Exploring Aquifers Lesson Five:
"Threats to Aquifer Water"

Academic Questions: What is the impact of pumping on aquifers?
How does pollution impact aquifers?
How do droughts impact aquifers?

Objective(s):

- To understand the movement of water through an aquifer
- To understand the threats to water quantity and quality within an aquifer by human activities
- To understand the threats to water quality and quantity within an aquifer by non human activities
- To understand the relationship between a watershed and an aquifer
- To understand the importance of aquifers to the water supply of Texas

Key Terms: precipitation rates, municipal use, drawdown, subsidence, MTBE, contaminants, filtration, nonpoint pollution, droughts, rain harvesting
Click here for definitions to Exploring Aquifers vocabulary.

Process (Activities):

Part One: Impact of Pumping

1. Have students compare the water table level of each of their model aquifers when removing water with pumps.

2. Ask the class to research groundwater well levels for the different aquifers for each month of the year and compare to precipitation rates in USGS records.

3. Ask students to research areas of the state for municipal water use and irrigation water use of the aquifer discharges. Each year, the TWDB conducts an Annual Survey of Ground and Surface Water Use in Texas. This information can be found on their web site at: http://www.twdb.state.tx.us/data/water_use/tex_hist.htm.

4. Using the information that they learned in Lesson Four, ask students to designate on their aquifer models the main users of groundwater, either municipal or agricultural. They can create surface structures such as windmills or shopping malls on their watershed molds (created in Lesson Four) or on the aquifer model to indicate groundwater use.

5. Explain the problems of drawdown when a large pumper, like a city, overpumps its portions of the aquifer. Explain that some people can lose their wells and will be required to drill deeper. Water quality may change due to the thinner layer of fresh water allowing the intrusion of saline water from a bad water line or coastal waters. Some over pumped aquifers have top layers settle, causing the land to subside. This is due from pressure of the heavy overlying layers compressing the empty water-bearing layer pores. Even if water is pumped back into the aquifer layer, the pore spaces will not come back, and the water porosity of the aquifer stays altered.

Part Two: Impact of Pollution

1. Explain to the students about nonpoint pollution and where the pollutants enter groundwater via runoff from surface flow. Information on the limits for pollutants, affects on humans and source of pollutants are found on EPA's web site at: http://www.epa.gov/safewater/mcl.html.

Included are the current drinking water standards allowable limits of pollutants for human health and welfare. Some of these are: Chloride 250 mg/L, Copper 1.0 mg/L, Fluoride 2.0 mg/L, Foaming Agents 0.5 mg/L, Iron 0.3 mg/L, Manganese 0.05 mg/L, Odor 3 threshold odor number, pH 6.5-8.5, Sulfate 250 mg/L, with a Total Dissolved Solids of 500 mg/L.

2. Allow students to explore how effective aquifers are filtering runoff pollutants using different substrate in canisters to compare filtration ability. Ask students to use Lesson One: Geology of Aquifers materials that explored permeability and percolation time. Explain that the surface layers are important in the filtration of groundwater for aquifers that rely on percolation of recharge. The aquifers that have permeable rock layer exposed at the surface are without an additional filtration level. Students whose aquifer models have percolation will add a surface layer of newspapers, sand or plant matter to their watershed molds or the aquifer models. (Students will need to increase the number of drainage holes in the watershed model to insure proper drainage into the aquifer model.) Make a mixture of muddy water, containing bits of Styrofoam, foil, paper, and macaroni. Pour into the test containers. How much of the pollutants entered the aquifer substrate and the water table?

3. Ask students to research the contaminants of wells surveyed by USGS (see below) and list the pollutants as either man-made or as naturally occurring.

4. The well data for specific counties can be accessed through the EPA's Safewater site, found at: http://www.epa.gov/safewater/dwinfo/tx.htm. To look for assessments of Texas Drinking Water, enter a county within your aquifer and then select a particular water supplier. Choose suppliers for 30 people to 30,000 people. The site will tell when the well was monitored and, if there was contamination, what was found. Also, see Texas Water Development Board's Groundwater Well Map at: http://www.twdb.state.tx.us/publications/reports/GroundWaterReports/GWDatabaseReports/Aquifer%20Maps/MajorAq.pdf.

   To determine if a site is near their aquifer, students can also look up the Superfund sites in Texas at: http://www.epa.gov/earth1r6/6sf/6sf-tx.htm.

5. As an extension activity, students can learn about the groundwater pollution by MTBE. MTBE (methyl-t-butyl ether) is a member of a group of chemicals commonly known as fuel oxygenates and is used in gasoline to reduce greenhouse gases in emissions. Releases of MTBE to ground and surface water can occur through leaking underground storage tanks and pipelines, spills, and from air emissions. Students can investigate the procedures in place for detection of MTBE in your aquifer's groundwater: http://www.epa.gov/safewater/imagesrtp/ogwdwus.gif.

   If there is drinking water supplied by a public water system within your aquifer, you can contact the system directly and ask whether they monitor for MTBE and what levels, if any, have been detected. In 2001, public water systems serving most of the population will be required to monitor for MTBE.

Part Three: The Impact of Droughts

1. Ask students to research the historic records for their area for droughts and wells drying up. Have students share the results and discuss how severe water shortages are during droughts.

2. Once students understand that water shortages occur during drought conditions, ask the students to brainstorm ways water can be conserved. Ask students, using a minimum set of materials, to make a rain harvest system over their aquifer model to catch and store the

maximum amount of water from a controlled "rain shower" poured over the model. In this instance, of course, the rain harvesting prevents water from entering the recharge features of an aquifer. The usual consequence to most precipitation is entry into streams and waterways, which may or may not feed the aquifer as a losing stream or through a sinkhole.

3. Ask students to look at the percentage of water used in municipalities for landscape watering and estimate total gallons of water needed to be collected by rain harvesting barrels for landscape use.

Product/Application: Have students return to their aquifer models. Ask them to remove half the groundwater by pumping. How might that affect other well owners over the aquifer? How much water storage would be lost if the entire pore space without water is compressed? Ask students to explore the impact pumping, runoff pollution, and droughts have on the water table of their aquifer.

Assessment/Evaluation: Ask students to create a plan for limiting water pumping for their models during different seasons of the year. Ask students to determine possible sources of contaminates in the wells. How did this pollution enter their aquifer?

Conclusion: Have student demonstrate to the class, using their aquifer models, what they have learned about the impact of pumping, pollution, and droughts on their aquifer.

Resources:

Technical Documents for 57 Water Supply Options by South Central Regional Water Planning:
http://www.watershedexperience.com/007/007_pdf.html

Program of the USGS in Texas Hydrogeology, Simulation of Ground-Water Flow, and Land-Surface Subsidence in the Chicot, Evangeline, and Jasper Aquifers, Houston Area, Texas:
http://txwww.cr.usgs.gov/project.asp?cc=4648&ac=21200

Texas Drinking Water:
http://www.epa.gov/safewater/dwinfo/tx.htm

EPA Safe Water and MTBE detection:
http://www.epa.gov/safewater/imagesrtp/ogwdwus.gif

Texas Water Development Board's Groundwater Well Map:
http://www.twdb.state.tx.us/publications/reports/GroundWaterReports/GWDatabaseReports/Aquifer%20Maps/MajorAq.pdf

USGS in Texas, Relations of the occurrence and magnitude of contaminants to selected environmental characteristics for watersheds in Texas:
http://txwww.cr.usgs.gov/project.asp?cc=4648&ac=19000

Trinity Aquifer Groundwater Continuous Monitoring Databases of rainfall and well levels:
http://www.eardc.swt.edu/trinity/trinity.html

SaltNet: Saltwater Intrusion Resources Network--Resources related to salt water intrusion into coastal groundwater aquifers:
http://www.ce.udel.edu/faculty/cheng/saltnet/index.html

Municipal Water Demand Projections:1990-2050--Water demand projections in acre feet by region with figures for counties, places, etc.:

http://www.twdb.state.tx.us/data/popwaterdemand/popwaterdemandmain.htm#totals

Texas Guide to Rainwater Harvesting:
http://www.twdb.state.tx.us/publications/reports/RainHarv.pdf

Texas Water Information--Drought Monitoring:
http://www.texaswaterinfo.net/Monitoring/Meteorological/Drought/index.htm

Groundwater Conditions in Texas--This page provides access to summary pages of real-time hydrologic data at about 520 sites in Texas:
http://tx.water.usgs.gov/nwis-bin/current/?type=groundwater

USGS's High Plains Regional Ground Water Study in National Water-Quality Assessment Program--High Plains aquifer system underlies eight states, and 20% of irrigated land in the US.
http://co.water.usgs.gov/nawqa/hpgw/HPGW_home.html

Time Frame: Three 45-minutes class period
Grade Level: 6th-12th

TEKS Correlation:
Science
Grade 6: 6.1, 6.2, 6.3, 6.4
Grade 7: 7.1, 7.2, 7.3, 7.47.5,
Grade 8: 8.1, 8.2, 8.3, 8.4, 8.12, 8.14
Aquatic Science: (b)1, 4.B, 5.A,D, 8.A,B,C,D
Environmental Science: (b)1 5.B,E,F
Geology, Meteorology, and Oceanography: (b)1, 10A,B

Mathematics
Grade 6: 6.1, 6.8, 6.11, 6.12, 6.13
Grade 7: 7.3, 7.4, 7.9, 7.13, 7.14, 7.15
Grade 8: 8.14, 8.15
Geometry: 6
Precalculus: 2

Technology Applications
Grades 6 –8: 2, 4, 5, 6, 7, 8

Social Studies
Grade 6: 6.7, 6.20, 6.21, 6.22, 6.23
Grade 7: 7.21, 7.22, 7.23
Grade 8: 8.10, 8.30, 8.31, 8.32

English
Grade 6: 6.1, 6.2, 6.5, 6.13, 6.17, 6.20, 6.22, 6/24
Grade 7: 7.1, 7.2, 7.5, 7.13, 7.17, 7.20, 7.22, 7.24
Grade 8: 8.1, 8.2, 8.5, 8.7, 8.10, 8.13, 8.17, 8.18, 8.20, 8.22, 8.24
English I: 1, 4, 6, 8, 13, 15, 16, 21
English II: 1, 4, 6, 7, 8, 13, 15, 16, 21

USGS Texas Abstract
http://tx.usgs.gov/biblio/abstracts.asp?seq=1091

Ground-water quality of the Trinity, Carrizo-Wilcox, and Gulf Coast aquifers, February–August 1994

Abstract: Ground-water samples were collected from wells in the outcrops of the Trinity, Carrizo-Wilcox, and Gulf Coast aquifers during February–August 1994 to determine the quality of ground water in the three major aquifers in the Trinity River Basin study unit, Texas. These samples were collected and analyzed for selected properties, nutrients, major inorganic constituents, trace elements, pesticides, dissolved organic carbon, total phenols, methylene blue active substances, and volatile organic compounds as part of the U.S. Geological Survey National Water-Quality Assessment Program. Quality-control practices included the collection and analysis of blank, duplicate, and spiked samples.

Samples were collected from 12 shallow wells (150 feet or less) and from 12 deep wells (greater than 150 feet) in the Trinity aquifer, 11 shallow wells and 12 deep wells in the Carrizo-Wilcox aquifer, and 14 shallow wells and 10 deep wells in the Gulf Coast aquifer. The three aquifers had similar water chemistries--calcium was the dominant cation and bicarbonate the dominant anion. Statistical tests relating well depths to concentrations of nutrients and major inorganic constituents indicated correlations between well depth and concentrations of ammonia nitrogen, nitrite plus nitrate nitrogen, bicarbonate, sodium, and dissolved solids in the Carrizo-Wilcox aquifer and between well depth and concentrations of sulfate in the Gulf Coast aquifer. The tests indicated no significant correlations for the Trinity aquifer.

Concentrations of dissolved solids were larger than the secondary maximum contaminant level of 500 milligrams per liter established for drinking water by the U.S. Environmental Protection Agency in 12 wells in the Trinity aquifer, 4 wells in the Carrizo-Wilcox aquifer, and 6 wells in the Gulf Coast aquifer. Iron concentrations were larger than the secondary maximum contaminant level of 300 micrograms per liter in at least 3 samples from each aquifer, and manganese concentrations were larger than the secondary maximum contaminant level of 50 micrograms per liter in at least 2 samples from each aquifer. The pesticides atrazine, deethylatrazine, and pp'-DDE were detected in at least one sample from each aquifer. Diazinon was detected in 11 Trinity aquifer samples and 4 Carrizo-Wilcox aquifer samples. Each aquifer had one detection of a volatile organic compound--benzene in the Trinity aquifer, trichlorofluoromethane in the Carrizo-Wilcox aquifer, and trichloromethane in the Gulf Coast aquifer.