers have relatively high permeability. They also are recharged more readily than most bedrock aquifers because precipitation and runoff are concentrated into the topographic low spots that correspond with stream and river networks that formed these aquifers. Collective extent of the Alluvial and Terrace Aquifers in Oklahoma exceeds 6.1 million acres. Considering these numerous factors, it is no surprise that the Alluvial and Terrace Aquifers are a major groundwater resource for Oklahoma. Since 1990, the Alluvial and Terrace Aquifers were the source for ~17.5% (~130 MGD) of groundwater withdrawn, second only to the High Plains Aquifer that was the source for ~58.1% of groundwater withdrawn.

Hypothetical groundwater-surface water interactions are illustrated here:

http://ga.water.usgs.gov/edu/earthgwdecline.html

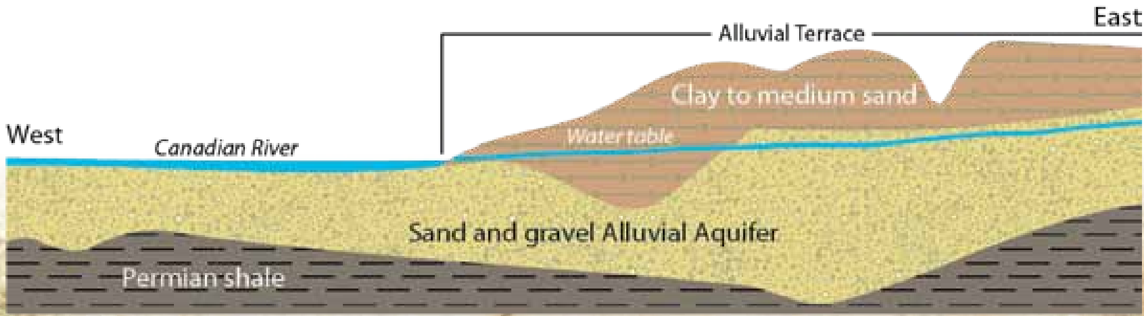




Hydraulic conductivity is a measure of the ease with which water can move through pore spaces or fractures. The diagrams on the left represent close-up views of Terrace Aquifer material and sand and gravel Alluvial Aquifer material. 60% of each sample is solid, granular material, and 40% is pore space.

Questions to Ponder/ Activities

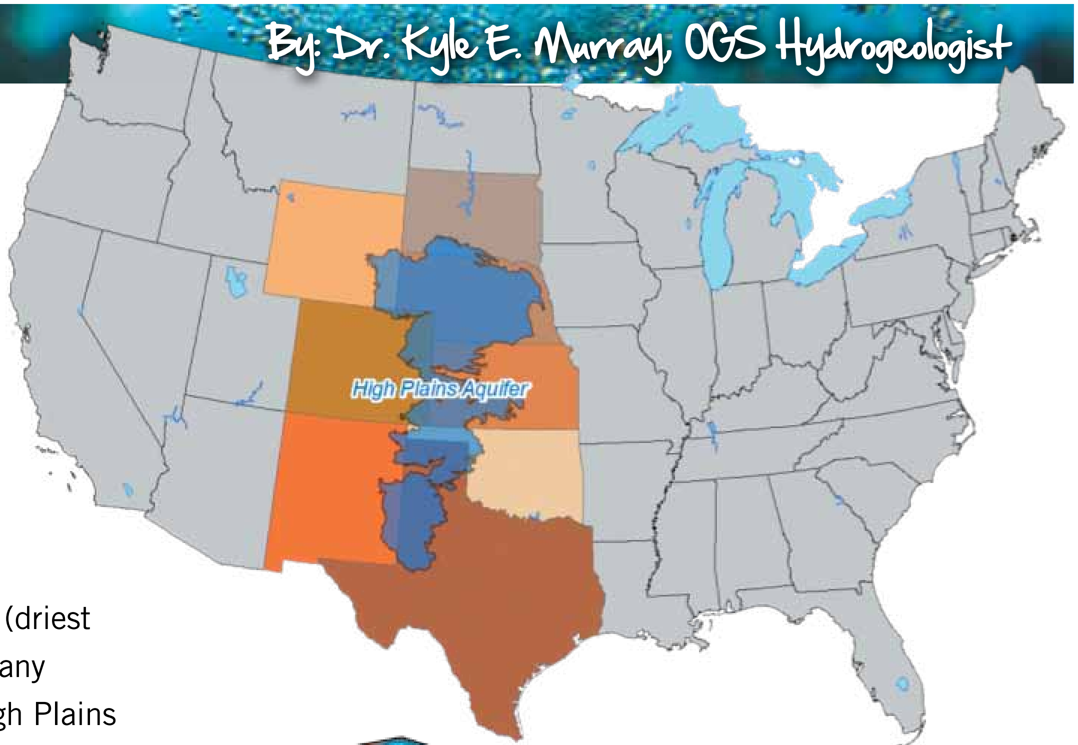
1. With a pencil, trace the path that groundwater would take between T1 and T2 and then the path between A1 and A2. Use a stopwatch to time how long it takes you to trace each path, while keeping your pencil only in the saturated pore space (cannot go through solid particles).
2. Give two reasons why it takes longer for groundwater to move from T1 to T2 than from A1 to A2. In other words, why is the hydraulic conductivity of the clay to medium sand material less than hydraulic conductivity of the sand and gravel material?



Generalized Cross-Sectional Profile Not to Scale

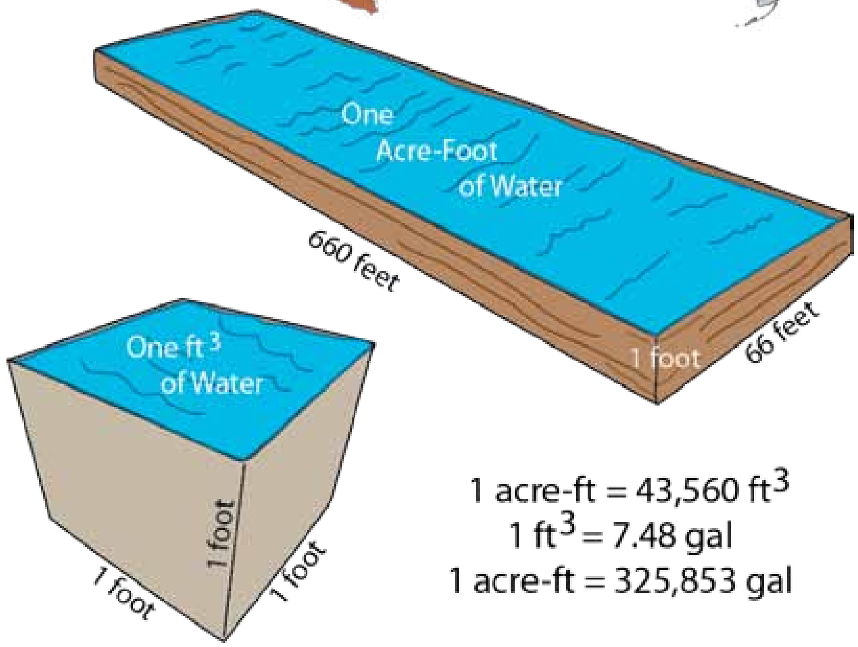
High Plains (Ogallala) Aquifer

By: Dr. Kyle E. Murray, OGS Hydrogeologist



The High Plains Aquifer is one of the most prolific aquifers in the United States. It encompasses parts of eight states including Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming. The High Plains Aquifer is sometimes referred to as the Ogallala Aquifer because the Ogallala is the primary geologic formation in the system. The High Plains Aquifer underlies the panhandle (driest part of Oklahoma) and has the greatest extent of any aquifer in Oklahoma. It is the presence of the High Plains Aquifer and thousands of groundwater wells that allow for irrigated agriculture, livestock and aquaculture in this part of the state. Approximately 252 MGD of groundwater are withdrawn from the High Plains Aquifer in Oklahoma with 86% used for irrigation and 8% used for livestock and aquaculture.

In regions where ranching and agriculture are the predominant land use, plots of land are measured in units of acres. These regions of the United States may be responsible for water volumes being measured in units of "acre-feet."



$$1 \text{ acre-ft} = 43{,}560 \text{ ft}^3$$
$$1 \text{ ft}^3 = 7.48 \text{ gal}$$
$$1 \text{ acre-ft} = 325{,}853 \text{ gal}$$

Questions to Ponder/Activities:

1. If the population in the parts of Oklahoma overlying the High Plains Aquifer was 47,740 and the total groundwater withdrawal was 252 MGD, how many gallons of groundwater were withdrawn per person per day?
2. Why is this so much higher than the statewide average of about 514 gal freshwater withdrawn per person per day?
3. If you have a water meter, look at two consecutive water bills for your home, how many gal of water does your household use per month? How many people are in your home? What is the water use per person per day? And how does it compare to the other numbers you've calculated?

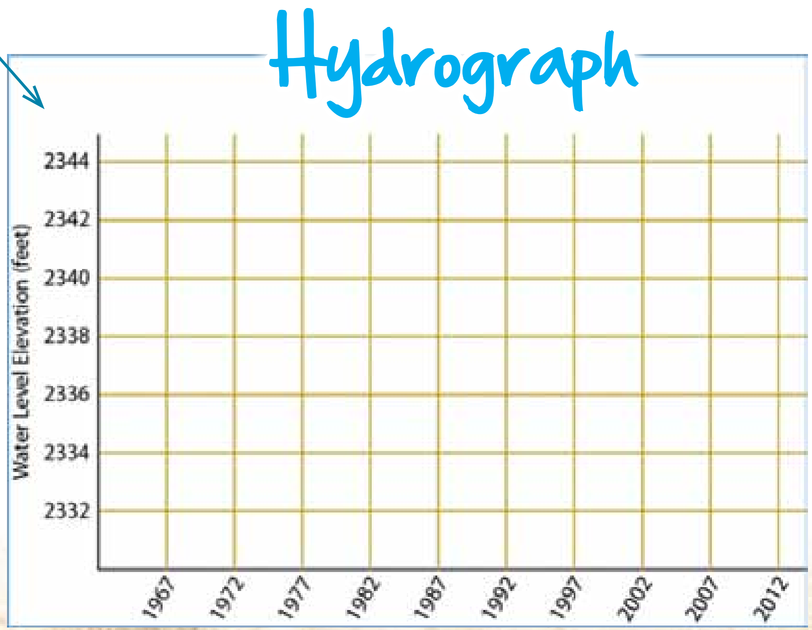
High Plains (Ogallala) Aquifer

By: Dr. Kyle E. Murray, OGS Hydrogeologist

Data Analysis:

1. Depth to water (DTW) in a Beaver County well has been measured in January of every year since 1967. Calculate the Water Level Elev (ft) for each year listed in the table below, using the equation: Water Level Elev (ft) = Ground Surface Elev (ft) – DTW (ft). Note: Ground Surface Elev is 2400 ft. **Then plot as a hydrograph.**
2. What trend is illustrated in the hydrograph?
3. What is the rate of water level change (ft/yr) in this particular well?

Year	DTW (ft)	Water Level Elev (ft)	Year	DTW (ft)	Water Level Elev (ft)
1967	55.6	2344.4	1992	62.5	
1972	57.2		1997	63.5	
1977	58.2		2002	63.7	
1982	60.5		2007	63.7	
1987	62.2		2012	64.3	



It is well known that the amount of water withdrawn from the High Plains Aquifer far exceeds the amount of water that naturally recharges the aquifer each year. As a result, water levels have declined (on average) between pre-development and 2009: CO (-13.2ft), KS (-22.8ft), NB (-0.9ft), NM (-15.1ft), OK (-12.3ft), SD (0.0ft), TX (-36.7ft), and WY (-0.4ft).

More resources:
http://pubs.usgs.gov/sir/2011/5089/pdf/SIR2011-5089.pdf
http://water.usgs.gov/ogw/aquiferbasics/hpaq.html

Municipalities such as Chandler, Del City, Edmond, Guthrie, Midwest City, Norman, Oklahoma City, and Shawnee draw a large portion of their public water supply (~66%) from the Central Oklahoma aquifer. The geologic units of the Central Oklahoma aquifer system include the Hennessey, Garber Sandstone, Wellington Formation, and the Chase, Council Grove, and Admire Groups. Arsenic, chromium, selenium, and radioactive elements are naturally occurring in these units; therefore, these elements are dissolved or suspended in groundwater produced from wells. Arsenic concentrations in groundwater have been measured to be as high as 122 parts per billion (ppb), and several parts of the aquifer produce water that exceeds the EPA permissible concentration (10 ppb) of arsenic in drinking water. As a result, most public water utilities either: (1) blend surface water (lower arsenic levels) with groundwater (higher arsenic levels) to reduce the concentration, or (2) treat the water using a process that, for example, removes As(III) and As(V) by adsorption onto a ferric oxide media similar to the mineral goethite.

Hypothetical Problem:

1. You own groundwater wells that are located close to the end users, so it is economical to produce water from wells and distribute that water through a public water supply. However, because the Arsenic concentration (C_{GW} = 20ppb) from your groundwater wells exceed the EPA MCL, you must blend it with water from a reservoir that has a concentration (C_{SW}) of 2ppb to reduce the concentration to a permissible level. If your target concentration for the drinking water (C_{DW}) is 5ppb, how many gallons of surface water (V_{SW}) must be blended per gallon of groundwater (V_{GW}) that you produce? See equations below to get started.

More resources: http://water.usgs.gov/ogw/aquiferbasics/cenok.html

Photograph of Garber Sandstone outcrop close to Lake Thunderbird

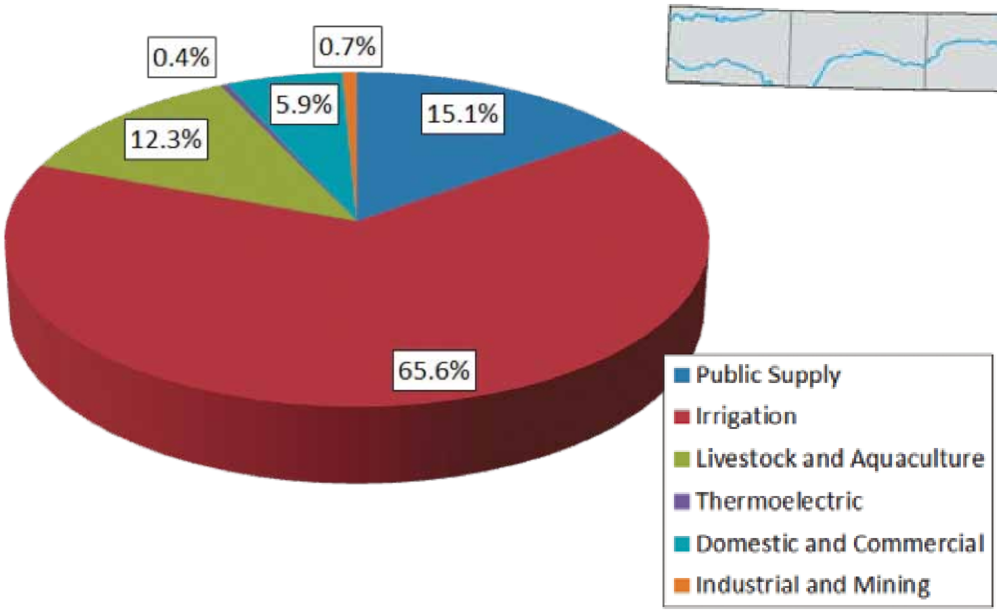
Solve for V_{SW} using the equations below:

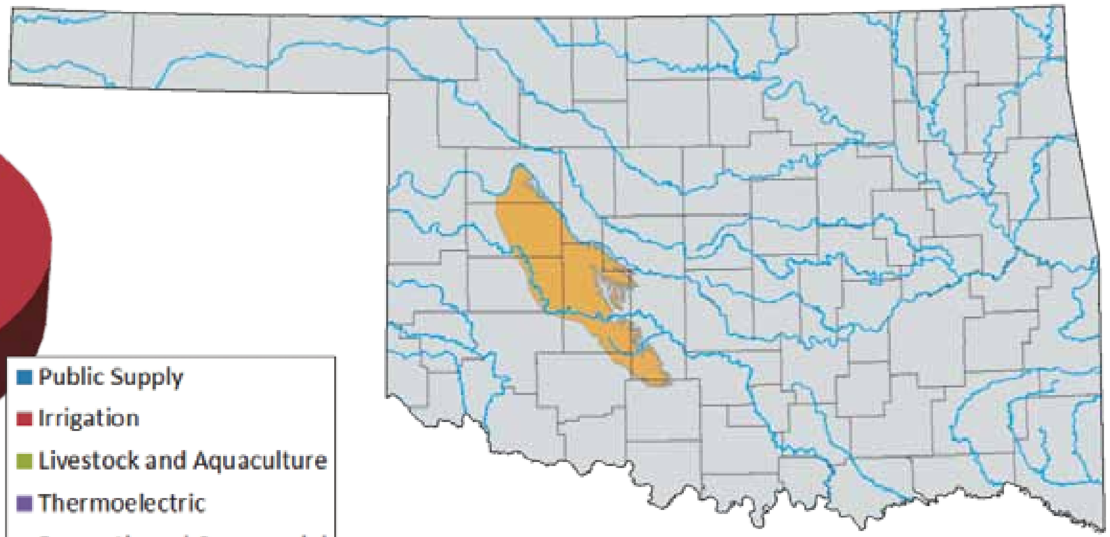
$$C_{GW}V_{GW} + C_{SW}V_{SW} = C_{DW}V_{DW}$$
$$(20ppb)1gal + (2ppb)V_{SW} = (5ppb)V_{DW}$$

$$V_{GW} + V_{SW} = V_{DW}$$
$$1gal + V_{SW} = V_{DW}$$

Rush Springs Aquifer

By: Dr. Kyle E. Murray, OGS Hydrogeologist





The Rush Springs Aquifer is located in west-central Oklahoma where the formations yield substantial amounts of water to groundwater wells. A groundwater well in the Rush Springs Aquifer yields an average of about 200 gallons per minute (gpm), but may produce more than 800 gpm. The Rush Springs Formation, the namesake of the aquifer, is approximately 250 to 300 feet thick and is relatively homogeneous, very fine to fine-grained quartz sandstone. Total groundwater withdrawal in 2005 was estimated to be 51.6 million gallons per day (MGD), with 65.6% of the withdrawal going to irrigation. Well-drained soils above the Rush Springs Aquifer, in addition to the high well yields make this part of the state suitable for irrigated crop production and other agricultural activity, but also prone to contamination.

Water quality is a concern when groundwater from the Rush Springs aquifer is used for drinking water, because nitrate (NO_3) concentrations often exceed the EPA's maximum allowable concentration for drinking water of 10 parts per million (ppm). Median (11 ppm) and mean (14 ppm) concentrations of NO_3 in groundwater from Rush Springs wells exceed permissible limits. Because natural background concentrations are generally less than 2 ppm, these elevated NO_3 levels are due to anthropogenic (human-made) sources such as fertilizer, animal waste, decomposing organic material, and sewage or wastewater from septic system leachfields.

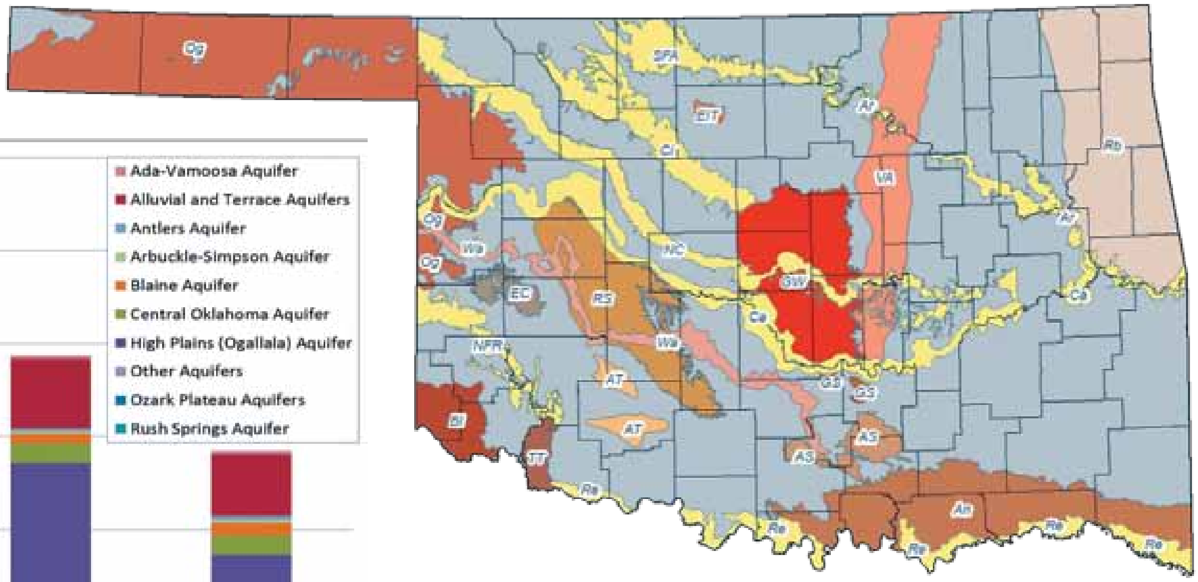
Discover more about the nitrogen cycle here:

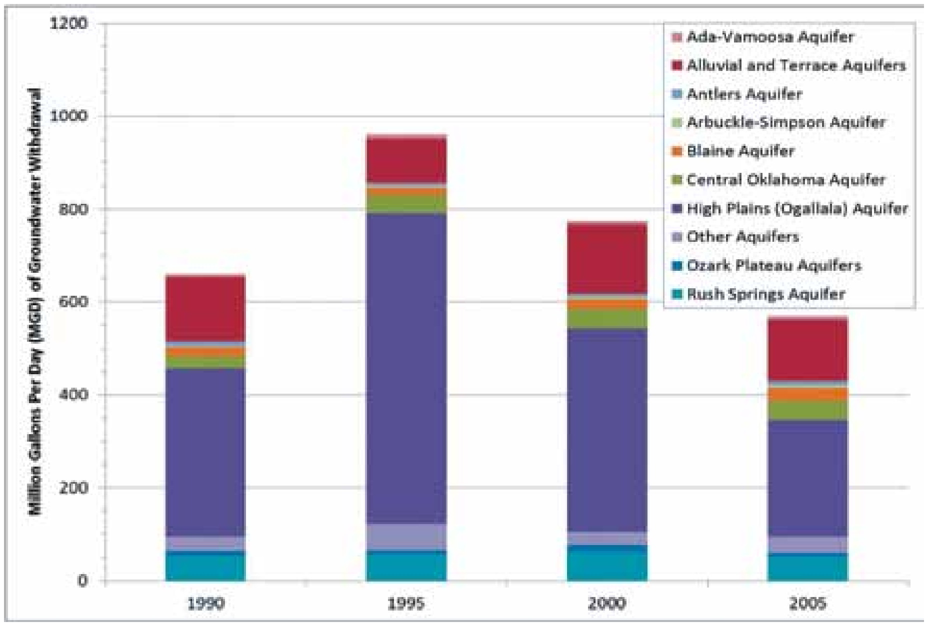
http://www.windows2universe.org/teacher_resources/nitrogen_main.html or look at the nationwide vulnerability of groundwater to nitrate contamination

http://ga.water.usgs.gov/edu/nitrogen.html

Other Aquifers

By: Dr. Kyle E. Murray, OGS Hydrogeologist





Summaries of hydrogeologic settings, water use, and water quality issues were presented for several major aquifers in the preceding pages of this workbook. The top 4 producers, in terms of annual groundwater withdrawals, were the High Plains, Alluvial & Terrace, Rush Springs, and Central Oklahoma Aquifers. It is important to recognize that the hydrogeologic setting is different for each aquifer and groundwater is used for different purposes in each part of the state. In addition, the amount of precipitation and overlying land use may be vastly different and affect the rate of recharge or potential for contamination.

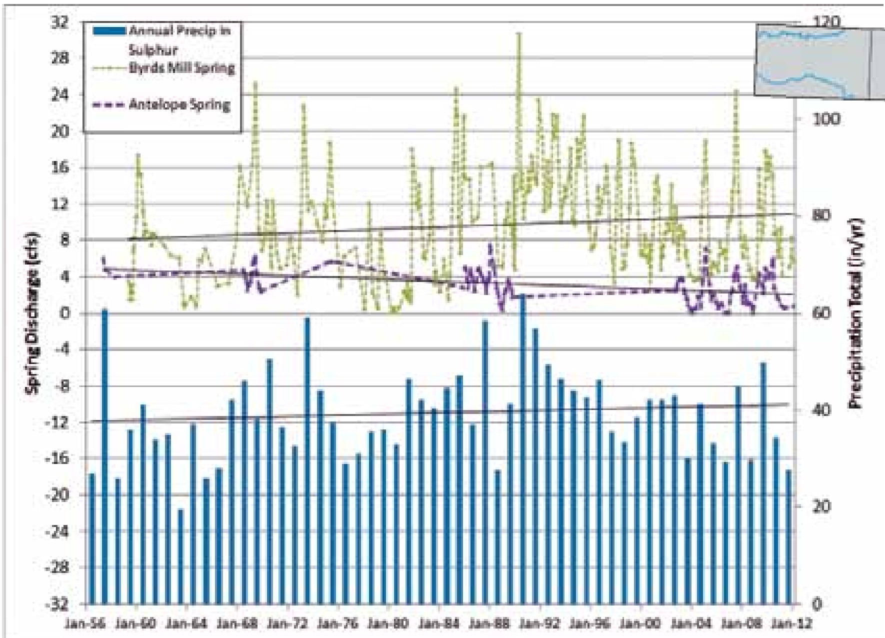
On the next few pages we will examine a couple other major aquifers that cover much smaller geographical areas within Oklahoma. Nonetheless, groundwater from these aquifers and all others are vital to maintaining Oklahoma industries and our way of life.

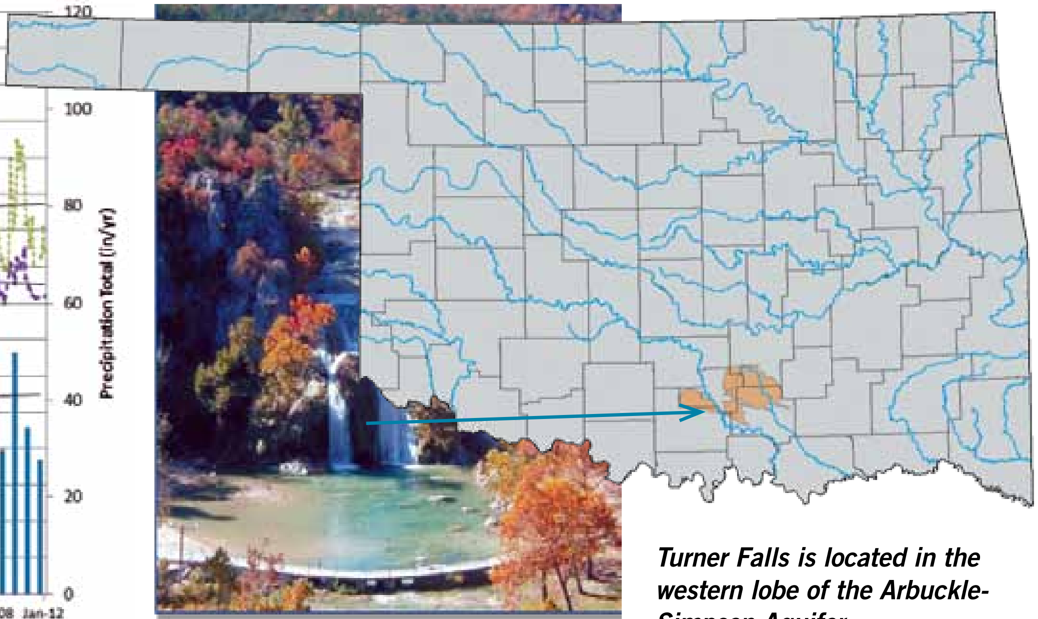
Water for Thought:

1. Some aquifers are completely contained within the borders of Oklahoma and others cross the state boundary. Thus, each aquifer can be categorized as (A) an Oklahoma aquifer, or (B) a regional aquifer. Refer to maps on previous pages to categorize the 9 aquifers shown in the chart above (excluding other aquifers group).
2. Which "Oklahoma aquifer" has not yet been covered in this workbook?
3. Which "regional aquifer" that has not been referenced in this workbook, has the largest volume of groundwater withdrawal?
4. The Ozark Plateaus Aquifer system is comprised of several parts including the Boone Aquifer and Roubidoux Aquifer. Take a look at some other resources on this aquifer system to understand its distribution:
   http://pubs.usgs.gov/ha/ha730/ch_d/gif/D088.GIF
   and
   http://pubs.usgs.gov/ha/ha730/ch_d/D-text5.html

Arbuckle-Simpson Aquifer

By: Dr. Kyle E. Murray, OGS Hydrogeologist





Turner Falls is located in the western lobe of the Arbuckle-Simpson Aquifer.

The Arbuckle-Simpson Aquifer is predominantly limestone with relatively intense fracturing and faulting. Limestone slowly dissolves to create focused recharge features and openings or caves above and below the water table. This "karstification" makes the Arbuckle-Simpson a karst limestone aquifer. In karst regions, groundwater and surface water are a single dynamic hydrologic system where solution channels exchange water between the surface and subsurface. The Arbuckle-Simpson Aquifer encompasses parts of Carter, Coal, Garvin, Johnston, Murray, and Pontotoc Counties and is the principal source of drinking water for about 22,000 people in south-central Oklahoma. Because of the importance of the aquifer for water supply, the U.S. EPA designated the eastern segment of the Arbuckle-Simpson as a sole source aquifer. Groundwater withdrawals from karst aquifers impact surface streams, and vice versa, which requires conjunctive use strategies for managing surface water and groundwater as a collective water resource. In this type of geologic setting, groundwater levels in the unconfined portion of the aquifer will rapidly respond to precipitation events and be affected by periods of drought. This connection to climatic variability makes it difficult to discern natural variations in water levels from anthropogenic impacts.

Water management and regulatory frameworks are designed to sustain water resources long into the future. In the case of the Arbuckle-Simpson Aquifer, the volume of water in storage (estimated to be 9,408,461 acre-feet) plus annual recharge (estimated to be 182,288 acre-feet or ~14.4% of average annual precipitation) could be considered the supply, and the annual groundwater withdrawal (estimated to be 7,365 acre-feet) plus baseflow/spring discharge at the surface (unknown amount) could be considered the demand. If annual recharge exceeds annual demand then groundwater storage and levels should be sustainable under current practices and average climatic conditions. If annual demand exceeds annual recharge then the aquifer may be depleted over time.

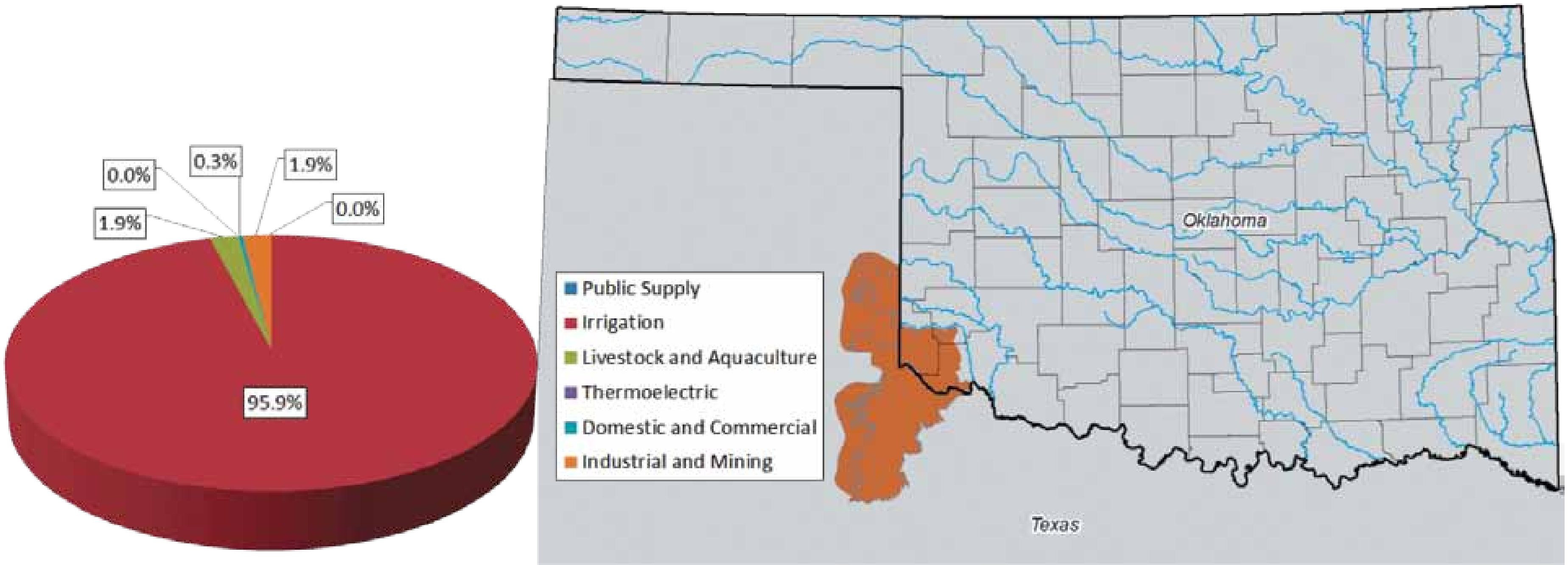
Questions to Ponder/Activities

1. How many acre-feet of water would be discharged at the surface via springs or baseflow to balance the equation: Annual Recharge = Annual Groundwater Withdrawal + Annual Baseflow/Spring Discharge?
2. What is the average annual total discharge from the 2 largest monitored springs in the Arbuckle-Simpson Aquifer area?

Spring	Average Annual Discharge (acre-feet per year)
Antelope Spring	5430
Byrds Mill Spring	6284

Blaine Aquifer

By: Dr. Kyle E. Murray, OGS Hydrogeologist



The Blaine Aquifer spans southwestern Oklahoma and northern Texas. The Permian age Blaine Formation is composed of red silty shale, gypsum ($CaSO_4 \cdot H_2O$), anhydrite ($CaSO_4$), salt, and dolomite. Groundwater is obtained from cavities, solution channels, and fractures in the gypsum, anhydrite, and dolomite rich beds. Produced water is relatively poor in quality with most wells yielding water that ranges from 1000 ppm to 10,000 ppm total dissolved solids (TDS). Water from the Blaine Aquifer is seldom used for public or domestic supply because less than 1000 ppm is "fresh" water and EPA's secondary drinking water standard for TDS is 500 ppm. In many cases the sulfate concentrations exceed the EPA's secondary standard of 300 ppm, which is due to the abundance of sulfur containing minerals and rocks.

Additional Resources for Blaine Aquifer:
http://water.usgs.gov/ogw/aquiferbasics/blaine.html

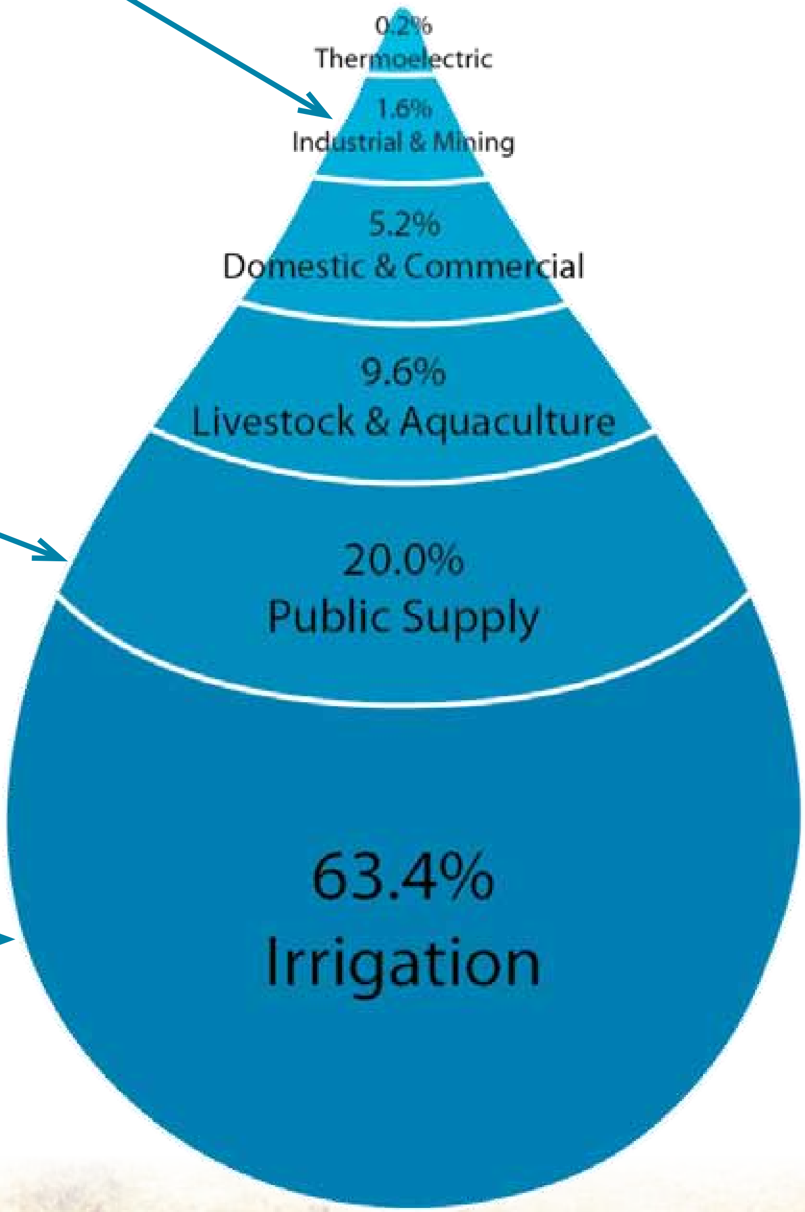
Groundwater is a vital resource for all citizens and sectors of our economy. The standard of living that we enjoy in the United States and Oklahoma is partly due to our ability to use and manage water as a resource. Goods, services, and products that we sometimes take for granted would not be possible without careful management of water, mineral, and earth resources. Some public utilities and private water users in the state of Oklahoma have been providing and using groundwater for more than 100 years. In some cases, best management practices have reduced water loss and water consumption. In other situations, there is a lot of room for improvement. It is in the best interest of our state to conserve and protect our precious groundwater resources.

Questions and Activities:

1. The percentage of groundwater withdrawals attributed to six sectors are shown in the pie chart above. What percentage of the Blaine Aquifer groundwater withdrawals are used for non-agricultural purposes?
2. Groundwater high in TDS and sulfate is used for irrigation above the Oklahoma portion of the Blaine Aquifer. What surface water system might receive the runoff water?

Industrial & Mining: Oklahoma enjoys an abundance of quality mineral resources (aka aggregates) including sand, gravel, limestone, granite and gypsum. These minerals form the foundation of Oklahoma's multibillion dollar annual construction market. Mining operations use water in a variety of ways, such as for dust suppression, transfer of minerals around a mine site or for cleaning mined aggregate to meet government specifications. Mining operations typically recycle and re-use water multiple times making them highly conservative and efficient. In Johnston County, for example, 13,096,966 tons of product was mined in 2007 and groundwater withdrawals for all industrial & mining activity was about 25.6 million gallons. That equals an average of 2 gallons of groundwater withdrawn per ton of mined material.

Public Supply: Many cities and towns in Oklahoma derive part of their public water supply from aquifers. As a result, 20% of the groundwater withdrawn from our aquifers goes to public supply. Oklahoma County, which contains the Oklahoma City-Edmond-Del City-Midwest City urban center, is the most populated county in the state and overlies the Central Oklahoma Aquifer. In 2005, the population of Oklahoma County was approximately 684,200 people and the estimated volume of water withdrawn from surface water and groundwater systems (for public supply) was 34.2 billion gallons. That equates to 137 gallons per day per person. If each person in Oklahoma County reduced their consumption by 10% then 3.4 billion gallons of water would be conserved each year.



Irrigation: Groundwater makes agriculture possible in some parts of Oklahoma that do not receive sufficient precipitation. Thus, a large majority of the groundwater withdrawn from many of our aquifers goes to the irrigation of crops. Texas County is one of the most productive agricultural regions of the state, with an estimated 210,826 acres of irrigated land. The High Plains aquifer provides approximately 54.4 billion gallons of irrigation water each year for use in Texas County, or 258,100 gallons per acre.

Encourage Responsible Use: We have seen steady declines in statewide groundwater withdrawals from 1995 (960 MGD) to 2000 (774 MGD) to 2005 (570 MGD). This may be the result of improved management practices in all sectors. Hopefully, we will continue to see improvements and responsible water use.

Oklahoma Rocks, Water and Aggregate Mining

The Oklahoma Aggregates Association (OKAA) is proud to be a sponsor of this Edition of Oklahoma Rocks. As you have learned in these lessons, groundwater is found in a variety of different rock and sand formations throughout Oklahoma. Many of these aquifers are near mineral deposits that are mined by our members to produce crushed stone for concrete and asphalt, limestone for cement, sand for concrete and glass, gypsum for sheetrock, and many other uses. Some of these mines were in operation when Oklahoma became a state.

There is an old miners' saying that goes "If it can't be grown, it has to be mined." Take a few minutes and think about this (maybe for some extra credit!): How would our lives be different without materials mined from the earth? What would our roads look like? Your school building? Your house?

Oklahoma Aggregates Association

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Many mines operate near groundwater aquifers and almost all use water in their operations. Muddy gravel and stone makes weak concrete, so water is often used to wash material before it is sold. Water is also sprayed on the mine roads to control dust. Many years ago, water was hard to come by and miners knew the true value of it. Once the water was used in the mine, it was muddy, so they invented ways to settle and remove the silt so the water could be reused. These same methods are still in use today.

Mining is strictly regulated and mine sites are designed to prevent contaminants from reaching the water supply. Retired mine pits can become water reservoirs that provide backup sources for downstream users during droughts. Some of these reservoirs feed marshes or wetlands that provide excellent habitat for waterfowl and wildlife.

OKAA members work hard to make certain our natural resources are used in a sustainable fashion so that future generations can enjoy the same great lifestyle we do today.

What Local Professional Organization Supports Science Education ?

The Oklahoma Geological Foundation is a tax-exempt organization that has funded scholarships and awards throughout the State of Oklahoma to pre-college students, undergraduate and graduate students, teachers, and educational institutions on an annual basis.

The Foundation is strongly committed to making a significant, positive impact to science education and to the lives of students.

The Foundation's Directors encourage teachers and educators at all levels throughout Oklahoma to contact the Foundation regarding financial support and assistance with your science programs.

The Oklahoma Geological Foundation

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