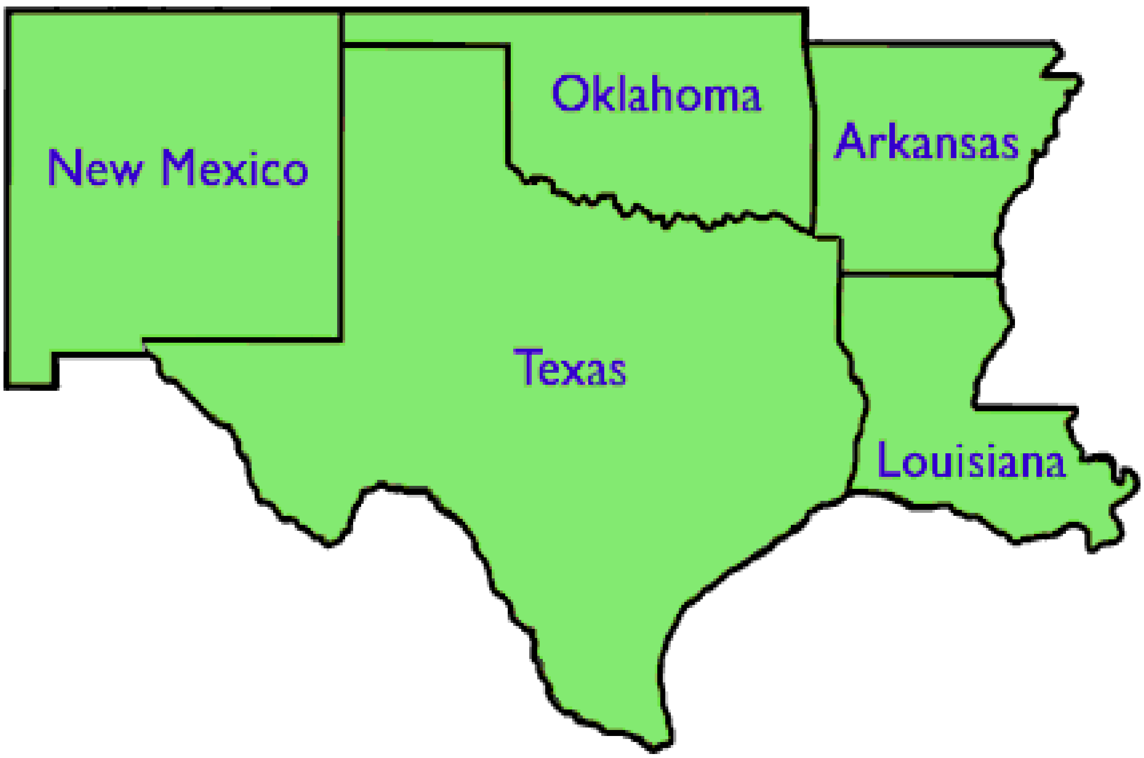
STATE OF THE GROUND WATER REPORT



Ground Water Center
U. S. Environmental Protection Agency
Region 6

Prepared by the Ground Water Center

Source Water Protection Branch

Team Lead: Robert Todd

Team Members: Michael Bechdol, Lisa Pham, Omar Martinez

Significant Contributors: Chris Lister, Clay Chesney, Angela Restivo

U. S. Environmental Protection Agency, Region 6

January, 2009

Table of Contents

State of the Ground Water Report

Introduction

Arkansas

Louisiana

Louisiana (cont.)

New Mexico

Oklahoma

Oklahoma (cont.)

Texas

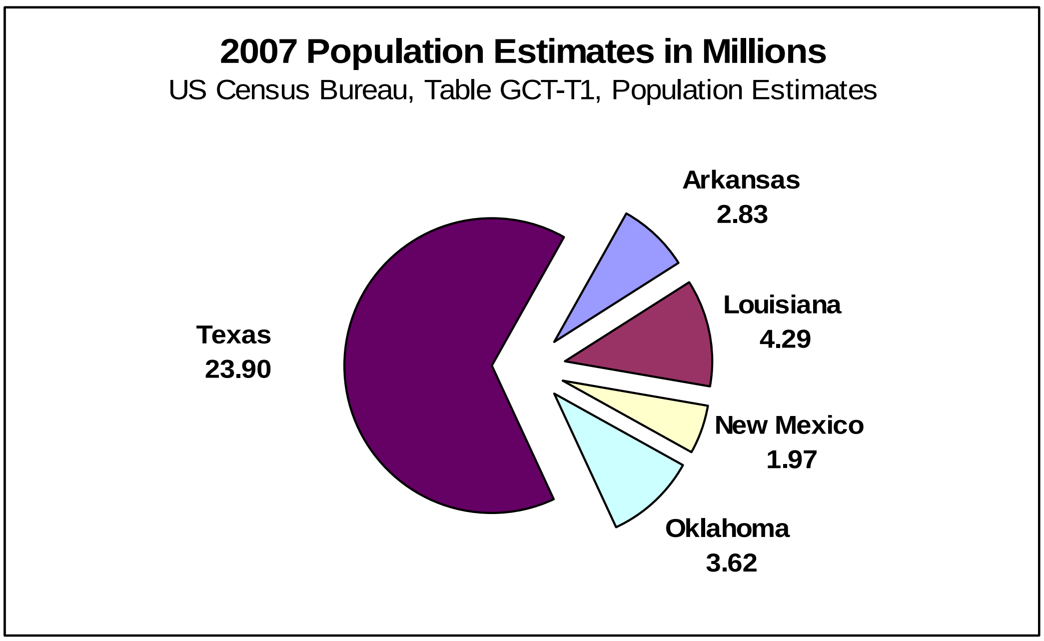
STATE OF THE GROUND WATER REPORT
Introduction
REGION 6

Purpose of the Report

This report is written for the U. S. Environmental Protection Agency's (EPA) Region 6 management team. Its purpose is to provide a summary and short analysis of the region's ground water resources. The report gives a "snapshot" view of the general ground water conditions in each of the region's states and each of the state's regions. Each state is covered in detail with technical references noted, if further information is desired by the reader.

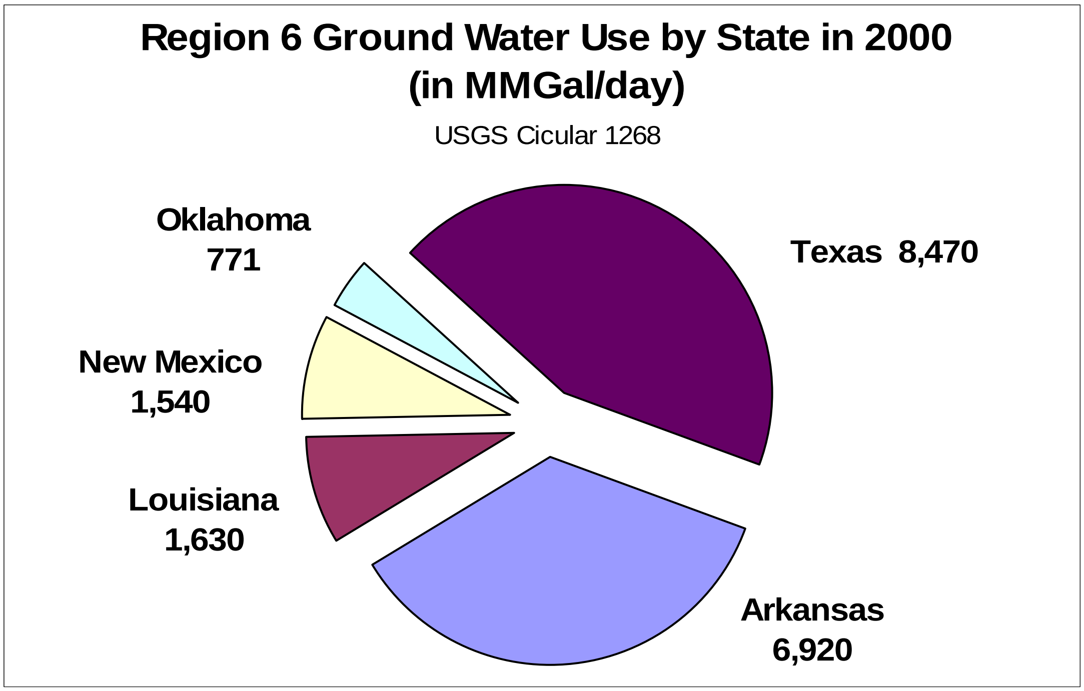
Area and Population

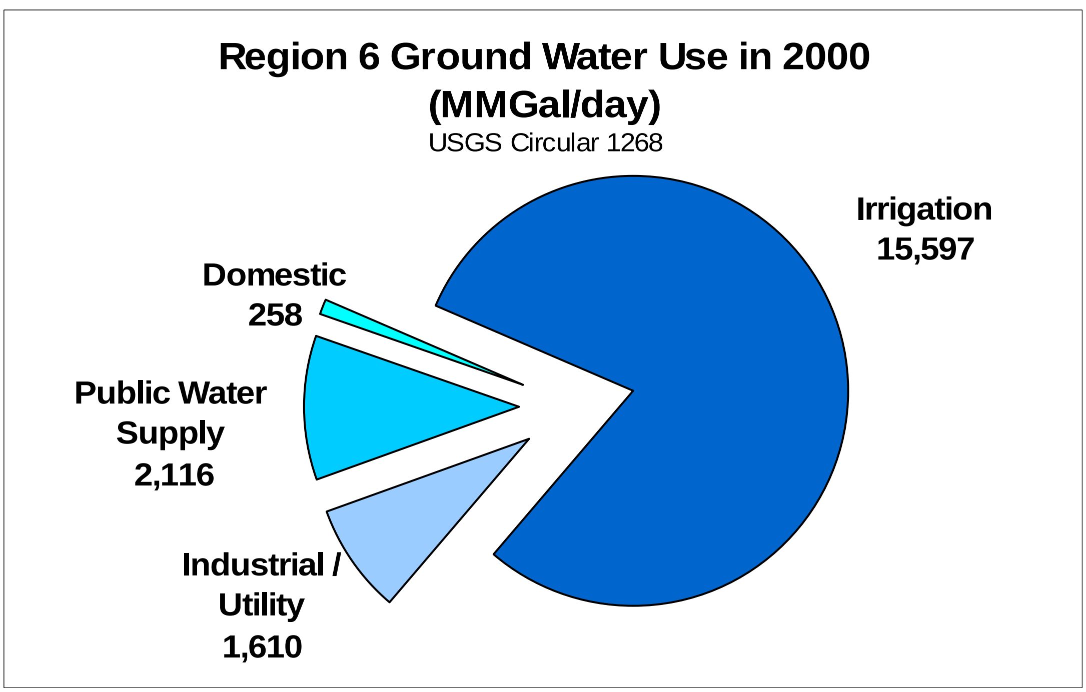
The US EPA's Region 6 includes Arkansas, Louisiana, New Mexico, Oklahoma, and Texas. Region 6 has the authority and responsibility to assure compliance with the nation's major water related pollution control laws within the five states. Lands belonging to 67 Native American tribes are included in that area. The Region's population is estimated to be over 36 million and is distributed among the states as follows:



Use of Ground Water

The population and industry of Region 6's states are reliant on ground water. According to the US Geological Survey, ground water in the region was being consumed at a rate of 19,341 million gallons per day in 2000. The two dominant uses of ground water were to irrigate crops and provide drinking water to the population. The two largest users of ground water in the region are Texas and Arkansas. Both states have large agricultural industries that are heavily dependant on ground water. The major uses of ground water and the distribution of ground water use among the states are depicted in the accompanying graphs.





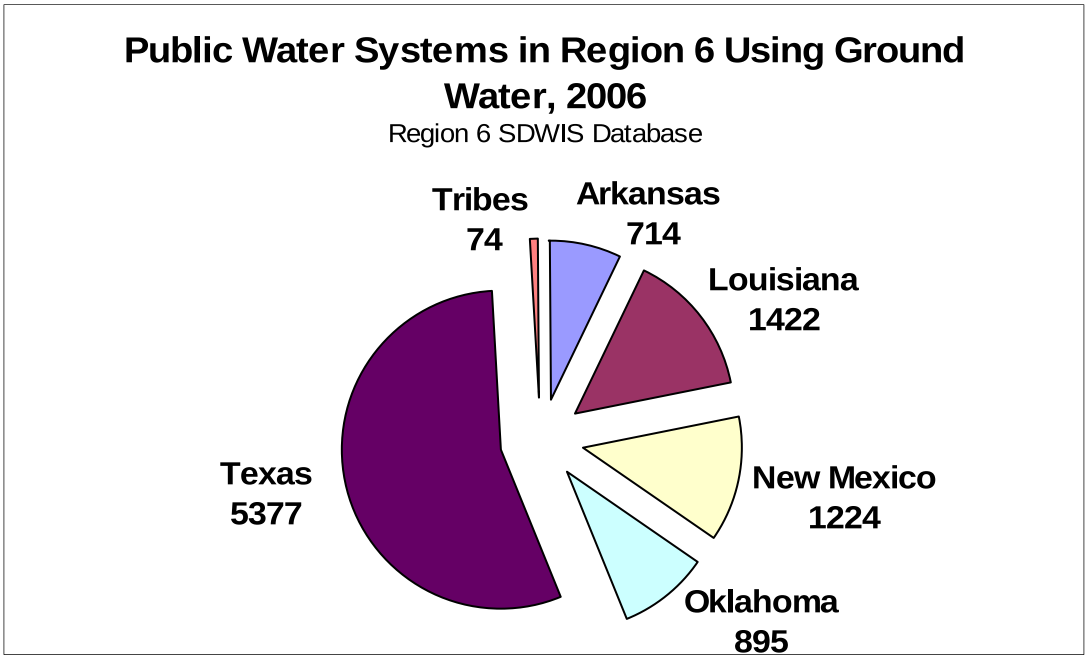
Ground Water Quality

About half of the Region's available ground water has naturally occurring contamination (including fluorides, sulfates, radionuclides, chlorides, and arsenic) which often makes it unsuitable for drinking water without treatment, though much is still usable for irrigation and industrial purposes. In a number of areas, confined animal feeding operations, crop fertilization, use of pesticides, industrial contamination, underground storage tank leakage, and other surface sources have created local water quality problems in the shallower aquifers. These problems are primarily elevated concentrations of nitrates, pesticides and petroleum hydrocarbon constituents. A very important, and vulnerable, source of ground water in the region is the Edwards Aquifer, in the San Antonio/Austin area of Texas. It is a karst aquifer system that can allow surface contamination to quickly enter the body of the aquifer without benefit of the natural filtration and treatment processes provided by natural soils or sands.

Ground Water Quantity

While quality issues are of concern in local areas, a potentially larger concern for the Region involves the available quantity of usable ground water. Many of the most used aquifers are becoming depleted as more water is pumped from the aquifers than surface recharge can replace. The Sparta Aquifer in southern Arkansas and northern Louisiana, the Ogallala Aquifer in the Texas and Oklahoma panhandles, and multiple aquifers in the El Paso and Houston areas are becoming substantially depleted. Critical to this concern is that as the level is lowered, contaminant intrusion such as brine water from underlying geologic strata often reduces the quality of the water, and once the level of an aquifer is substantially lowered, the geologic structure can compress such that it will no longer be recharged with fresh water from the surface. Aquifers in central southern Louisiana experienced extended declines over the last few decades, but have begun to recover as the result of effective water use permitting and conservation programs.

At the end of 2006, there were approximately 9,700 Public Water Supply systems in Region 6 states depending, in whole or in part, on fresh, high quality ground water. The majority of these are small, supplying less than 3,300 people. Some major cities in Region 6 relying on ground water include San Antonio, El Paso, Houston, Albuquerque, Baton Rouge, and Lafayette. The following graph depicts the distribution of these systems among the five states and Tribal lands.



Regulation and Ground Water Protection Programs

EPA's authority over ground water and its use is limited. No Federal contaminant level programs exist for ground water. EPA is not authorized to regulate domestic wells and there is no Federal regulation governing the amount of ground, or surface, water used in the states. Most ground water protection in these areas is afforded by the individual states through their own authority. EPA offers funding, guidance and expertise to the states to assist them in these areas.

EPA does administer two major environmental statutes that do have a direct impact on the quality of the nation's ground water. These two major Federal Statues are the Safe Drinking Water Act (SDWA) and the Clean Water Act (CWA).

The Underground Injection Control (UIC) program, authorized by the SDWA, regulates injection of liquid wastes into the ground. The program assures that the wastes injected into subsurface zones do not threaten underground sources of drinking water. Each of the Region 6 states has developed a state program to implement the UIC program in their states with the Region providing oversight of the delegated programs.

The Source Water Assessment and Protection Program and the Wellhead Protection Program, also authorized by the SDWA, focus on protecting waters that serve as a source for public water supply wells. These programs concentrate on identifying and controlling potential sources of ground water contamination near the water supply wells. Each Region 6 state participates in this basic water protection program.

The Sole Source Aquifer (SSA) protection program, authorized by the SDWA, is designed to safeguard aquifers designated by EPA as the sole or principal source of drinking water for a population. Under the program, federal grants, loans, loan guarantees and other financial assistance can be denied for projects threatening these aquifers. Region 6 has designated six sole source aquifers: the Chicot and Southern Hills Aquifer systems in Louisiana; the Espanola Basin Aquifer system in New Mexico; the Arbuckle Simpson Aquifer in Oklahoma; and the Edwards Underground Reservoir and the Austin Area Edwards Aquifer in Texas. Region 6 states with SSAs have taken action to reduce and prevent contamination of these vital resources.

The CWA allows EPA to award funds to state environmental protection agencies so they may develop and implement independent programs to prevent the pollution of both surface and ground water. Although the CWA is primarily a surface water program, EPA strongly recommends our states apply 15% of CWA Section 106 grant monies (for point-source contamination) toward developing and implementing ground water protection programs. All of the Region 6 states have maintained active programs for ground water protection under these grants. A portion of the CWA Section 319 (for non point sources) has also been used in ground water protection projects. Surface water protection programs, particularly those funded under Section 106 and 319, also act to protect ground water by reducing pollutant loads that enter the state's aquifers during recharge. The surface water discharge permit program under the National Pollutant Discharge Elimination System (NPDES) serves the same indirect function.

General Trends

In general, each of the states has taken an active role in ground water protection including; ground water study and planning, management of agricultural contaminants, regulation of spill clean up activities, permitting programs to improve the quality of waste water treatment and limiting the contaminants released to ground water recharge zones by industrial sources. As a result, the ground water of the Region remains generally of good quality with some areas of concern.

Each of the states promotes conservation of water resources, including ground water. For example, water withdrawals from Louisiana's Sparta Aquifer have been reduced by over 45% since 1980. These efforts include public education, promotion of conservation, and water use permitting in certain areas.

While conservation efforts have been successful in reducing withdrawals from the Sparta, and other aquifers in the region, there remains a need to reverse the long term declines in many major aquifers. In particular, the Sparta aquifer in southern Arkansas and northern Louisiana, the Chicot and Southern Hills aquifer systems in central and south Louisiana, and the Ogallala, Hueco-Bolson, Carrizo-Wilcox and Gulf Coast Aquifers in Texas all show evidence of dramatic decline over the last decades. Recent rainfall in Oklahoma has helped alleviate the decline of ground water levels in that state's alluvial aquifers, but has not had a noticeable impact on declining bedrock aquifers. A return to a drought cycle in Oklahoma, without increased conservation efforts, is likely to once again place the state's aquifers in jeopardy.

Unrestrained use of ground water for agriculture and human consumption will continue to lower the water levels of major aquifer systems. When this happens, saltwater intrusion into the affected aquifers reduces the overall water quality of the aquifer and allows geologic subsidence to occur. In the Houston area, overuse of the Gulf Coast bedrock aquifer has caused significant land subsidence, which, in turn, severely impairs the underlying aquifer's ability to be recharged. Every Region 6 state except New Mexico has definite problems with saltwater intrusion into at least one of their major aquifers.

Conclusion

The overall quality of recoverable ground water in Region 6 states is good, but with areas of high concern. Pollution threatening the shallower alluvial ground water aquifer is, in most cases, man made. Areas of naturally occurring contamination affect about one half of the known ground water in the region, but much of that is useable for irrigation and industry.

The Region's state governments have taken on responsibility for implementation of EPA's Underground Injection Control, Source Water Assessment and Protection, and Wellhead Protection Programs. Every state except New Mexico has a ground water monitoring program to assess the quality of accessible ground water. The state of Texas has given special status to the recharge zones for the Edwards aquifers in central Texas due to the vulnerability of these karst systems to ground level pollution.

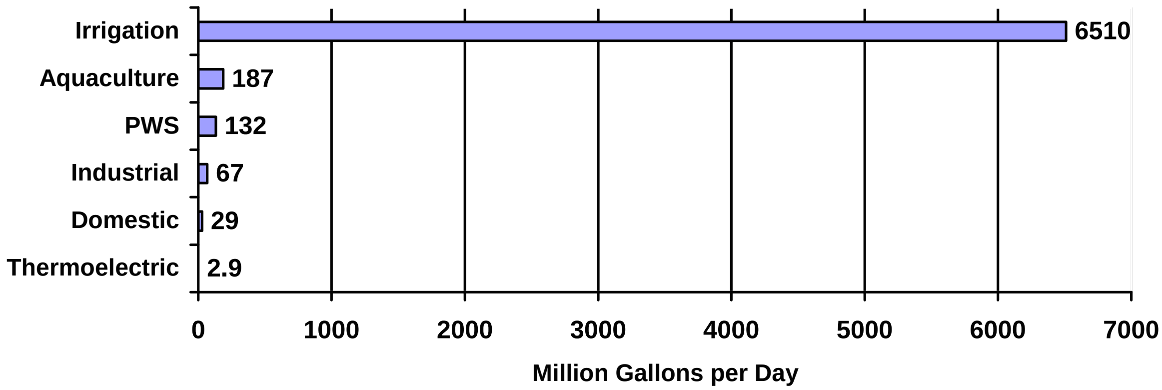
The state of New Mexico does not have a systematic statewide ground water quality monitoring program in place. New Mexico needs to begin this effort in order to completely characterize the conditions of the state's water resources. The other four Region 6 states need to continue their efforts to better characterize and protect the condition of their ground water through their current ground water monitoring. Each state would benefit from increased or stable funding sources to solidify their ground water monitoring programs.

Following this introduction each Region 6 state is described in detail. At the end of these descriptions, future efforts that could protect the overall quality and condition of groundwater in the state are identified along with ways in which the US EPA could be involved with the state. All the Region 6 states could benefit from additional EPA resources, both in funding and personnel to achieve their goal of protecting groundwater.

Arkansas

GROUND WATER SUPPLIES 33%OF THE POPULATION'S DRINKING WATER

GROUND WATER USE (in 2000)



IMPORTANCE OF GROUND WATER IN ARKANSAS

Drinking Water

Ground water is important to the health of the citizens of Arkansas; it supplies 33% of the State's drinking water (Hutson, from pp. 14, 17). About 13 % of the State's residents rely on domestic wells which are not regulated to assure adequate water quality (Hutson, p. 17).

Agriculture

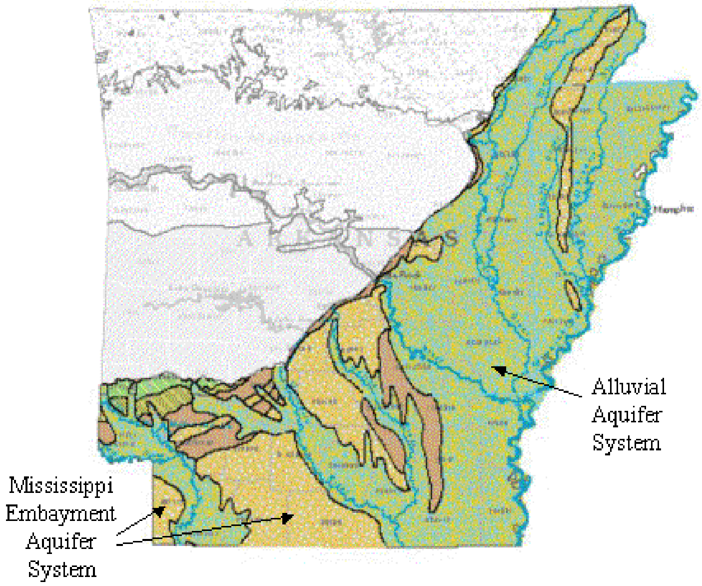
Because rice is a major crop in the State, withdrawal for irrigation is by far the largest category of water use. Irrigation accounts for 73% of the total water withdrawals and 94% of the ground water withdrawals in the state. Arkansas ranks third in the U.S. for the amount of ground water used for irrigation, and ranks fourth, after California, Texas, and Nebraska for total ground water use (Hutson, from pp 6, 21).

MAJOR AQUIFERS & GROUND WATER QUALITY

The State can be divided into three regions- aquifers and water quality problems in each.

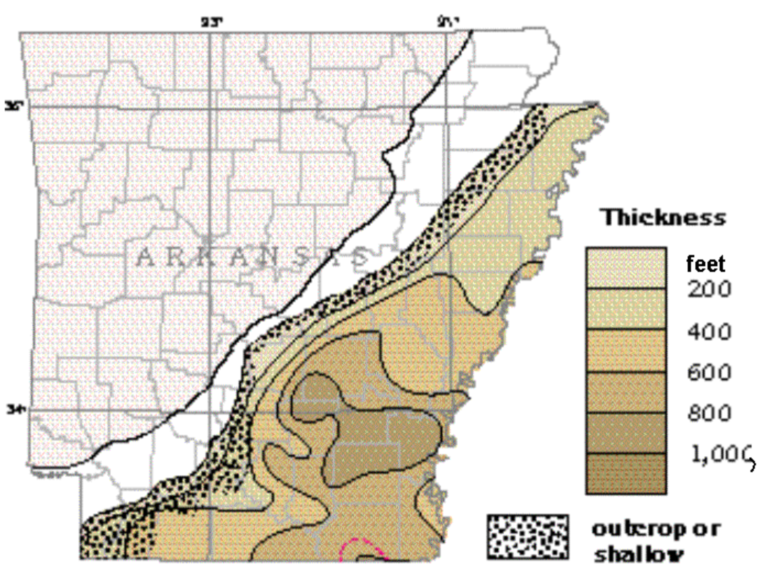
The Mississippi Embayment – abundant water-bearing sands

By far, the largest aquifers in Arkansas are contained in the Mississippi Embayment, a regional physiographic province that centers on the lower Mississippi River and includes large parts of Louisiana, Arkansas and Mississippi. The two aquifer systems in the Embayment contain sands that produced almost 99% of the ground water pumped in the State during 2003 (Arkansas, Arkansas Ground Water Protection, from p. 86).



Aquifers of the Mississippi Embayment

Sedimentary deposits from the major rivers in Arkansas have formed an alluvial aquifer system which covers much of the surface of the Mississippi Embayment. This system produced about 95% of the ground water withdrawn in Arkansas during 2003 (Arkansas, Arkansas Ground Water Protection, p. 17). This surface layer (shown in green on the map to the left) was built up by the Mississippi River, but deposits from other rivers have merged with those from the Mississippi. The Red River alluvium occupies a separate area in the southwest of the state. Water from the alluvial aquifers is high in manganese, iron and salinity in many places. It is used extensively for irrigation. In places were better quality water is not available from deeper aquifers, water from the alluvial is used as a source of public and domestic drinking water (Czarnecki, p. 1).



SPARTA and MEMPHIS AQUIFERS

Beneath the alluvial aquifer, but exposed in several areas, is the Mississippi Embayment's aquifer system. This system contains several aquifers that provide significant amounts of water locally for public and domestic use. The most important of these is the Sparta aquifer and its northern extension, the Memphis aquifer. Together these two provide 4% of the ground water used in Arkansas (Arkansas, Arkansas Ground Water Protection, from p. 86). The Sparta provides good quality water to industry and agriculture located in southeastern and eastern Arkansas. Cities and communities in the area use the Sparta aquifer for their public water supply (PWS) with minimal treatment (McKee, p. 2)

Water Quality Problems

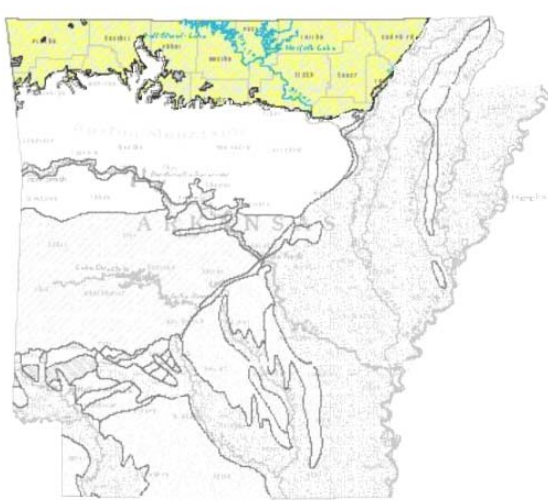
Arsenic: Arsenic is found in several areas in the alluvial aquifer; 22% of the samples from terrace deposits (older stream deposits) and 18% of the samples from the alluvial aquifer in the Bayou Bartholomew area in the Southeast part of the state (Ashley and Drew Counties) show arsenic concentrations above the maximum contaminant level (MCL) of 10 parts per billion. This contaminant is probably desorbing naturally from soils in the area (Kresse, et. al., Occurrence of Arsenic, p 5). Arsenic is not a significant problem for PWSs, however, since less than 1% has been shown to have levels of arsenic requiring treatment.

Pesticides: About 1/3 of the samples from the alluvial aquifer contain detectible pesticides, but none exceeds the MCL. The presence of low levels of pesticides has been recognized for many years (Kresse, et. al., Pesticides, Water Quality, pp 24, 55).

Salt Water Intrusion: There are areas of salt water intrusion from deeper layers into the alluvial aquifer in the Southeast part of the state, related to heavy drawdown of water, irrigation practices and area hydrogeology (Arkansas, Integrated Water Quality, 2004, p 137).

Oil Field, Brine and Bromine Contamination: Contamination of ground water caused by the oil, brine and bromine extraction industries along the southern border of Arkansas has been a problem in the area. However, efforts to clean up sites and improve operations are improving the ground water quality in the area (Arkansas, Integrated Water Quality, 2004, pp A-67, A-77).

The Ozark Plateau – Limestones and Sandstones



Ozark Plateau Aquifers

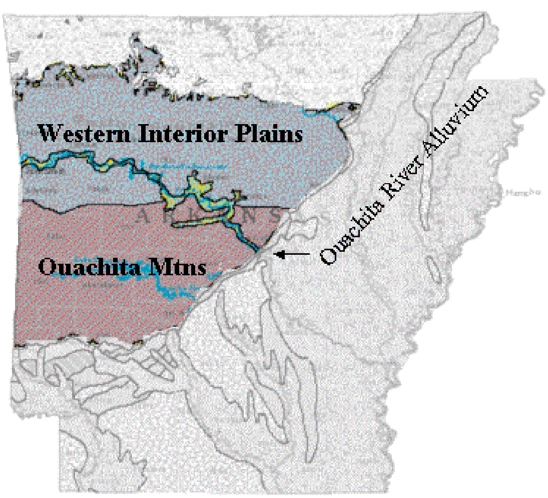
This is an area where limestones cover much of the surface and provide abundant water to shallow wells and feed a number of springs. Ground water is contained in fissures, caves, and fractures and is especially vulnerable to contamination because thin soils and the large conduits within the aquifer provide little natural filtration and treatment for water which enters from the surface (Renken, Ozark Plateaus section). PWS wells in this area are typically completed into deeper sandstones, dolomites and limestones in order to reach better water.

Water Quality Problems

Bacteria and Nitrate: The limestones of the Ozark Plateau have been a long-term problem for ground water quality. Contamination by nitrate and fecal coliform bacteria from septic systems and animal wastes is common, and a number of springs have been posted by the Health Department as health hazards. Aquifer testing shows nitrate elevated above historic levels over wide areas, but exceeding the MCL only in limited areas**.** Land application of manure from numerous poultry farms and infiltration from domestic septic systems are major contributors to contamination (Peterson, p 6-10).

Radiologic Contaminants: The deeper aquifers in the Ozark Plateau contain water with radioactive compounds in sufficient quantities to exceed EPA's MCL for drinking water in some places (Adamski, p. 58-59). These are naturally occurring (Peterson, p. 14) and may need to be reduced in order to meet the U.S. EPA's drinking water standards for radionuclides (Federal Register, p. 76722, p. 76748).

Low - Yield Aquifers in West Central Arkansas



Low Yield Area

South of the Ozark Plateau lies a large area occupied by the Western Interior Plains and the Ouachita Mountains. Much of this area is heavily forested and sparsely populated. The Ouachita River drains from west to east through this area. The alluvial deposits along the course of the river provide abundant water to cities and towns along its course.

In the remaining portions of this area, there is relatively little ground water available because of the dominance of low permeability rocks. Ground water is contained in fractures of the formation's confining unit. Wells within the formation do not produce adequate water for public supply systems and are mainly used for domestic purposes. The Ouachita Mountains region contains deep fissures and fault zones creating ground water flow patterns responsible for the thermal springs located in central Arkansas (Renken, Minor Aquifers section).

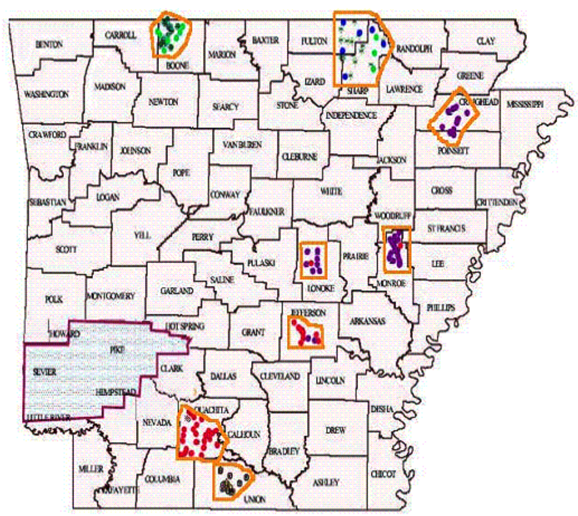
Water Quality Problems

Because of the general lack of aquifers which cover large areas in this part of the State, ground water contamination is generally from point sources of pollution and is usually limited to small areas.

As in the Ozarks, thin soils and relatively large conduits in the fractured rock result in little filtration and attenuation of contaminants from the surface. There is evidence of nitrate contamination of the area aquifers (Arkansas, Contemporary Ground Water, from pp 38, 39).

State Regulation of Ground Water Quality

Arkansas defines ground water as part of "the waters of the state" which are subject to the protections afforded by the Arkansas Water and Air Pollution Control Act. Ground water is thus eligible for clean up and protection activities to the same extent as surface water. The state has no permit system to protect ground water quality, but offers protection through several other avenues. The Arkansas Department of Environmental Quality (ADEQ) conducts ground water studies and oversees cleanup activities at contaminated ground water sites and, sometimes in conjunction with the Arkansas Natural Resources Commission (ANRC), investigates potential and verified contaminant sources. The ANRC also operates a non point source abatement program to protect ground water from agricultural contaminants in the Ozark karst area. The Arkansas Department of Health (ADH) implements the Source Water Protection program and the Wellhead Protection Program which act to protect the quality of ground water serving as a source for PWS wells. The State Plant Board began implementing the Arkansas Agriculture Pesticide Management plan for ground water in 1992. Ground water quality protection activities in Arkansas are funded in large part by EPA grants under Sections 106 and 319 of the Clean Water Act.



ADEQ Ground Water Monitoring Areas in Arkansas
Dots show sample well locations – colors to indicate different aquifers

As a major element of ground water protection in Arkansas, the ADEQ has developed a ground water monitoring program to help assess the quality of ground water in the State. Under the program, begun in the 1980s, nine areas were selected for monitoring and analysis, with sampling conducted on multiple wells in each area on a 3-year rotational basis. These areas were chosen as high risk localities on the basis of local contamination threats and aquifer vulnerabilities. Sampled wells included PWS, industrial, and domestic. Samples are analyzed for targeted contaminants based on potential threats in the area.

The Safe Drinking Water Act requires states to conduct assessments of potential threats to public drinking water systems and report the results to the public. The ADH has completed an assessment of all 426 of its Community Water Supply systems that use ground water as a source of drinking water. These systems provide drinking water to about 900,000 people throughout the state.

The assessments indicate that 156 systems (36%) are highly susceptible to contamination and that individual septic systems are the most prevalent threat to water quality (Williams, Kork).

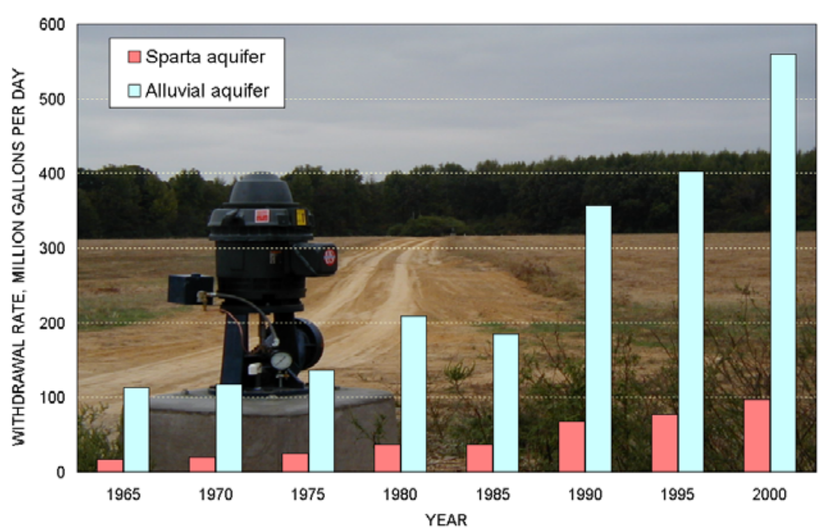
General Assessment of Ground Water Quality

The website for the ADEQ contains the following assessment of ground water quality: "In general, ground-water quality is very good to exceptional throughout the State. Exceptions to this situation are high iron concentrations and areas of high chloride content in localized areas of the Gulf Coastal Plain in eastern Arkansas. Impacts from non-point sources, although regional in scope, dominantly result in low-level contamination below established health standards. Point-source or site-specific sources result in higher levels of contamination but are restricted to smaller areas (commonly on site boundaries)." (Arkansas, Water Quality Planning Branch website,)

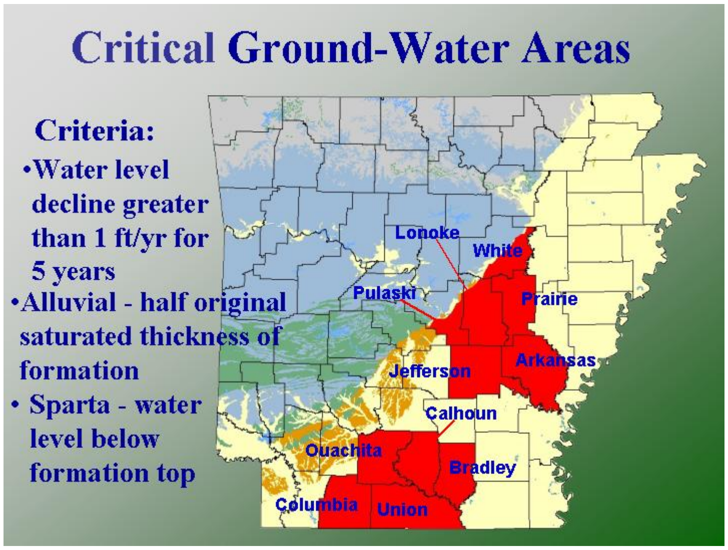
Most of the contamination occurs in the shallow ground water and is not a major problem for PWS systems because deeper aquifers of better quality are typically available. Domestic water wells are more vulnerable to arsenic, nitrate and bacterial contamination due to the shallow depth of these wells. Overall, ground water quality in the State is good, but widespread contamination of the shallow ground water in the Ozark Plateau is a continuing concern.

GROUND WATER QUANTITY

In some areas of the State, ground water withdrawals are so large that demand on the aquifer exceeds the natural recharge. The graph at right depicts withdrawal rates from the Alluvial and Sparta aquifers in Arkansas County, Arkansas from 1965 through 2000. As can be seen water usage has increased dramatically over the last 40 years. As a result, ground water levels in many parts of Arkansas have been dropping substantially (McKee, p 2).



The ANRC has authority to designate "critical areas" of ground water depletion and implement management plans in those areas. The Commission has designated two Critical Ground Water Areas as shown on the map below: a five-county area of the Sparta aquifer in southern Arkansas and the Grand Prairie area in eastern Arkansas.



Since designation as a critical area in 1996 the South Arkansas Study Area declines have been significantly reduced primarily due to education and conservation efforts. The Grand Prairie Study Area continues to show significant declines in the alluvial aquifer.

The primary concern with the continued decline in aquifer levels is compaction of the aquifer media. Once compaction occurs in an aquifer the specific yield will never recover. The compacted sediments within the aquifer cannot hold as much water as during pre-compaction times.

FUTURE EFFORTS THAT COULD HELP PROTECT GROUND WATER

- Investigation of pesticides in ground water.
- Study of the potential impacts from confined animal operations.
- Investigation of saltwater intrusion in southeastern Arkansas.
- Information on the natural geochemical evolution of ground water as a result of water interaction with rock. The state would like to see any available literature or research results that would identify sources of radium and fluoride in several “hot” spots in northern Arkansas. This information could be used to minimize the potential for contamination of wells in these areas (by casing out objectionable horizons).
- Training opportunities to use MODFLOW or other models.
- Any research results or methods that would help in determining the sufficient amount of casing to use in Karst or fractured bedrock terrains to prevent surface water influence.

POTENTIAL EPA INVOLVEMENT

- Provide technical assistance to the state in addressing ground water usage and aquifer management.
- Increase dialogue with state ground water managers with focus on exploring areas where EPA could provide programmatic, technical or other ground water assistance to the state.

REFERENCES

Adamski, J., et. al., Environmental and Hydrologic Setting of the Ozark Plateaus Study Unit, Arkansas, Kansas, Missouri, and Oklahoma, 1995, U.S. Geological Survey, Water-Resources Investigations Report 94-4022. Available online at http://pubs.usgs.gov/wri/wri944022/WRIR94-4022.pdf

Arkansas. Arkansas Geological Commission, Water – A Discussion, accessed October, 2006. Available on line at http://www.state.ar.us/agc/water.htm#Ground%20Water

Arkansas. Arkansas Department of Environmental Quality, Water Quality Planning Branch
website, last updated October 13, 2006. Available online at http://www.adeq.state.ar.us/water/branch_planning/

Arkansas. Arkansas Department of Environmental Quality, Contemporary Ground Water Quality, State of Arkansas (1994-1996), June, 1996, WQ96-06-01. Available online at http://www.adeq.state.ar.us/water/branch_planning/publications.htm

Arkansas. Arkansas Department of Environmental Quality, Integrated Water Quality Monitoring and Assessment Report, 2002, WQ02-10-1. Available online at http://www.adeq.state.ar.us/water/branch_planning/pdfs/WQ02-10-1.pdf

Arkansas. Arkansas Department of Environmental Quality, Integrated Water Quality Monitoring and Assessment Report, 2004, WQ05-07-01. Available online at http://www.adeq.state.ar.us/water/branch_planning/pdfs/WQ05-07-01.pdf

Arkansas. Arkansas Natural Resources Commission, Arkansas Ground Water Protection and Management Report for 2005, January, 2006. Available online at http://www.aswcc.arkansas.gov/Groundwater.html

Czarnecki, J. B., Hays, P. D., Mckee, P. W., The Mississippi River Valley Alluvial Aquifer in Arkansas: A Sustainable Water Resource? Fact Sheet FS-041-02, August, 2002, U.S. Geological Survey. Available on line at http://ar.water.usgs.gov/sun/data-bin/publications

Federal Register. "National Primary Drinking Water Regulations; Radionuclides; Final Rule." Federal Register 65 (07 December, 2000): 76707-76753. Available online at http://www.epa.gov/fedrgstr/EPA-GENERAL/2000/December/Day-07/g30421.pdf

Hutson, Susan S., et al., Estimated Use of Water in the United States in 2000, U.S. Geological Survey, USGS Circular 1268, released March 04, 2004, revised April 12, 2004, May 11, 2004 and February 07, 2005. Available online at http://pubs.usgs.gov/circ/2004/circ1268/

Kort, Evelyn, Arkansas Department of Health and Human Services, personal interviews March 9 and March 12, 2007.

Kresse, T., Fazio, J., Pesticides, Water Quality and Geochemical Evolution of Ground Water in the Alluvial Aquifer, Bayou Bartholomew Watershed, Arkansas, Arkansas Department of Environmental Quality, Arkansas Ambient Ground-Water Monitoring Program, Water Quality Report WQ02-05-01,May 2002. Available online at http://www.adeq.state.ar.us/water/branch_planning/pdfs/WQ02-05-1.pdf

Kresse, T., Fazio, J., Occurrence of Arsenic in Ground Waters of Arkansas and Implications for Source and Release Mechanisms, Arkansas Department of Environmental Quality, Arkansas Ambient Ground-Water Monitoring Program, Water Quality Report WQ03-03-01, March 2003. Available online at http://www.adeq.state.ar.us/water/branch_planning/pdfs/WQ03-03-1.pdf

McKee, P. W., Hays, P. D., The Sparta Aquifer: A Sustainable Water Resource? Fact Sheet FS-111-02, December, 2002, U.S. Department of the Interior, U.S. Geological Survey. Available on line at http://pubs.usgs.gov/fs/fs-111-02/fs-111-02.pdf

Peterson, J. W., et. al., Water Quality in the Ozark Plateaus, Arkansas, Kansas Missouri, and Oklahoma, 1992-1995, 1998, U.S. Geological Survey Circular 1158. Available on line at http://pubs.usgs.gov/circ/circ1158/

Renken, R. A., Ground Water Atlas of the United States; Arkansas, Louisiana, Mississippi: HA 730-F, U.S. Geological Survey, 1998. Available online at http://capp.water.usgs.gov/gwa/ch_f/

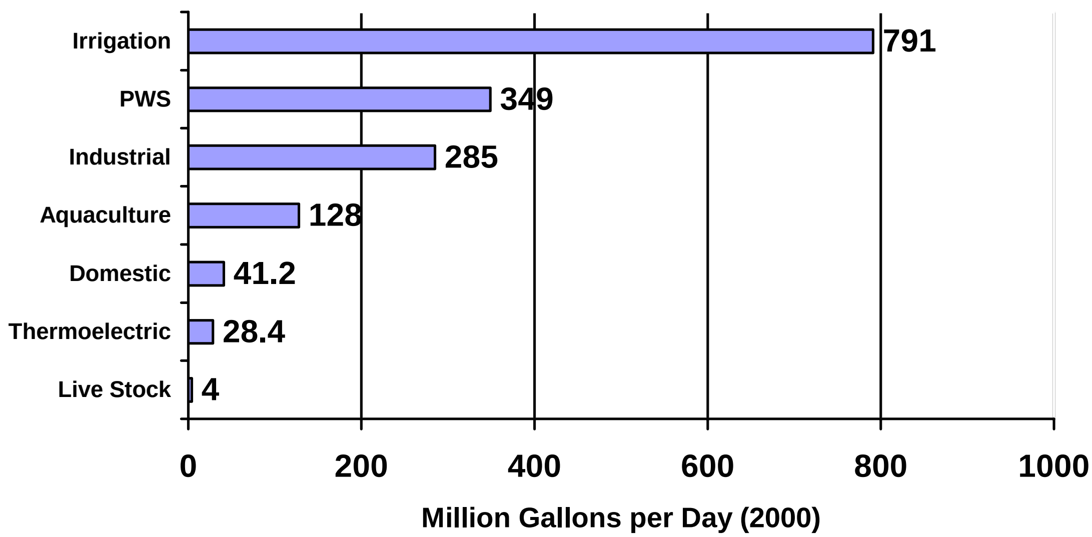
"Table: GCT-T1-R Population Estimates (geographies ranked by estimate) Geography: United States -- States; and Puerto Rico." July 1, 2005, United States Census Bureau. Available on line through http://factfinder.census.gov/

Williams, Ken, U.S Environmental Protection Agency, Dallas Regional Office, personal interview March 9, 2007.

Louisiana

GROUND WATER SUPPLIES 49% OF THE POPULATION'S DRINKING WATER

GROUND WATER USE (in 2000)



IMPORTANCE OF GROUND WATER IN LOUISIANA

Drinking Water

Ground water is important to the health of the citizens of Louisiana. Ground water provides 49.1% of the state's drinking water. Public water supply (PWS) system use accounted for 21.4% of the state's ground water withdrawals. Reported domestic ground water withdrawals in 2000 accounted for 2.5% of total withdrawals from the state's aquifers.

Agriculture

Rice irrigation accounted for 41.7% of the ground water withdrawals and is the largest single use of fresh water in the state during 2000. General irrigation and livestock accounted for 7% of the ground water withdrawals the same year.

Other Uses

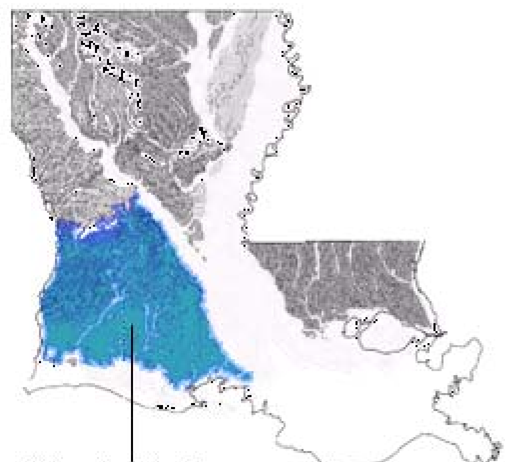
Industrial and power generation accounted for 19.3% of ground water withdrawals during 2000. Aquaculture used 7.9% of ground water during the same year (Hutson).

MAJOR AQUIFERS & GROUND WATER QUALITY

There are fourteen aquifers or aquifer systems covering over 80% of the state. Of these, the Chicot and Southern Hills Aquifer Systems are designated Sole Source Aquifers. In many areas shallow clay layers protect water quality in deeper aquifers. Three of the fourteen aquifer/aquifer systems produced more than 88% of the ground water used in Louisiana in 2000 (Sargent, pp 102-103). These three major aquifer systems are described below.

Chicot Aquifer

The Chicot Aquifer, located in the southwest section of the state, produced about 49% of the ground water discharged in the state during 2000 (Sargent). It is a Pleistocene aged aquifer composed of sand and gravel interspersed with clay layers of varying thickness (Aquifer Summary 2000-2003). The dominant use of the water drawn from the aquifer is rice irrigation. PWS is the second most extensive use of water drawn from the aquifer (Sargent).



<u>Water Quality Problems</u>

Nitrate: Demchick, Tollet, et. al., found two shallow monitoring wells exceeding the 10 milligram per litre (mg/L) USEPA drinking water standard for nitrates.
Arsenic: Arsenic was found in one well above the 10 microgram per liter (ug/L) U.S. Environmental Protection Agency (USEPA) drinking water standard in the Demcheck and Tollett study. The source of the arsenic in this well was not determined.
Radon: Radon was detected above the USEPA's proposed drinking water standard of 300 picocuries per liter (pCi/L) in four domestic wells sampled by Demcheck and Tollette in the years 1999 – 2000. (This finding is inconsistent with earlier studies of radon in Louisiana.) The source of the radon readings has not been determined. Radon is not normally included in the Louisiana Department of Environmental Quality's (LDEQ) tri-yearly testing cycles.
Trends: In examining the long term trends of the aquifer, LDEQ indicates in their report on the Baseline Monitoring Project's (BMP) 2003 testing cycle that "a comparison of present and historical BMP data averages shows that for the most part the data averages are consistent."

Mississippi River Alluvial Aquifer

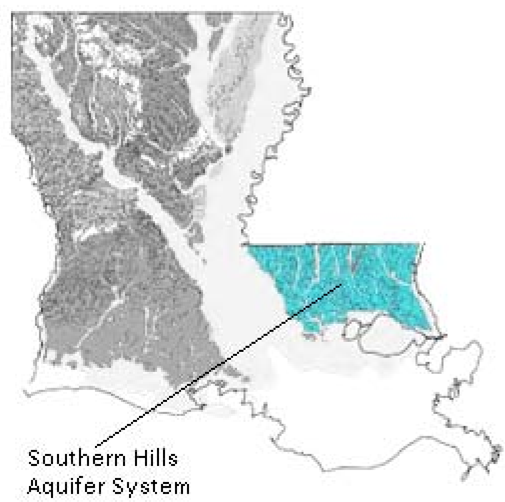
The Mississippi River Alluvial Aquifer follows the Mississippi River bed from southern Missouri to central Louisiana providing approximately 22% of the state's aquifer water discharged to the surface (Sargent). It is a coarse sand and gravel aquifer ranging from 25' to 150' in depth. It is confined by the fine sands, silt and clay of the river bed. It is Pleistocene in age (Aquifer Summary 2000-2003). The main uses of water drawn from the aquifer are irrigation (both rice and general uses), industrial and aquaculture. (Sargent).

<u>Water Quality Problems</u>

Arsenic: Five wells exceeded the current 10 ug/L drinking water standard for arsenic during the LDEQ's BMP 2003 testing cycle. The ranges of arsenic measured ranged from 11.1ug/L to 61.9 ug/L. The source of the arsenic was not identified.

Southern Hills Aquifer System

The Southern Hills Aquifer system, located in southeast Louisiana, is typically described as an amalgam of the aquifer systems spanning the three major geologic ages represented in the area. The aquifers in the Pleistocene are referred to as the Chicot Equivalent systems. The Evangeline Equivalent is made up of Pliocene aged aquifers. And the Jasper Equivalent is of Miocene aged aquifers. (Aquifer Summary 2000-2003). The system provides almost 18% of the ground water withdrawn from the state's aquifers (Sargent). The aquifers overlay each other at varying depths below ground level. Their composition ranges from very fine sand to coarse sand and gravel with clay confining beds interspersed. The major uses of water drawn from the Southern Hills Aquifer System are public water supply and industrial.



Water Quality Problems

Chicot Equivalent Aquifer System

Arsenic: Arsenic was detected at one well during LDEQ's BMP 2003 testing cycle. The results were noted at 12.9 ug/L which is above the EPA's primary MCL of 10 ug/L. No other instances of arsenic were found during the 2003 LDEQ testing cycle. The source of the arsenic has not been identified. Demcheck and Tollet's 2000 survey also noted a single well exceeding the arsenic MCL. No further information on arsenic is found in the Demcheck and Tollet report.

Mercury: Mercury was detected in two ground water wells during the LDEQ's 2003 testing cycle. Neither sample was above the primary MCL.

Volatile Organic Compounds: One private well tested positive for the presence of 1,2-Dichloroethane during the LDEQ's 2003 testing cycle.

Radon: Radon was detected above the USEPA proposed drinking water standard of 300 picocuries per liter (pCi/L) in five domestic wells sampled by Demcheck and Tollette in the years 1999 – 2000. The source of the radon readings has not been determined. (This finding is inconsistent with earlier studies of radon in Louisiana.) Radon is not normally included in the LDEQ's tri-yearly testing cycles.

Trends: In examining the long term trends of the aquifer, LDEQ indicates in their report on the BMP 2003 testing cycle that iron has increased steadily in the aquifer samples, but in general "the averages have been consistent with only slight fluctuations."

Evangeline Equivalent and Jasper Equivalent Aquifer Systems

Demcheck and Tollette did not address the aquifers of the Evangeline Equivalent and the Jasper Equivalent systems in their 1999-2000 study. During the LDEQ's 2003 testing cycle, no exceedances of primary MCLs were discovered with little historical variation considering past BMP sampling efforts in the system.

Trends: The LDEQ's report on the BMP 2003 testing cycle on the Evangeline Equivalent aquifer indicates "a comparison of present and historical BMP data averages shows that for the most part the data averages are fairly consistent, with chloride and color averages decreasing and pH, iron and sulfate averages increasing." The same report on the Jasper Equivalent aquifer indicates "a comparison of present and historical BMP data averages also shows that for the most part the data averages are fairly consistent, with small increases in alkalinity, hardness, iron, sulfate, and zinc." (Louisiana, Aquifer Summary, p 6, Appendix 13)

State Regulation of Ground Water Quality

Louisiana defines ground water as part of "the waters of the state" subject to the protections afforded by the Louisiana Environmental Quality Act. (Louisiana Administrative Code (LAC) §107). The State has no permit system to protect ground water quality, but does offer protection through other avenues. The LDEQ conducts ground water studies, oversees cleanup activities at contaminated ground water sites and investigates potential and verified contaminant sources (LAC §503). The LDEQ also manages, in conjunction with other state entities, a non point source abatement program to protect ground water in the state. The LDEQ also implements the Source Water Protection program and the Wellhead Protection Program which act to protect the quality of ground water serving as a source for public water supply wells. The Louisiana Department of Agriculture and Forestry implements the state's Agriculture Pesticide Management plan. The Louisiana Department of Natural Resources (LDNR) administers the underground injection control program in the state. The LDNR regulates and permits the injection of hazardous waste, brine and industrial waste into underground strata, ensuring the waste does not contaminate or endanger usable sources of drinking water. Ground water quality protection activities in Louisiana are funded in large part by EPA grants under Sections 106 and 319 of the Clean Water Act.

As a major element of ground water protection in Louisiana, the LDEQ has developed a ground water monitoring program to help assess the quality of ground water in the State. Under the program, begun in 1990, fourteen aquifers or aquifer systems are monitored and analyzed on a 3-year rotational basis, with sampling conducted on multiple wells in each area of concern. These areas were chosen because they are major sources of freshwater in the state. The sampled wells include PWS, industrial, and domestic wells. Samples are analyzed for presence of inorganic (total metals), nutrients, volatile organic compounds, semi-volatile organic compounds, pesticides and polychlorobiphenyls. During the 2003 testing cycle, 194 wells were sampled.

The Safe Drinking Water Act requires states to conduct assessments of potential threats to public drinking water systems and report the results to the public. The LDEQ has completed assessments of the 1,009 Community Water Supply systems that used ground water as a source of drinking water in 2003. These systems provide drinking water to approximately 3,000,000 people throughout the state. The assessments indicated that no system had an active problem or potential threat requiring action above those already underway.

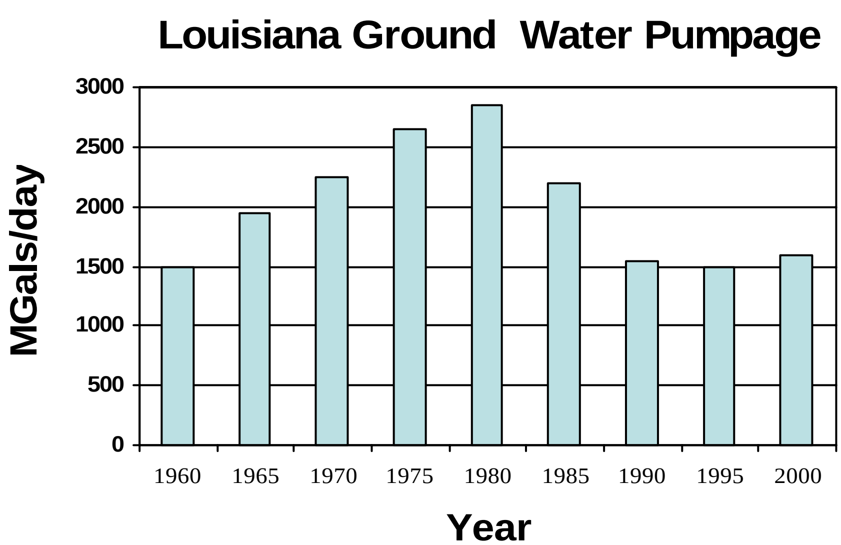
General Assessment of Ground Water Quality in Louisiana

The LDEQ's Ground Water Brochure states "Louisiana currently has an abundance of high quality ground water." A review of the available reports from LDEQ's Baseline Monitoring Project indicates the usable ground water in the state's fourteen aquifers is "generally soft and of good quality". (Louisiana, Aquifer Summary 2000-2003) It should be noted the coastal ground waters of the state are naturally brackish in nature. The same is true for a ridge of brackish water that underlies the Mississippi River Alluvial aquifer in the southern portion of the state. Noted areas of contamination are limited in nature with sources of contamination identified and being remediated. Other wells with sampled contamination were either rural domestic or industrial wells without indication of a spread of the contamination. (Owner's of the domestic wells have been made aware of the contamination.)

More than 200 sites have known shallow ground water contamination. Organic contaminants detected, but not exceeding regulated standards, include benzene, toluene, ethyl benzene, xylene, trichloroethylene, dichloroethylene, trichloroethane, 1,2-dichloroethane, vinyl chloride, tetrachloroethylene, methyl tert-butyl ether. Most contaminated wells are associated with industrial sites or known sources and are subject to remediation programs. The number of site-specific incidents is not unusual for a large state.

Fourteen PWS systems are known to have been impacted by volatile organic compounds from 1989 to 2002. Arsenic concentrations exceeding EPA's 2003 MCL have been detected at approximately twenty small PWS systems. All are in the process of coming into compliance with the new arsenic MCL.

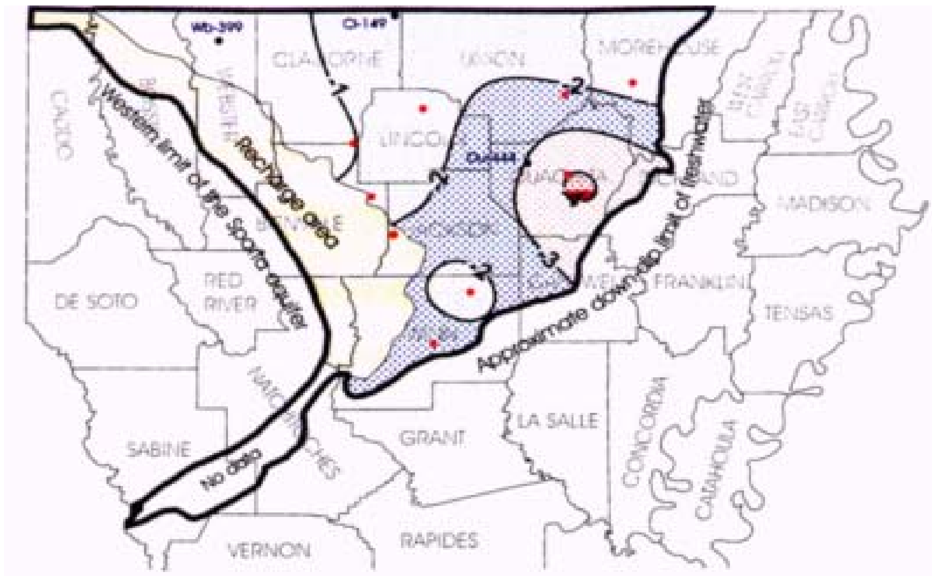
GROUND WATER QUANTITY



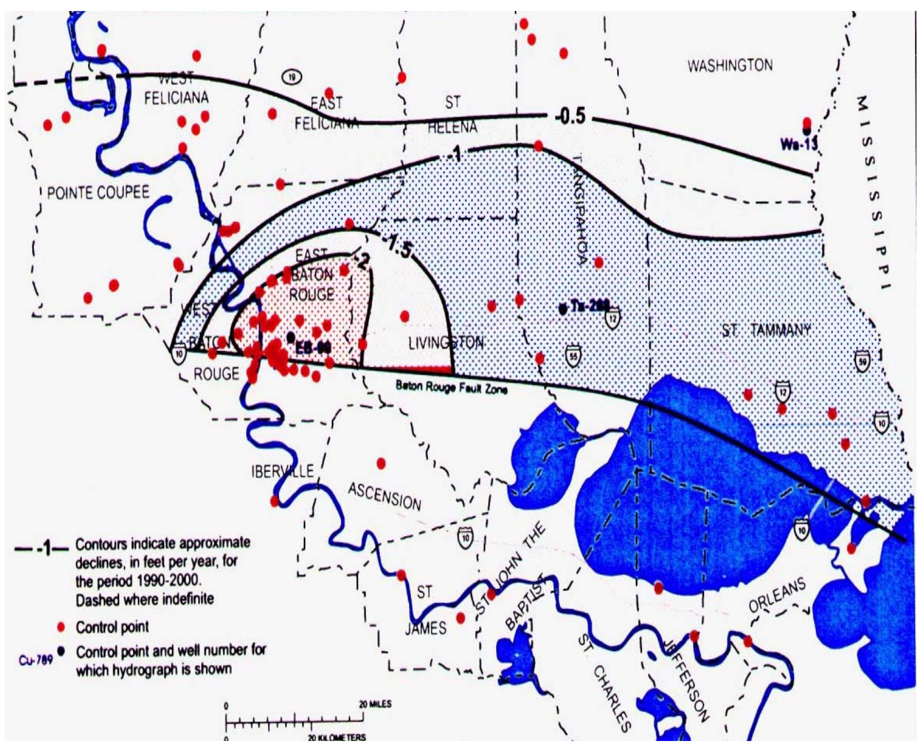
Overall use of ground water in Louisiana has declined from a high of approximately 2,800 million gallons per day (Mgal/d) pump rate in 1980 to approximately 1,500 Mgal/d since 1990. The 1,500 Mgal/d pump rate is approximately the same as the rates measured in 1960. Even with this stabilization in total withdrawals from the state's aquifers, there remains a need to further conserve the water resources of certain aquifers within the state. The three major aquifers and aquifer systems within the state have been identified as losing water level in some areas.

Below are contour maps illustrating water level declines from 1990 though 2000 (Contour Maps from Tamaszewski).

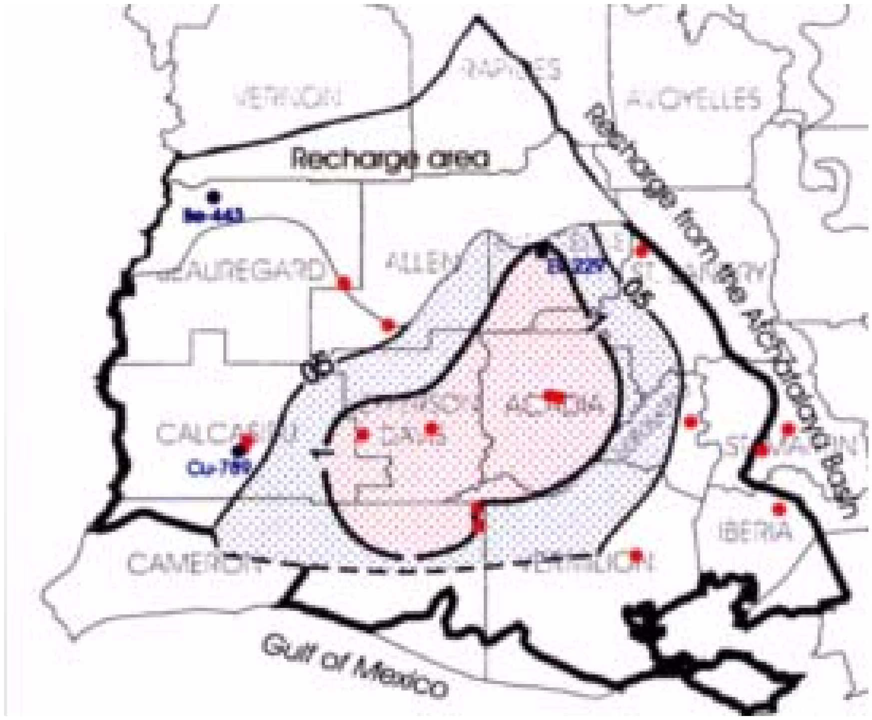
Contours Indicating Approximate Water Level Declines in Feet per Year 1990-2000



Sparta Aquifer
North LA



Southern Hills Aquifer
System, Southeast LA



Chicot Aquifer
Southwest LA

State Regulation of Ground Water Quantity

The LDNR has responsibility for conserving the state's water resources and operates a notification and usage system to evaluate the ongoing water usage of the state's aquifers and determine if new wells will adversely impact aquifers within the state. If LDNR believes a well will have an adverse impact it will be subject to restrictions. The LDNR issued Order AGC-1-05 on August 15, 2005 (Welsh) declaring portions of the Sparta Aquifer, in northern Louisiana, to be "areas of ground water concern." The action mandates water conservation education programs, reporting of static water level measurements to the LDNR and pursuit of alternate sources of potable water to replace use of the Sparta Aquifer waters.

LDNR hosts the state's Ground Water Management Commission and an Advisory Task Force designed to evaluate the need and impact of water usage in the state. The commission and task force developed a draft Comprehensive Water Management Plan for Louisiana and, together, provide a forum for input by the public and those affected by the restrictions and overuse of the aquifers.

FUTURE EFFORTS THAT COULD HELP PROTECT GROUND WATER

- Allot up to 15% of the EPA Section 106 water grant funding for ground water protection and provide other secure sources of funding to staff and perform Louisiana's protection and monitoring programs.
- Address the declining water levels in the Sparta and Chicot aquifers and the Southern Hills Aquifer system.
- Address the saltwater intrusion of coastal aquifers.

POTENTIAL EPA INVOLVEMENT

- Provide technical assistance to the state in addressing ground water usage and aquifer management.
- Increase dialogue with state ground water managers with focus on exploring areas where EPA could provide programmatic, technical or other ground water assistance to the state.

REFERENCES

Boniol, Donovan, et al. Recharge potential of Louisiana Aquifers (to Accompany State Recharge Potential Maps). Louisiana Geological Survey, Open-File Series No. 88-07. 1989.

Buono, Anthony, The Southern Hills Regional Aquifer System of Southeastern Louisiana and Southwestern Mississippi. U.S. Geological Survey, Water-Resources Investigations Report 83-4189. 1983. Available online at http://onlinepubs.er.usgs.gov/djvu/WRI/wrir_83_4189.djvu

Demcheck, Dennis K., et al. 2004, Water Quality in the Acadian-Pontchartrain Drainages, Louisiana and Mississippi. 1999-2001: U.S. Geological Survey, Circular 1232. Available online at http://pubs.usgs.gov/circ/2004/1232/pdf/circular1232.pdf

Hutson, Susan S., et al., Estimated Use of Water in the United States in 2000, U.S. Geological Survey, USGS Circular 1268, released March 04, 2004, revised April 12, 2004, May 11, 2004 and February 07, 2005. Available online at http://pubs.usgs.gov/circ/2004/circ1268/

Jennings, John, "Louisiana Baseline Monitoring Program", Paper. Proceedings, 2004 Annual Forum Ground Water Protection Council, Sept. 2, 2004. Available online at:
http://www.gwpc.org/e-Library/Proceedings/AF04/Attachments/Abstracts/Jennings-John-FP.pdf

Louisiana. Louisiana Department of Environmental Quality. Aquifer Summaries 2000–2003, Baseline Monitoring Program, Aquifer Evaluation and Protection, Water Quality Assessment. Accessed August, 2006. Available online at http://www.deq.louisiana.gov/portal/tabid/1717/Default.aspx

Sargent, B. P., 2002, Water Use in Louisiana, 2000, Water Resources Special Report No. 15, Department of Transportation and Development, State of Louisiana and U. S. Geological Survey. Available on line at http://la.water.usgs.gov/pdfs/WaterUse00.pdf

"Table: GCT-T1-R Population Estimates (geographies ranked by estimate) Geography: United States -- States; and Puerto Rico." July 1, 2005, United States Census Bureau. Available on line through http://factfinder.census.gov/

Tollett, R., et al., 2003, Quality of Water in Domestic Wells in the Chicot and Chicot Equivalent Aquifer Systems, Southern Louisiana and Southwestern Mississippi, 2000-2001. National Water-Quality Assessment Program, U.S. Geological Survey, Water-Resources Investigations Report 03-4122. Available online at http://la.water.usgs.gov/pdfs/qw_domwells_chicot.pdf

Tomaszewski, D., et al., 2002, Water Withdrawals and Trends in Ground-Water Levels and Stream Discharge in Louisiana. Louisiana Department of Transportation and Development, Public Works and Water Resources Division; in cooperation with the U.S. Geological Survey. Available on line at http://la.water.usgs.gov/pdfs/trends.pdf

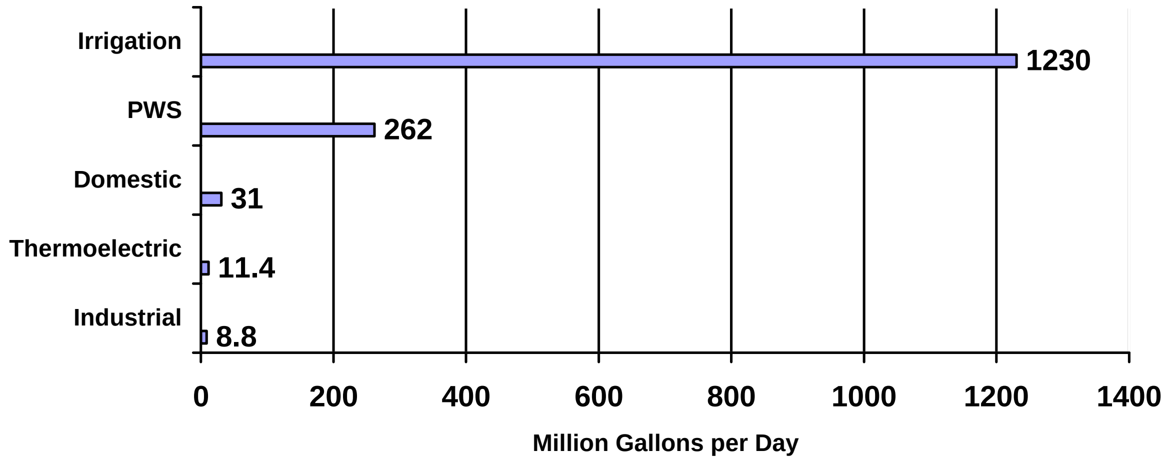
United States. Environmental Atlas of the Lake Pontchartrain Basin, Basin Geology, Center for Coastal and Marine Studies, US Geological Survey. Updated 14 May 2002. Accessed August 2, 2006. Available online at http://pubs.usgs.gov/of/2002/of02-206/intro/toc.html

Welsh, James H. "Jim", Memo to Interested Parties, Department of Natural Resources, Office of Conservation, Baton Rouge, Louisiana. August 15, 2005. Available online at http://dnr.louisiana.gov/cons/Orders/AGC-1-05-Memo.pdf

New Mexico

GROUND WATER SUPPLIES 90% OF THE POPULATION'S DRINKING WATER

GROUND WATER USE (in 2000):



IMPORTANCE OF GROUND WATER IN NEW MEXICO

Drinking Water

Ground water is important to the health of the citizens of New Mexico; 89.6% of the drinking water used in 2000 was supplied by ground water, 80.0% was used by public water supply (PWS) systems and 9.6% was drawn from private domestic water wells. Drinking water accounted for approximately 19% of the withdrawal from the state's aquifers (Hutson).

Agriculture

Ground water withdrawals for agricultural uses account for approximately 80% of the ground water used in the state and represent the largest category of water use. New Mexico ranks 11th in the U.S. for the amount of ground water used for irrigation, and ranks 38th for total ground water use (Hutson).

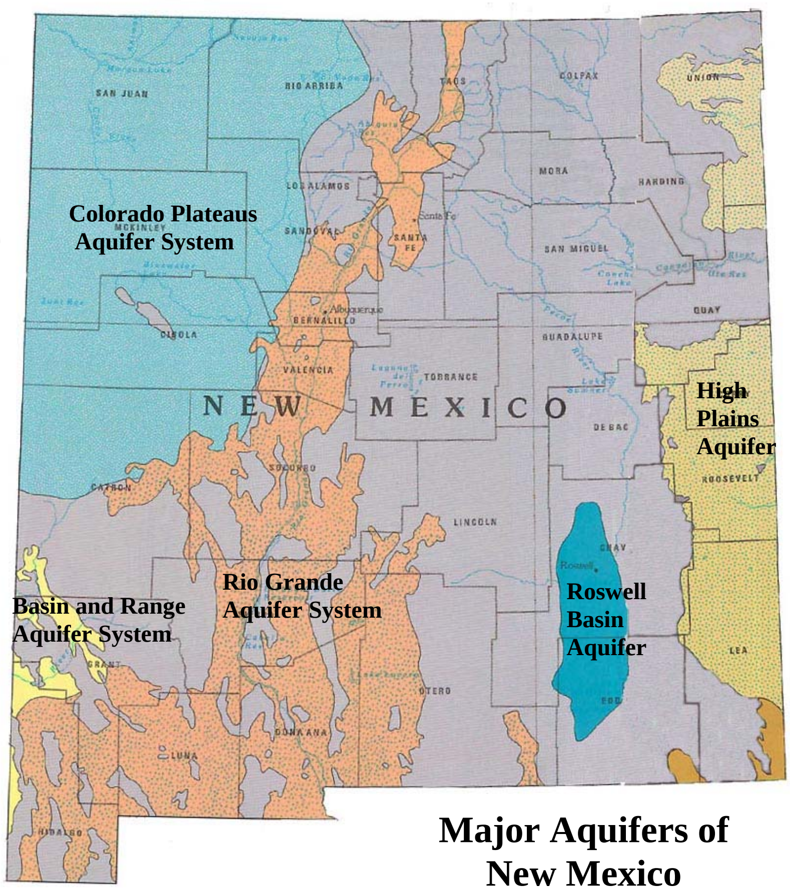
MAJOR AQUIFERS & GROUND WATER QUALITY

New Mexico's hydrogeology is highly variable and complex; as a result, the availability of ground water varies greatly from place to place. The State's ground waters are concentrated in five areas, some containing more than a single accessible aquifer, while much of the rest of the state has very little ground water.

The Basin and Range Aquifers

A relatively small portion of the Basin and Range Aquifers that thread through Utah, Nevada, California and Arizona extend into southwestern New Mexico. In

New Mexico, the Basin and Range Aquifers are located only in Catron, Grant and Hildago counties. This is an arid, desert area of the state. The aquifers are located in both permeable alluvial sediments and relatively impermeable consolidated rock geological units (Robson).



Major Aquifers of New Mexico

<u>Water Quality Problems</u>

The water from the Basin and Range aquifers in New Mexico is reported to have generally good quality suitable for most uses. Areas of the Basin and Range aquifers are subject to contamination from domestic septic systems, agricultural and some industrial activities in the areas (McQuillen), (New Mexico, <u>Water Information</u>, Contamination by Septic Systems).

The Rio Grande Aquifer System

The Rio Grande Aquifer System consists of a network of hydraulically interconnected alluvial aquifers in basin-fill deposits located along the Rio Grande Valley as well as nearby valleys. There is ground water present in both confined and unconfined layers in the system. Water levels from confined layers in areas near discharge points generally are higher than water levels from unconfined layers due to the increased pressure on the confined layers (Robson).

<u>Water Quality Problems</u>

The water taken from the Rio Grande aquifer system is generally classified as hard with some areas of softer water in the northern and southwestern portions of the aquifer system. The mineral content of the ground water and the high rate of evaporation in the state have caused some zones of slight salinity due to irrigation (Robson). The USGS and New Mexico Environmental Department have identified several sources of contamination to the shallow aquifers of the Rio Grande Aquifer System. They include agricultural chemicals infiltrating the aquifer with recharge from irrigation water, the presence of domestic septic systems in heavily populated areas, chlorine solvent contamination attributed to industrial sources, gasoline leaking from underground storage tanks and dairy waste seeping into the aquifer from unlined treatment ponds (New Mexico, Water Quality, 2002, p 22).

The High Plains Aquifer

The High Plains Aquifer stretches from South Dakota through Texas, covering eight states. In New Mexico, the High Plains Aquifer is located in six of the state's eastern counties, along the border with Texas. The Ogallala formation is the principal geologic unit of the High Plains Aquifer. Agricultural irrigation is the main use of the High Plains aquifer waters (Robson). There has been a trend toward depletion of the available water in the High Plains since the beginning of agricultural irrigation in the early part of the twentieth century.

Water Quality Problems

The 2003 USGS report studying the water quality of the southern High Plains tested water from six domestic wells drawing water from this aquifer. The testing identified 4 samples that exceeded the EPA's proposed drinking water standard of 300 picocuries per liter (pCi/L) for Radon -222. The testing also found two of the six wells exceeded the established dissolved solids secondary maximum contaminant level (MCL) standard of 500 milligrams per liter (mg/L) (Fahlquist, p 33, 38).

The Roswell Basin Aquifer System

The Roswell Basin aquifer system is located in southeastern New Mexico underlying Chaves and Eddy counties. The system consists of a carbonate rock aquifer that is partially overlain with an alluvial aquifer that follows the Pecos River between Roswell and Carlsbad. The major withdrawal from the system is through large capacity irrigation wells used for agricultural purposes. Water level declines were measured between 1937 and 1975. More recent data on overall water levels were not available, but USGS's ground water atlas states seasonal water levels have varied between 40 and 100 feet due to irrigation, with water levels returning to near the previous year's maximum when withdrawals declined after the growing season (Robson).

Water Quality Problems

About 10% of the point source contamination identified in New Mexico has occurred over the Roswell Basin (New Mexico, Water Quality, 2002, from Figure 16, p 86). Other sources of contamination of the aquifer system include non-point sources such as domestic septic systems and cesspools (New Mexico, Water Quality, 2002, from p 86). The water coming from the western portion of this system has been classified as very hard due to the preponderance of calcium sulfate or calcium magnesium sulfate present in the water. Along the

Northeastern ridge of the system, the waters have high levels of sodium chloride (Robson).

The Colorado Plateaus Aquifers

The Colorado Plateaus aquifers underlay the northwestern portion of New Mexico. The principal aquifers and aquifer systems are the Uinta-Animas, the Mesaverde, the Coconino-De Chelly, and the Dakota-Glen Canyon. Smaller, more localized aquifers are also defined as part of the Colorado Plateaus aquifers. While the yield and quality of water found in these aquifers varies widely there is enough water of adequate quality available to support domestic use and an agricultural industry in this area (Robson).

Water Quality Problems

The quality of water from these aquifers and systems has been described by the USGS as highly variable with total dissolved solids generally measuring under 1,000 mg/L with several areas reporting concentrations as high as 35,000 mg/L (Robson). Areas of slight salinity have also been detected. Little monitoring data is available for the area. In the year 2000, 182, or 14.7%, of the identified point source contamination of ground water incidents in the state were located in the three counties completely encompassed by the Colorado Plateaus. During the same year, 93, or 7.5%, of the identified point source contamination incidents occurred in counties partially covered by these same aquifers (New Mexico, Water Quality, 2002). This means the Uinta-Animas aquifer, which is the shallowest of the components, was exposed to this source of pollution. The Uinta-Animas is also the recipient of non-point source contamination from septic systems and application of agricultural chemicals to the surface area.

State Regulation of Ground Water Quality

Under the authority of the Water Quality Act, a basic framework for water quality management has been adopted in New Mexico. Major ground water components of this framework include:

- A Continuing Planning Process to provide a framework for water pollution control activities.
- Ground Water Quality Standards for 47 contaminants or classes of contaminants included in the state's Ground Water Protection Regulations.
- Ground Water Protection Regulations designed to protect all ground water with TDS concentrations of 10,000 mg/L or less for domestic and agricultural water supply.
- Underground Injection Control Regulations imposing technical requirements on injection wells used for effluent disposal and in-situ mineral extraction. (These are in addition to those in the federal UIC program.)
- Regulation of Spill Cleanup.

- Ground Water Pollution Abatement Regulations.
- Utility Operator Certification.
- Wastewater Facility Construction Loan Regulations.
- A Non-point Source Management Program.

The State does not have an ambient ground water quality monitoring program. Information on water quality is generated by aquifer-specific and area-specific studies conducted by the Ground Water Bureau of the New Mexico Environment Department, and by the water quality monitoring program of the USGS.

General Assessment of Ground Water Quality

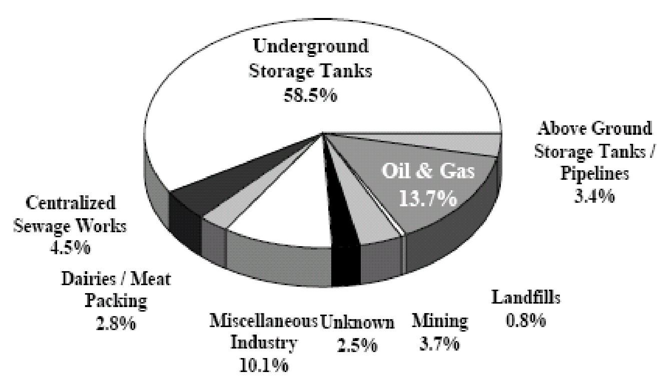
Overall the quality of 4.4 billion acre-feet of recoverable fresh and slightly saline water is assumed to be good, although there are significant pollution problems known to affect certain areas throughout New Mexico. The figure below describes the known point sources of contamination to the State's aquifers (New Mexico, Water Quality 2002, Figure 20, p 89). At least 1,240 ground water contamination plumes emanating from point sources, and numerous areas of widespread contamination from non-point sources, have been identified in the State through June 2004. This contamination has impacted 191 public and 1,721 private water supply wells. As of June 2001, 351 cases have received or will soon receive some degree of remediation (New Mexico, Water Quality, 2002 p 85—93).

There are over 250 sites of known shallow ground water contamination and there are many more under investigation for possible contamination. There were also 9 public water supply systems impacted by volatile organic compound contamination of ground water between 1989 and 1992.

Non-point source contaminants include iron, manganese, sulfides, arsenic, nitrates, pesticides, and total dissolved solids (TDS). More than one half of all identified cases of ground water contamination in New Mexico have been caused by non-point sources, predominantly by large numbers of domestic septic tanks concentrated in an area such as a subdivision. Other non-point sources which may impact ground water include residual minerals from evapotranspiration, pesticides and fertilizers from agricultural and urban sources, discharges from mine water and urban runoff (New Mexico, Water Quality, 1998 p 70).

Point source contaminants include benzene, toluene, ethyl benzene, xylene from

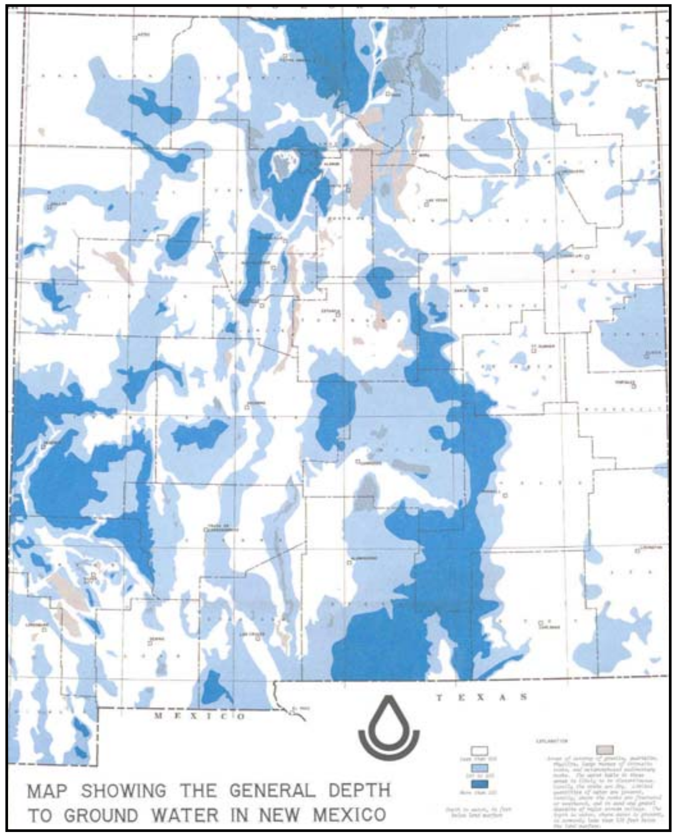
Point Sources of Ground Water Contamination by Source Type



leaking underground storage tanks, chlorinated solvents from landfills, nitrates and total dissolved solids from mining and milling sites, trichloroethylene and other halogenated aliphatics (benzenes, chlorinated methanes, ethanes, ethylenes and propanes) from various manufacturing processes (dry cleaning industry, degreasing metals, .etc.), and polychlorinated biphenyls, aluminum, cadmium, cobalt, iron, lead, manganese, selenium, and zinc from miscellaneous industrial sources (New Mexico, Water Quality, 1998 p 70-71).

WATER QUANTITY

New Mexico's ground water quantity capacity has been estimated at 20 billion acre-feet. These ground water supplies are found in the areas described above. Over 4 billion acre-feet of this amount is thought to be recoverable. Of the recoverable amount, approximately 3 billion acre-feet is fresh water. An additional 1.4 billion acre-feet of slightly saline, but useful, water is also recoverable. In some areas with significant ground water use, ground water levels have declined due to withdrawals in excess of recharge (New Mexico, Water Quality, 1998 p 16).



FUTURE EFFORTS THAT COULD HELP PROTECT GROUND WATER

- Evaluate ambient ground water quality throughout New Mexico.
- Evaluate disposal practices for untreated discharge such as sludge and septage disposal, large volume septic tank/leach fields and agricultural discharges. Specifically, NMED is in the process of developing septage tracking regulations and is working with local governments and private operators to permit environmentally sound and legal septage disposal facilities around the state.
- Develop cost effective treatment technologies for nitrogen-based discharges such as food processing plants, dairies, and other agricultural facilities.
- Develop and maintain a systematic ground water monitoring program and data management system for ground water quality data.

POTENTIAL EPA INVOLVEMENT

- Streamline compliance with state and federal sludge disposal regulations to maximize ground water protection and reduce paper-work needed to show compliance.
- Assist state in training and evaluation related to permitting of septic systems.
- Provide technical assistance to the tribes to help them develop ground water protection programs.
- Provide training to tribes on design and operation of decentralized waste water treatment systems.
- Provide technical assistance to the state in addressing ground water usage and aquifer management.
- Increase dialogue with state ground water managers with focus on exploring areas where EPA could provide programmatic, technical or other ground water assistance to the state.

REFERENCES

Fahlquist, Lynne, 2003, Ground-water Quality of the Southern High Plains Aquifer, Texas and New Mexico, 2001: U.S. Geological Survey Open-File Report 03-345. Available online at http://co.water.usgs.gov/nawqa/hpgw/reports/ofr03_345.pdf

Hutson, Susan S., et al., Estimated Use of Water in the United States in 2000, U.S. Geological Survey, USGS Circular 1268, released March 04, 2004, revised April 12, 2004, May 11, 2004 and February 07, 2005. Available online at http://pubs.usgs.gov/circ/2004/circ1268/

McQuillan, D., Parker, J.; Ground-Water Contamination and Remediation in New Mexico: 1927-2000, New Mexico Environment Department, Ground Water Quality Bureau, July, 2000.
Accessed September, 2006. Available online at http://www.nmenv.state.nm.us/gwb/Technical%20resources/gwc2000.htm

New Mexico. New Mexico Environmental Department, Liquid Waste (Septic Tank) Program. Water Information web page. Accessed September, 2006. Available online at http://www.nmenv.state.nm.us/fod/LiquidWaste/water.info.html

New Mexico. New Mexico Environmental Department. Ground Water, New Mexico's Buried Treasure. Accessed September 9, 2006. Available online at http://www.nmenv.state.nm.us/gwb/buried_treasure.htm

New Mexico. Office of the State Engineer, Interstate Stream Commission, Water Planning and Communications Bureau, Water Plan for Regions 1 – 16. Available on line at http://www.ose.state.nm.us/isc_regional_plans.html

New Mexico. Office of the State Engineer, New Mexico Water Use Data 2000 by County, Technical Reports. Accessed September 9, 2006. Available on line at http://www.ose.state.nm.us/publications_technical_reports_wateruse_county00.html

New Mexico. Water Quality Control Commission, Water Quality and Water Pollution Control in New Mexico, Report to Congress, 1998, Chapter 4. Available online at http://www.nmenv.state.nm.us/swqb/305b/1998/1998_305b_chapter_4.pdf

New Mexico. Water Quality Control Commission, Water Quality and Water Pollution Control in New Mexico, Report to Congress, 2002, Chapter 5. Available online at http://www.nmenv.state.nm.us/swqb/305b/2002/2002_305b_Report-Chapter5.pdf

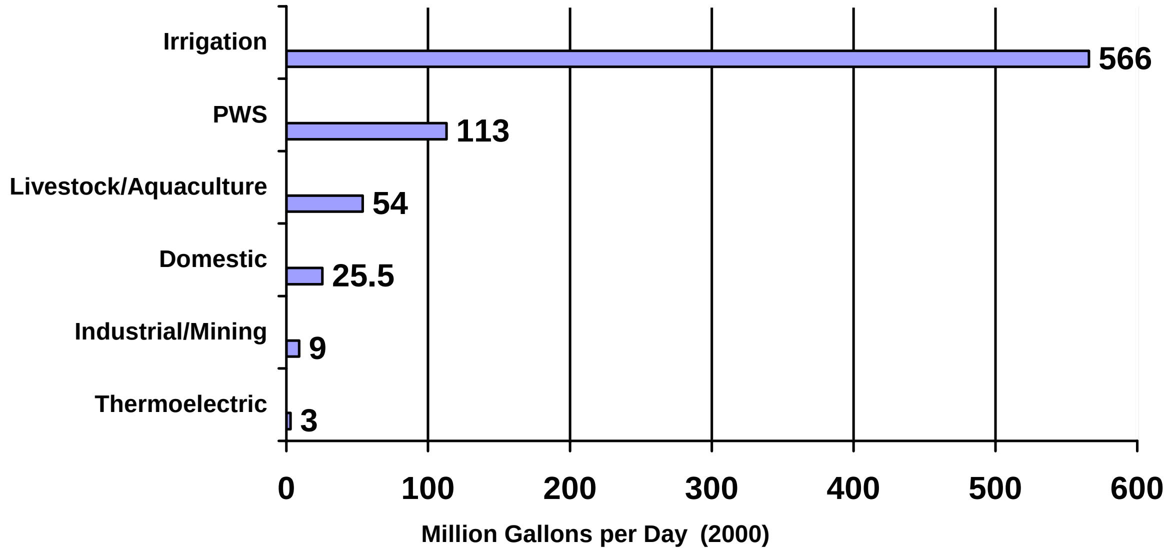
Robson, S. G., Banta, E. R., Ground Water Atlas of the United States; Arizona, Colorado, New Mexico, Utah: HA 730-C, U.S. Geological Survey, 1995. Available online at http://capp.water.usgs.gov/gwa/ch_c/

"Table: GCT-T1-R Population Estimates (geographies ranked by estimate) Geography: United States -- States; and Puerto Rico." July 1, 2005, United States Census Bureau. Available on line through http://factfinder.census.gov/

Oklahoma

GROUND WATER SUPPLIES 18% OF THE POPULATION'S DRINKING WATER

GROUND WATER USE (in 2000)



IMPORTANCE OF GROUND WATER IN OKLAHOMA

Drinking Water

Ground water is important to the health of the citizens of Oklahoma. In 2000, ground water supplied 18% of the state's drinking water. About 14.7% of the state's fresh ground water withdrawals were for public water supply system uses. Reported domestic ground water withdrawals in 2000 accounted for 3.3% of total withdrawals from the state's aquifers.

Agriculture

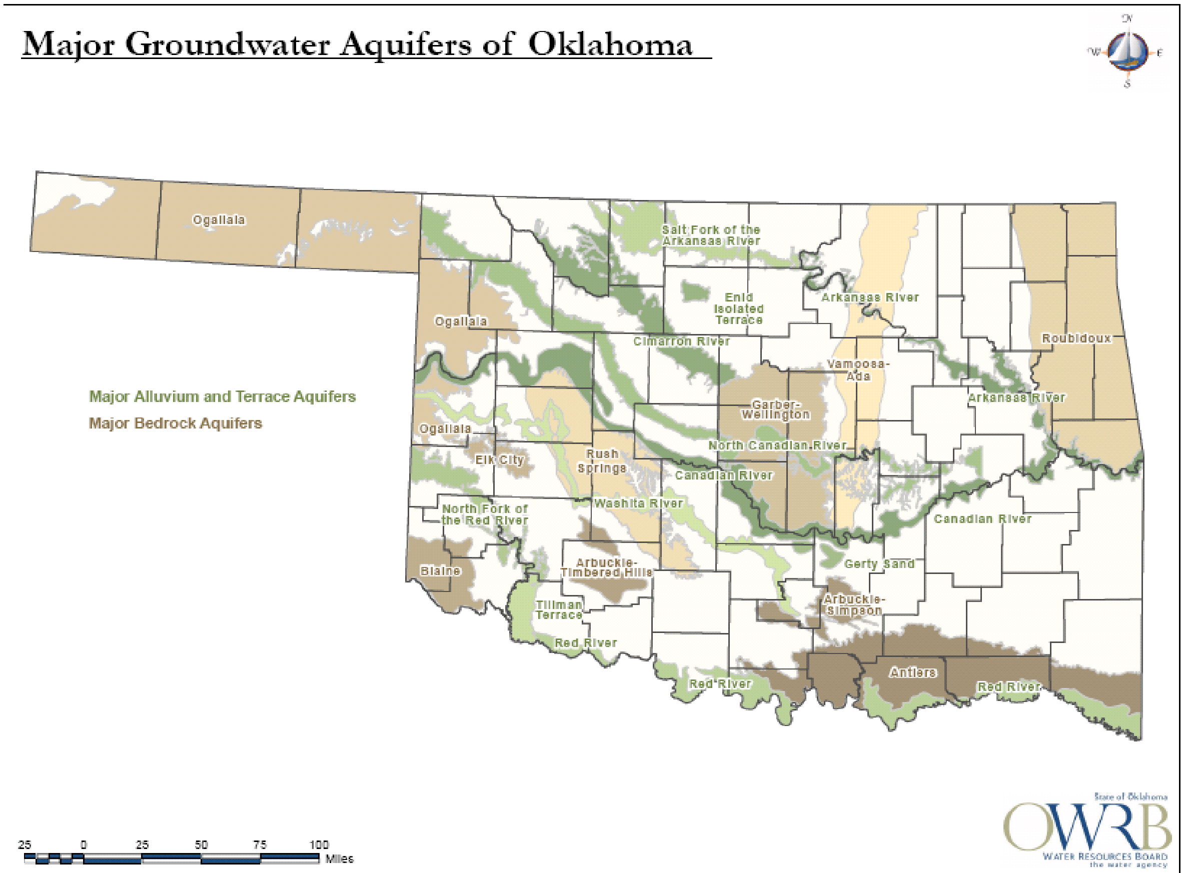
Irrigation accounted for 74.5% of the ground water withdrawals and is the largest single use of fresh water in the state during 2000. Aquaculture and live stock uses accounted for 7% of the ground water withdrawals the same year.

Other Uses

Industrial, mining and power generation accounted for 1.6% of ground water withdrawals during 2000 (Tortorelli).

MAJOR AQUIFERS & GROUND WATER QUALITY

The Oklahoma Water Resources Board (OWRB) lists twenty-one major aquifers in Oklahoma. They are of two types. The first type of aquifer is the alluvial and terrace aquifers consisting of sand and gravel along major rivers, including the North Canadian and Cimarron Rivers shown in the illustration below. The second type is the bedrock aquifers, which cover large areas of the state and consist of hardened materials ranging from sandstone to limestone and gypsum. Examples of bedrock aquifers include the Central Oklahoma, the Rush Springs, the High Plains and the Ozark Plateau aquifers. Large areas of the state generally contain local, low yield aquifers or do not produce ground water. The following map from the OWRB shows the major aquifers.

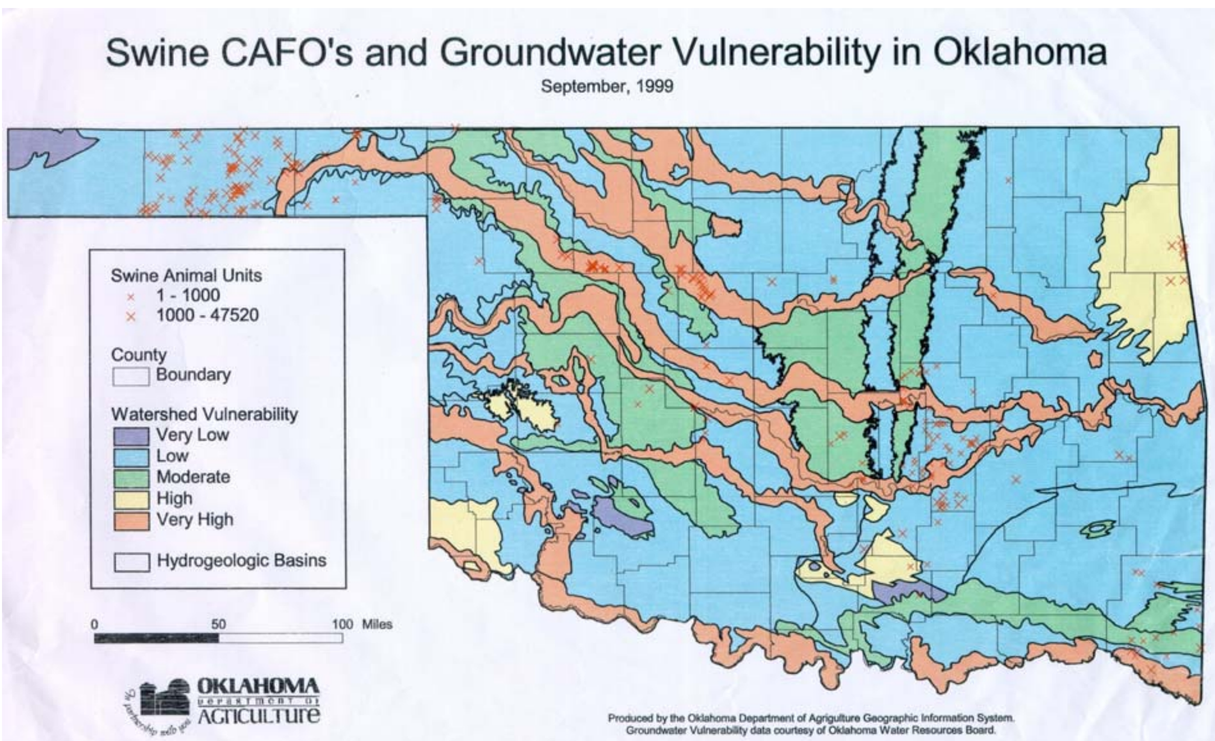


Alluvial and Terrace Aquifers

The alluvial and terrace aquifers consist of sand and gravel beds found along the states' major rivers (Ryder). The alluvial and terrace aquifers illustrated above include those found in the basins of the Salt Fork of the Arkansas, the Arkansas, the Cimarron, the North Canadian, the Canadian, the Washita and the Red Rivers, as well as the Enid Isolated Terrace and the Gerty Sand. On Oklahoma Aquifer Map No. 2 (below) the areas in orange illustrate terrace and alluvial aquifers that are considered to have very high level of vulnerability to contamination.

Water Quality Problems

Salinity: Naturally occurring saltwater is found at several localities, especially in the western part of the state, and saltwater has intruded from deeper layers into the alluvial and terrace aquifers along the Cimarron and Salt Fork of the Arkansas River. Incidents of saltwater contamination connected with oil and gas production operations are common and scattered across the state (Oklahoma Department of Environmental Quality (ODEQ), Water Quality).
Nitrate: Nitrate is the most commonly reported contaminant in Oklahoma and it is usually associated with land application of chemical fertilizers for crop production and the operation of animal feeding operations which produce large amounts of animal waste (ODEQ, Water Quality). The map below shows vulnerability of ground water to contamination based on the DRASTIC system (OWRB). The alluvial and terrace deposits along the major rivers (shown in orange) are especially vulnerable because they consist of coarse-grained sediments which allow easy infiltration of surface waters and because the availability of water make them attractive sites for agriculture. As shown on the map, a number of swine operations are located on the vulnerable alluvial and terrace aquifers. High concentrations of nitrate are common in the ground water along much of the Cimarron and North Canadian River because of these concentrated animal feeding operations (CAFOs) and crop production (Becker). Poultry farms in Southeastern Oklahoma are also a concern.



Oklahoma Aquifer Map No. 2

Region 6 and its partners have recently completed inspections of all of the state's licensed or permitted CAFOs. The focus of the inspections was compliance with the EPA's Dec. 15, 2002 CAFO rule. Sources found to be in violation have either corrected the situations or are now involved in enforcement actions.

Bedrock Aquifers

Major bedrock aquifers in Oklahoma include the Ogallala, Blaine, Elk City, Rush Springs, Arbuckle Timbered Hills, Central Oklahoma (also known as Garber Wellington), Arbuckle Simpson, Antlers, Vamoosa-Ada, and Roubidoux aquifers. Specific threats to two of the bedrock aquifers are described below (OWRB).

<u>Central Oklahoma Aquifer:</u>

The Central Oklahoma aquifer, which includes more than 6 geologic formations, is located in the central section of the state directly below a relatively densely populated area from Guthrie to south of Norman. The aquifer is used extensively for municipal, industrial, commercial, and domestic water supplies and is a major source for water supplies in central Oklahoma (Ryder).

<u>Water Quality Problems</u>

Known problems include concentrations of arsenic, chromium, selenium, and gross-alpha activity that exceed drinking-water standards. Other problems include possible contamination of the aquifer by oil-field brines and drilling fluids, pesticides, industrial chemicals, septic-tank effluent, fertilizers, and leakage from sewage systems and underground tanks used for storage of hydrocarbons. Arsenic concentrations exceed the maximum contaminant level (MCL) in some zones that are tapped by public water supply systems. This problem has been studied by the US Geological Survey (USGS), which concluded that the arsenic is desorbed off natural sediments in the aquifer when the acid nature of the water increases to a pH value of 8.5 or above. The reason for the increased pH values in the Central Oklahoma Aquifer is given as carbon dioxide (CO_2) uptake by recharge waters entering exposed areas of the aquifer. The CO_2 reacts with dolomites, freeing ions that later form acidic conditions as the waters are filtered into clay layers of the formation (Schlottmann). The USGS has launched a major study of the aquifer under its National Water Quality Assessment program. Results of the study, when available, will be posted on the USGS website.

<u>Roubidoux Aquifer (Tar Creek Superfund site):</u>

Lead and zinc mining operations in the tri-state area of northeastern Oklahoma, southeastern Kansas and southwest Missouri began in the early 1900’s and continued through the 1960’s. The mining operation brought ore up from the Boone formation. The Boone also contains an aquifer. The mining operations required the aquifer be emptied of water, which in turn allowed the sulfur in the formation to oxidize. After mining ceased in the area, water reentering the mines reacted with the sulfur oxides to form acidic water which eventually came to the surface, severely impacting Tar Creek. The site was named a Superfund site in 1983. Initial attempts to clean up the problem with the Boone aquifer have met with little success (OSE, Task 1 Report 1-3).

Water Quality Problems

The Boone aquifer is not considered a useable source of drinking water and is not useful for irrigation or agricultural purposes in its current state. The water is contaminated with traces of lead and zinc, as well as being acidic in nature. The position of the Boone aquifer makes it a potential source of pollution to the Roubidoux aquifer. The Roubidoux is a significant source of drinking water in the state. While up to 83 abandoned oil and gas drilling wells have been plugged to protect the Roubidoux, monitoring is still underway to identify and assess potential damage. As long as there remains a potential for transfer of contaminated water from the Boone to the Roubidoux, monitoring of the Roubidoux will be required (OSE, Task 1 Report 1-3).

State Regulation of Ground Water Quality

Ground Water Quality Monitoring Program

The ODEQ is in the process of developing a statewide ground water monitoring program based on sampling of public water supply wells. This monitoring program should supply a considerable amount of needed information on aquifers used for drinking water by municipalities and non-community systems. However, water quality in the shallow aquifer zones will not be well represented in that network and the potential for developing protection for domestic well users will not be as great. ODEQ posts information on contaminants found in the state's aquifers as part of the monitoring program at the following website: http://www.deq.state.ok.us/WQDnew/groundwater/aquifer_maps.html

Although ODEQ is the lead agency for environmental programs, ground water quality research is spread among several state agencies. Oklahoma does not have a single strong central authority for ground water protection, as some of the other Region 6 states have. The OWRB has operated a ground water monitoring program in the past and has conducted a number of technical studies on the ground water resources of the state. The Department of Agriculture, Food and Forestry (ODAFF) has authority for ground water protection in the critical area of concentrated animal feeding operations. Other agencies, such as the Conservation Commission, also have an on-going interest in ground water, including its impacts on surface water.

General Assessment of Ground Water Quality

State publications and comments of state ground water program staff indicate that the majority of the principal aquifers provide water supplies that generally meet federal and state standards for drinking water. However, not all areas or depths within these aquifers produce good water. Ground water has been characterized as hard to very hard in the majority of the state's major aquifers.

The dry climate, topography and geology of the state and the effects of human activities have tended, in many places, to produce low quality shallow ground water, overlying better water whose quality decreases in deeper zones. Most of the aquifers are exposed to the surface, rather than buried beneath deeper impermeable layers. This makes them especially vulnerable to contamination. The OWRB maintains a listing of areas of the state where potable ground water is not available. (See OWRB, Title 784, Chapter 45, Appendix H)

Contamination of both surface and ground water in the lead and zinc mining district of northeast Oklahoma has been an on-going problem for many years. Problem ground water is strongly acidic and contains high concentrations of metals (OSE, Task 1 Report 1-3). The ability of ground water to contaminate surface water is dramatically illustrated by this case, which emphasizes the need for conjunctive planning and management of ground and surface water.

Elevated levels of nitrate are common among the state's aquifers, and a recent study by the USGS has shown that nitrate exceeding the MCL is widespread in the Rush Springs aquifer (see Oklahoma Aquifer Map No. 1), probably as a result of agricultural activities. The fact that this aquifer is rated as having "moderate" vulnerability suggests that even the more protected aquifers are problem areas for this contaminant.

GROUND WATER QUANTITY

Long term ground water level declines have not been as serious in Oklahoma as in the other Region 6 states. At the time of this report, while the state has experienced severe drought conditions in recent years, an increase in rainfall has helped water levels in most alluvial aquifers recover from earlier declines. The bedrock aquifers have not responded as quickly as the alluvial aquifers but some are maintaining water levels (Oklahoma, Drought Monitoring). An up to date picture of drought conditions can be obtained through the OWRB's web portal at http://www.owrb.state.ok.us/supply/drought/drought_index.php.

Probably the greatest protection against overuse of ground water has come from the permit system operated by the OWRB to limit withdrawals. The biggest water quantity issue is the prospect for transporting water from the Arbuckle-Simpson aquifer to Oklahoma City which is outgrowing its water supply. The state legislature has ordered the OWRB to perform a study to determine the amount of water which can be taken from the aquifer without reducing spring flows in the Arbuckle Mountains to unacceptably low levels.

FUTURE EFFORTS THAT COULD HELP PROTECT GROUND WATER

- Identify potential non-point sources of pollution and quantify all contributions of contaminants.
- Investigate the interconnection between surface and ground water.
- Implement the ambient ground water quality monitoring program.
- Monitor ground water quantity.
- Set priority mechanisms for remediation.
- Share data and resources for cleanup of unregulated sites.

POTENTIAL EPA INVOLVEMENT

- Provide training to tribes on design and operation of decentralized waste water treatment systems.
- Provide technical assistance to the state in addressing ground water usage and aquifer management.
- Increase dialogue with state ground water managers with focus on exploring areas where EPA could provide programmatic, technical or other ground water assistance to the state.

REFERENCES

Becker, Mark F., et al., Possible Sources of Nitrate in Ground Water at Swine Licensed-Managed Feeding Operations in Oklahoma, 2001, U.S. Geological Survey, Water-Resources Investigations Report 02-4257, Revised January 2003. Available online at http://pubs.usgs.gov/wri/wri024257/pdf/wri024257.pdf

Christenson, S. C., Parkhurst, D. L., Ground-Water Quality Assessment of the Central Okalahoma Aquifer, Oklahoma: Project Description, U.S. Geological Survey, Open-File Report 87-235, 1987. Available online at http://pubs.er.usgs.gov/usgspubs/ofr/ofr87235

Hutson, Susan S., et al., Estimated Use of Water in the United States in 2000, U.S. Geological Survey, USGS Circular 1268, released March 04, 2004, revised April 12, 2004, May 11, 2004 and February 07, 2005. Available online at http://pubs.usgs.gov/circ/2004/circ1268/

Oklahoma. Office of the Secretary of the Environment, Governor Frank Keating's Tar Creek Superfund Task Force, Water Quality Subcommittee, Task 1 Report, Surface and Ground Water Monitoring, July 26, 2000. Available online at http://www.deq.state.ok.us/lpdnew/Tarcreek/GovrTaskForce/WQTask1.PDF

Oklahoma. Oklahoma Department of Environmental Quality, Water Quality Assessment Integrated Report, 2002. Oklahoma City, Oklahoma. Available online at http://www.deq.state.ok.us/WQDnew/305b_303d/2002_integrated_report_final.pdf

Oklahoma. Oklahoma Water Resources Board. Drought Monitoring: Groundwater Level Trends in Oklahoma, webpage last updated September 5, 2006. Available online at http://www.owrb.state.ok.us/supply/drought/dr8_groundwater.php

Oklahoma. Oklahoma Water Resources Board. Major Groundwater Aquifers of Oklahoma, Illustration. Available online at http://www.owrb.state.ok.us/maps/pdf_map/major_aquifers.pdf

Oklahoma. Oklahoma Water Resources Board. Oklahoma Water Atlas, Groundwater, Oklahoma's Buried Treasure, pp 55 – 63, 1990. Available online at http://www.owrb.state.ok.us/news/publications/wa/pdf_wa/wa_groundwater.pdf

Ryder, Paul D., Ground Water Atlas of the United States; Oklahoma, Texas: HA 730-E, U.S. Geological Survey, 1996. Available online at http://capp.water.usgs.gov/gwa/ch_e/

Schlottmann, Jamie L., "Naturally Occurring Arsenic in the Central Oklahoma Aquifer (Extended Abstract)." USGS Workshop on Arsenic in the Environment, February 21-22, 2001, Denver, CO. U.S. Geological Survey, Oklahoma City, Oklahoma. 2001. Available online at http://wwwbrr.cr.usgs.gov/Arsenic/FinalAbsPDF/schlottmann.pdf

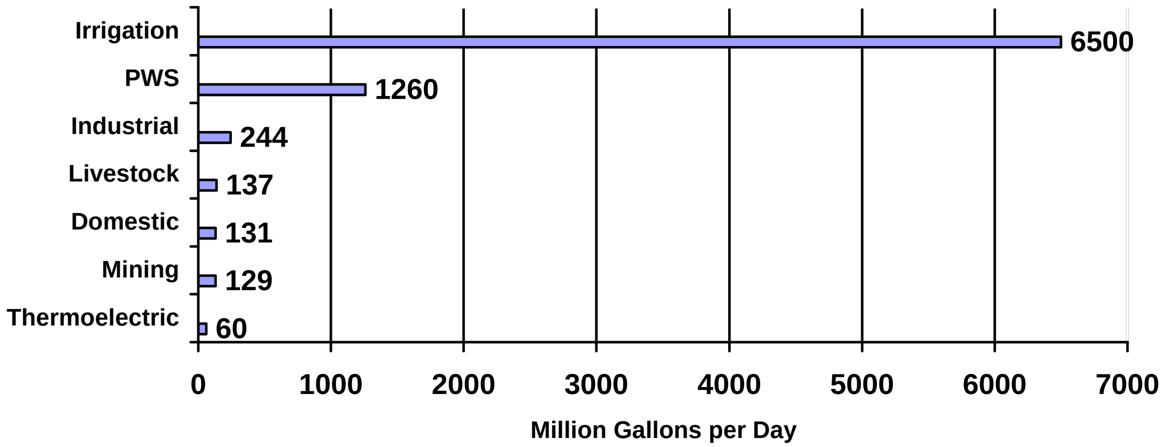
"Table: GCT-T1-R Population Estimates (geographies ranked by estimate) Geography: United States -- States; and Puerto Rico." July 1, 2005, United States Census Bureau. Available on line through http://factfinder.census.gov/

Tortorelli, Robert L., Estimated Freshwater Withdrawals in Oklahoma, 2000, Oklahoma Water Science Center website, U.S. Geological Survey, accessed August 09, 2006. Available online at http://ok.water.usgs.gov/wateruse/wateruse00.html

Texas

GROUND WATER SUPPLIES 32% OF THE POPULATION'S DRINKING WATER

GROUND WATER USE (in 2000)



IMPORTANCE OF GROUND WATER IN TEXAS

Drinking Water

Ground water is important to the health of the citizens of Texas; 31.9% of the drinking water used in 2000 was supplied by ground water, about 10% of that amount is drawn from private domestic water wells with the remainder used by public water systems (PWS). Drinking water accounted for approximately 16.4% of the total withdrawals from the state's aquifers (Hutson).

Agriculture

Ground water withdrawal for agricultural use accounts for approximately 76.8% of the ground water used in the state and is the largest category of water use. Texas ranks 4th in the U.S. for the amount of ground water used for irrigation, and ranks 2nd for ground water use and total water use in the nation (from Hutson).

Industrial Uses

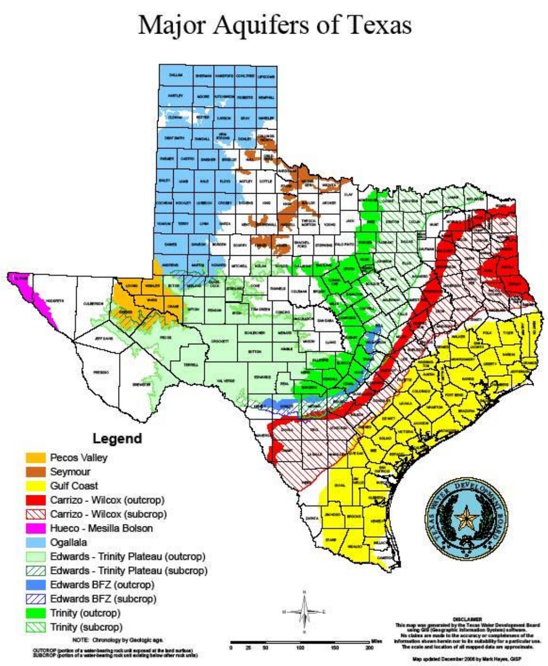
Industrial and related commercial uses, such as mining and electrical power generation, accounted for approximately 5% of the ground water consumption in Texas in 2000 (Hutson).

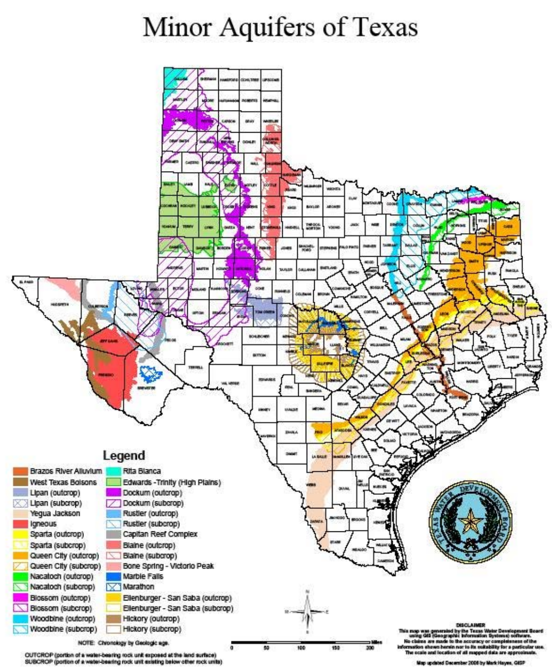
General Ground Water Quality

The 2002 ground water inventory efforts show that ground water quality in Texas varies among the twenty-one studied aquifers, but is generally good. Maximum contaminant level (MCL) exceedances occur for some parameters (nitrate, sulfate, total dissolved solids, or others) in ground water taken from a small percentage of water wells. Naturally occurring fluoride appears as a contaminant of concern sporadically throughout the sampled wells (Texas, Water Quality).

MAJOR AQUIFERS & GROUND WATER QUALITY

Nine major and twenty-one minor aquifers. Major aquifers supply about 96% of all the ground water currently used in Texas (Ground Water Protection Council). Both major and minor aquifers in Texas are composed of many rock types, including limestones, dolomites, sandstones, gypsum, alluvial gravels, and igneous rocks (Texas, Region K Water Supply Plan).





Cenozoic Pecos Alluvium

The Cenozoic Pecos Alluvium is located in the far western section of Texas. It extends from Reeves and Pecos counties in the south into New Mexico in northern reaches. It covers the major portions of Crane, Reeves, Ward and Winkler counties. Agricultural irrigation is the major use of water from this aquifer. Ashworth and Hopkins report a significant amount of water from this aquifer is "exported to cities east of the area." Other uses include industrial, power generation and public drinking supply (Ashworth).

Water Quality Problems

Salinity: Water from the aquifer is of varying quality, with the waters in the western Pecos Trough portion of the aquifer less desirable than the waters found in the eastern Monument Draw Trough. Much of the mineralization of the aquifer is naturally occurring. Agricultural irrigation in Pecos, Reeves and Ward counties has contributed to these problems.

Oilfield Contamination: Petroleum production operations in Ward, Loving and Winkler counties have contributed to the deterioration of water quality in these areas (Jones).

Seymour

The Seymour Aquifer is located in the North Central portion of Texas and consists of 22 segments scattered through the 20 counties in the upper Red River and upper Brazos River basins. The water is generally of good quality with some areas of slightly saline content. The major uses of the aquifer are agricultural, with a minor portion of withdrawals devoted to municipal, domestic and industrial uses (Ryder).

Water Quality Problems

Pesticide, Bacteria and Nitrate: Contamination by nitrate and fecal coliform bacteria from septic systems and animal wastes has resulted due to the presence of septic systems, sewage treatment plants, feedlots, and barn yards. Application of agricultural fertilizers and pesticides has also added to contamination problems in some areas (Ryder).

Oilfield Contamination: Oilfield activities have caused some contamination in sections of the aquifer due to brine disposal and leakage from well bores. These problems are localized and expected to remain so (Ryder).

Gulf Coast

The Gulf Coast Aquifer is found in 54 counties along the Gulf of Mexico coast. The aquifer itself covers a very large area of the United States from the Rio Grande Valley in Texas to Florida. The major uses of water from the aquifer are agricultural irrigation and municipal water use. This aquifer has produced much of the water used by the Greater Houston metropolitan area. Heavy industrial and municipal usage of waters from the aquifer has resulted in significant declines in water table levels over the last few decades. Ashworth and Hopkins have noted declines of 200 – 300 feet in parts of heavily populated and industrialized Harris and Galveston counties. Significant declines have been noted in Kleberg, Orange, Jefferson and Wharton counties. Ground level subsidence along the Gulf Coast is generally ½ foot or less, but subsidence of as much as 9 feet has been noted in the Harris county area (Ashworth).

Water Quality Problems

Saltwater Intrusion: Heavy pumping from the Gulf Coast aquifer for municipal and industrial use has allowed poorer quality waters and saltwater to migrate into the shallower, previously higher quality zones of the aquifer. In some Coastal areas, deterioration of water quality and updip migration of saltwater, caused by heavy municipal and industrial use, have been stabilized after reductions of pumpage from the aquifer (Ashworth).

Carrizo – Wilcox

The Carrizo-Wilcox Aquifer spans a 60 county area of Texas from the Rio Grande, through central Texas, into northeastern Texas and on into Louisiana and Arkansas. This aquifer is the principal source of water for Tyler, Bryan-College Station and Lufkin-Nacogdoches. Municipal and agricultural irrigation accounts for 85 percent of the water drawn from this aquifer (Ashworth).

Water Quality Problems

Oilfield Contamination: Ashworth and Hopkins indicate oilfield activities have caused some contamination in the southern areas of the aquifer due to direct infiltration of brine from surface operations and downward leakage of saline water from overlying formations (Ashworth).

Hueco – Mesilla Bolson

The Mesilla Bolson and Hueco-Bolson aquifers straddle the Franklin Mountains in El Paso County. The aquifers are the principal source of water for the city of El Paso and Ciudad Juarez, Mexico. Together, the two aquifers extend from El Paso County westward into Mexico and northward into New Mexico. South of the Franklin Mountains the two aquifers merge to form the Hueco-Mesilla Bolson Aquifer which continues southward along the Rio Grande into Hudspeth County (Ashworth).

Water Quality Problems

Municipal Water Withdrawals: Years of withdrawals from municipal well fields in the Ciudad Juarez and El Paso areas have resulted in major declines of water levels, which in turn are thought to have caused changes in the direction of flow, rate of flow and chemical quality of the water from the aquifer in these areas (Ashworth).

Ogallala

The Ogallala Aquifer (also known as the High Plains Aquifer) stretches from South Dakota through Texas. In Texas, the High Plains Aquifer, or Ogallala Aquifer, is located under 46 western counties. The Ogallala formation is the principal geologic unit of the High Plains Aquifer. Agricultural irrigation is the main use of the High Plains aquifer waters. There has been a trend toward depletion of the available water in the High Plains since the beginning of agricultural irrigation in the early part of the twentieth century (Ashworth).

Water Quality Problems

Nitrates: Fahlquist reported taking 48 samples from the southern High Plains (Ogallala) aquifer in 2001. Of those, 27 (56%) of the samples showed nitrate greater than the 2.5 milligram per liter (mg/L) background level McMahon had established for the area in 2001, suggesting an anthropogenic origin for much of the nitrate in the area. Six (13%) of the samples showed nitrate levels to be greater than EPA's maximum contaminant level (MCL) for drinking water of 10 mg/L (Fahlquist, 2003).

Arsenic, strontium, boron and manganese: Falhquist's samples showed arsenic was present in all 47 samples and above EPA's 2002 MCL for drinking water of 10 microgram per liter in 14 samples (30%). Strontium concentrations greater than the MCL were present in 8 (17%) of the samples. Concentrations of boron greater than the drinking water standard were present in 5 (11%) of the samples. Manganese concentrations greater than the drinking water standard were present in 4 (9%) of the samples them (Fahlquist, 2003).

Radon: Radon was present in all the samples taken and greater than the proposed drinking water standard of 300 picoCuries/Liter (pCi/L) in 36 (77%) of them (Fahlquist, 2003).

Edwards – Trinity Plateau

The Edwards-Trinity Plateau Aquifer lies under the Edwards Plateau. The aquifer provides water for 38 counties in the central and western portions of the state. The aquifer runs from the Central Texas Hill country westward into the Trans-Pecos area of the state. Of the water withdrawn from the Edwards-Trinity, 15% is used for municipal purposes. Agricultural irrigation accounts for another 70% of the water taken from the aquifer. With the exception of Reagan, Upton, Midland and Glasscock counties, Ashworth and Hopkins report this aquifer has not experienced large scale pumpage and variations in the water table levels are related to seasonal precipitation (Ashworth).

Water Quality Problems

Oilfield Contamination: Hudak reports evidence of brine contamination from surface oilfield operations. In 2003, Hudak compared the chloride/bromide ratios from 198 water wells in the aquifer. The samples were taken in eight west central Texas counties with histories of oil production and agricultural activities. Samples from 49 (25%) of these wells showed chloride concentrations above the secondary drinking water standard of 250 mg/L chloride. In 22 of these 49 wells (45%) there was evidence of chlorides and bromides consistent with brine from oilfield operations. In two of the 49 wells (4%) the ratio of chloride to bromide implied contamination from evaporite dissolution of brines from the surface (Hudak).

Edwards – Balcones Fault Zone (BFZ)

The Edwards BFZ aquifer underlies major parts of nine central and south central Texas counties, as well as minor parts of two adjoining counties. The aquifer underlies agricultural and ranch land as well as some of the more densely populated areas of Texas. This aquifer is roughly coincident with the highly fractured geology of the Balcones Fault (Ashworth).

Ashworth and Hopkins state 54% of the Edwards BFZ waters are drawn out for municipal uses. San Antonio, a city of approximately 1,250,000 residents, relies on wells in the Edward BFZ to provide water for all its municipal uses. Waters drawn from the western reaches are used primarily for irrigation (Ashworth).

Ashworth and Hopkins describe the updip (north and west) portions of the aquifer as honey combed with highly permeable solution zones and channels that promote the quick flow of waters into and out of the aquifer. These channels and zones are capable of storing and transmitting large volumes of water of good quality water in relatively short time frames. This makes the aquifer capable of yielding moderate to large amounts of water, as well as vulnerable to environmental and climate changes. The downdip (south and east) portions of the aquifer are more mineralized, which makes the water somewhat less desirable than the updip waters (Ashworth).

Water Quality Problems

Radon: Fahlquist and Ardis report radon gas was detected in samples from the Edwards BFZ in studies done from 1996 to 1998. The presence of radon exceeded the proposed USEPA drinking water standard of 300 pCi/L in 10 of the approximately 90 samples. The source of the radon is thought to be "granitic sediments and igneous intrusions into and below the Edwards aquifer" (Fahlquist, Ardis, 2004).

Trinity

The Trinity Aquifer underlies 55 central Texas counties from the northern Red River border in the north central portion of the state to the south central counties of Uvalde, Medina and Bexar. This aquifer provides water for communities along the densely populated Interstate 35 corridor. Withdrawals in the Dallas-Ft. Worth area historically have resulted in water level drops of up to 550 feet. A trend towards municipal development of surface water sources over the last three decades has helped the aquifer recover, but significant declines still occur in many areas. The aquifer is most highly developed in the Waco region where water level declines of 400 feet are reported, according to Ashworth and Hopkins (Ashworth).

Water Quality Problems

Pesticide, VOCs and Nitrate: Land and Moring detected the presence of insecticides in 50% of samples taken from shallow wells in the Trinity aquifer. Contamination by nitrate and volatile organic compounds from agricultural and buried fuel tanks was detected in fewer than 10% of the same samples. No primary drinking water standards were violated (Land).

Salinity: Water from the aquifer is of varying quality. While no evidence of violation of EPA's primary drinking water standards has been found, Long and Moring report an exceedance of EPA's secondary standards in 50% of samples taken from the Trinity aquifer (Land). Benyon also reported an exceedance of the secondary MCL in samples taken from shallow wells in Erath County (Benyon).

State Regulation of Ground Water Quality

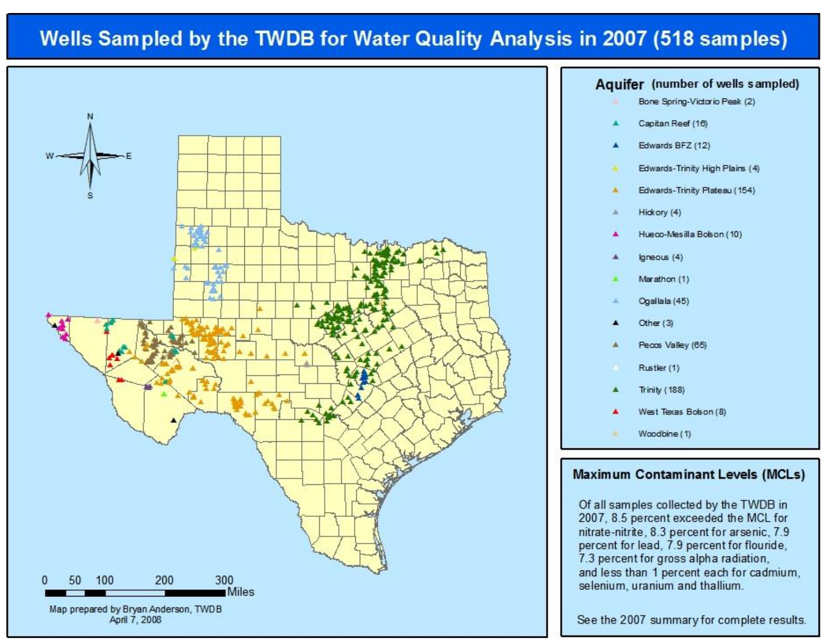
Specific Ground Water Quality Problems

As noted above, the most common contaminants reported are gasoline and other volatile organic compounds, pesticides, nitrates, salinity (dissolved solids), and radioactive constituents.

Leaking petroleum storage tanks are the primary cause of the release of gasoline, and other petroleum products. Agricultural runoff is the source of most pesticides and nutrients. Radioactive constituents are naturally occurring. The Edwards Aquifer, in the San Antonio and Austin areas, has been given special status by the Texas Legislature because of its vulnerability to pollution and overuse.

Ground Water Quality Monitoring Program

The Texas Water Development Board (TWDB) conducts a ground water resource assessment program. The data collected includes: occurrence, availability, quality, and quantity of ground water present and the current and projected demands on this resource. As part of this program, ground water sources are sampled and analyzed



for at least 25 primary and secondary constituents. The program monitors changes, if any, in the quality of ground water over time, and establishes the baseline quality of the State's aquifers. The TWDB samples 600 to 700 sites over a 4 year time span, with several aquifers being sampled every year. Collaborators sample another 200 sites. In 2007, the agency sampled 518 separate sites over more than 16 aquifers in the state. (See attached illustration of 2007 sampling sites.) The Texas Commission on Environmental Quality (TCEQ) also conducts a pesticide monitoring program for ground water wells throughout Texas.

Other Ground Water Quality Protection Programs

The TCEQ implements a variety of programs which address ground water protection and focus on both prevention of contamination and remediation of existing problems.

The Texas Water Development Board is responsible for statewide water planning, collection and maintenance of water resource information, and administration of financial assistance programs for water supply, water quality, flood control, and agricultural water conservation projects. The TWDB supports a Ground water Availability Model Program, an initiative to develop state-of-the-art, publicly available numerical ground water flow models.

The Texas Railroad Commission has regulatory authority over oil and gas exploration and production, surface mining and mine reclamation, and pipelines.

The Texas Department of Agriculture has lead authority for pesticide regulation in Texas. Certain pesticides have been identified as potential ground water contaminants.

The Texas State Soil and Water Conservation Board encourages the proper use of agricultural chemicals and provides education to those using them. The agency also establishes water quality management plans in areas that have developed, or have the potential to develop, agricultural or silvicultural nonpoint source water quality problems.

MAJOR AQUIFERS & GROUND WATER QUANTITY

The state's nine major aquifers and twenty-one minor aquifers underlie approximately 76% of Texas' surface area of 267,338 square miles. In terms of availability, the Ogallala, located in the Texas Panhandle, is by far the largest, modeled at 6.0 million acre feet per year (AF/Yr.) in 2010, followed by the Gulf Coast (1.8 million AF/Yr. in 2010), Carrizo-Wilcox (1.0 million AF/Yr. in 2010), Edwards-Trinity Plateau (0.57 million AF/Yr. in 2010), and the Dockum (0.41 million AF/Yr. in 2010) (Mace).

Overall, ground water resources are thought to be stable for much of the state, but declining overall. It has been estimated ground water supplies will decline overall by 32 percent between 2010 and 2060. The decline is due primarily to the depletion of the Ogallala and Carrizo-Wilcox aquifers, and reduced pumping from the Gulf Coast aquifer mandated to mitigate land subsidence in the some areas of the region (Mace, 2008). The Ogallala Aquifer in the Texas panhandle is becoming substantially depleted and availability is expected to be reduced by about 50% from 2010 to 2060 (Texas, Water for Texas, 2007). Significant subsidence, as much as several feet, has occurred in the Houston area. Critical to this concern is that as the level is lowered, contaminant intrusion can often reduce the quality of the remaining water, and once the level of an aquifer is substantially lowered the clay features of the geologic structures can compress such that they are no longer able to be recharged. The sand and gravel features of these aquifers will recharge with proper management

EFFORTS TO PROTECT GROUND WATER

Recognizing the importance of ground water, in 1989, the Texas Legislature created the Texas Groundwater Protection Committee (TGPC) which is composed of nine key state agencies and the Texas Alliance of Groundwater Districts. Major responsibilities of TGPC include coordinating interagency efforts in the area of ground water protection and developing the Texas Groundwater Protection Strategy. This strategy describes the roles and responsibilities of the various state agencies involved in ground water protection and how they carry out their programs through regulatory and non-regulatory models. The Strategy also provides recommendations and possible actions to protect ground water. The TGPC is also working on the Comprehensive Groundwater Protection Plan which provides appropriate resource protection, addresses remediation, and complies with State and Federal law.

FUTURE EFFORTS THAT COULD HELP PROTECT GROUND WATER

- Current well construction standards for domestic wells will protect the water source from surface or very shallow ground water contamination, but will not address naturally occurring contaminants or contamination in the targeted aquifer that migrates from another area due to nonpoint source contamination. A better understanding of the contamination issues facing private well owners is needed to assess how to better address this programmatic gap.
- The ground water quality monitoring program could use additional resources to sample more sites and provide a better picture of ambient ground water conditions. The suite of chemicals that is analyzed needs to be expanded to include organic and synthetic chemicals, especially pesticides. Present ambient monitoring is limited to anion and cation analysis, pH, and some radionuclides.

- Assessment of hazardous wastes in ground water is covered by state and federal programs. However, contamination of aquifers caused by substances that may be deemed naturally occurring and may have health effects, such as nitrates, arsenic, and radionuclides, need to be addressed.
- The ability to identify and locate actual and potential sources of contamination geographically is critically important to any planning process, but is currently not available throughout the TGPC member agencies since not all data are available in an electronic format. Therefore, the development of a central database to house this information or establish a platform that will allow for easy data sharing by all interested parties should be promoted.

POTENTIAL EPA INVOLVEMENT

- Provide technical assistance related to the desalination of ground water from the Rio Grande Alluvium and Hueco-Bolson aquifers in the Far West Texas Region of the state, which is necessary to meet the region's needs for additional water supplies.
- Provide technical assistance to the state in addressing ground water usage and aquifer management.
- Increase dialogue with state ground water managers with focus on exploring areas where EPA could provide programmatic, technical or other ground water assistance to the state.

REFERENCES

Ashworth, J. B., Hopkins, J. H., 1995, Major and Minor Aquifers of Texas. Texas Water Development Board Report 345. Available online at http://rio.twdb.state.tx.us/publications/reports/GroundWaterReports/GWReports/GWreports.asp

Benyon, B. E., 1991, Ground-Water Quality Monitoring of the Trinity Aquifer in the Vicinity of Erath County. Texas Water Development Board Report 331. Available online at http://rio.twdb.state.tx.us/publications/reports/GroundWaterReports/GWReports/GWreports.asp

Bradley, R. G., and S. Kalaswad, 2003, The Groundwater Resources of the Dockum Aquifer in Texas: Texas Water Development Board Report 359, 73 p. Available online at http://www.twdb.state.tx.us/publications/reports/GroundWaterReports/GWReports/Individual%20Report%20htm%20files/Report%20359.htm

Fahlquist, Lynne, and Ardis A.F., 2004, Quality of water in the Trinity and Edwards aquifers, south-central Texas. 1996-1998: U.S. Geological Survey Scientific Investigations Report 2004-5201. 17p. Available online at http://pubs.usgs.gov/sir/2004/5201/

Fahlquist, Lynne, 2003, Ground-water Quality of the Southern High Plains Aquifer, Texas and New Mexico, 2001: U.S. Geological Survey Open-File Report 03-345. Available online at http://co.water.usgs.gov/nawqa/hpgw/reports/ofr03_345.pdf

Ground Water Protection Council. Ground Water Report to Congress, Summaries of State Ground Water Conditions, October, 1999. Available online at http://www.gwpc.org/e-Library/Documents/Acrobat/texas.pdf

Hudak, P. F., Oil Production and Groundwater Quality in the Edwards-Trinity Plateau Aquifer, Texas., Abstract, Scientific World Journal, November 13, 2003, Vol. 3 p 1147-53. Available online at http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&list_uids=14646018&dopt=Abstract

Hutchinson, W. R., 2006, Groundwater management in El Paso, Texas: Ph.D. Dissertation, The University of Texas at El Paso, 329 p.

Hutson, Susan S., et al., Estimated Use of Water in the United States in 2000, U.S. Geological Survey, USGS Circular 1268, released March 04, 2004, revised April 12, 2004, May 11, 2004 and February 07, 2005. Available online at http://pubs.usgs.gov/circ/2004/circ1268/