Texas Water Resources Institute

July/August 1984
Volume 10
No. 4

Hope for the High Plains

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The Ogallala Aquifer, a vast reservoir of water underlying the High Plains of Texas, has enriched the lives of Texans since the first successful irrigation well was drilled in 1908.

Before the aquifer was tapped, the area was sparsely settled, for few streams dissect the wind-swept prairie and rainfall is too scarce to support much farming. Improvements in design and efficiency of pumps and power units in combination with a drought in the 1930s made irrigation on the High Plains a fact of life. In the years just after World War II, irrigated acreage grew at a phenomenal rate.

Today the region has approximately six million acres of irrigated land supplied by more than 70,000 irrigation wells and is a major agricultural production area for the United States.

Texans on the High Plains are paying a high price, however, to enjoy the economic prosperity made possible by irrigated agriculture. Their water debt continues to grow at the rate of four to six million acre-feet per year. The Ogallala Aquifer formation in Texas originally contained about 500 million acre-feet of recoverable water, but the U.S. Geological Survey estimated the quantity remaining in 1980 at 375 million acre-feet.

Changes in agricultural practices adopted in the past two decades have slowed the rate of depletion. The High Plains Underground Water Conservation District in Lubbock cites the following conservation practices which have reduced demand on the aquifer:

- adopting more efficient irrigation systems
- forming small dams, called furrow dikes, across furrows to prevent runoff
- using playa lake water for irrigation
- replacing open irrigation ditches with pipelines
- using soil moisture information to schedule irrigations

- selecting crop varieties which require less water
- collecting tailwater runoff and reusing it in irrigation systems

Conservation practices such as these have helped to stretch the water supply, but the outlook for High Plains agriculture is dismal if the current rate of withdrawal from the water account is not reduced.

Scientists and engineers specializing in water research, however, have discovered a technique called capillary water recovery which may help maintain the water supply for years to come. Simply stated, capillary water recovery involves pumping pressurized air into a zone beneath the root zone and above the saturated portion of the aquifer. The pressure forces droplets of water held loosely by soil particles downward into the saturated portion of the aquifer where they can be recovered by existing wells.

Soil moisture falls into three categories based on how tight the water is held by soil particles. The three categories are gravitational water, capillary water, and hygroscopic water. Immediately after a rain, the soil contains all three.

Gravitational water is pulled through the soil by the force of gravity as soon as it enters the surface. It is of little use to farmers since it does not remain available to plant roots and since it carries important soil nutrients below the root zone.

Hygroscopic water is always present in the soil, but it is held so closely to the soil particle by atomic forces that the only way to remove it is by baking it in a very hot oven.

Capillary water, on the other hand, is held between soil particles by weak molecular attraction and is the primary source of moisture for plants. It is also the water which scientists feel they may be able to "push" into the recoverable reservoir of the Ogallala.

The key word is "recoverable." The massive Ogallala formation contains substantial amounts of moisture or capillary water which is presently held in the soil layers and is unavailable to wells. Due to forces exerted on water molecules by the solid material in the formation (sand, gravel, clay), only 37 percent of the water held in the Ogallala Aquifer is actually "recoverable." Scientists estimate the volume of capillary water presently stored in the unsaturated zone of the Ogallala formation is 840 million acre-feet. This figure will increase as the water table declines and the aquifer is depleted. If a portion of this water could be recovered, the life of the aquifer could be significantly extended.

In 1981 the High Plains Underground Water Conservation District and the Texas Department of Water Resources (TDWR) initiated a joint effort to determine if this large amount of capillary water could be recovered. An extensive search of literature produced no information on available or emerging technologies for secondary recovery of groundwater.

"As far as I know, this technique has never been tried before anywhere in the world," says Wayne Wyatt, general manager of the High Plains Underground Water Conservation District.

A secondary recovery technique used by the petroleum industry to improve the efficiency of extracting oil and gas from reservoirs served as a starting point for the Ogallala experiment. The technique involves injecting air, water, or gas into an area. The increase in pressure forces oil from pores and pushes it to an area where it can be recovered by a conventional well. With this technique, the petroleum industry continues to extend the life of oil reservoirs significantly beyond what is possible with conventional methods of recovery.

Wyatt took this concept and modified it to work in a hydrologic system. After several other possibilities were considered, air was selected as a medium to displace water because it is inexpensive and easily obtained. Many were skeptical at first, but further investigation seemed to confirm the theory.

Through laboratory experiments and analytical calculations, scientists found that applying two to three pounds per square inch of air-driven pressure resulted in a 20 percent increase in water yield over that obtainable by gravity drainage alone. Experiments also showed that a confining layer over the air injection zone was required to prevent air from escaping back into the atmosphere. A layer of clay which works well as a confining layer covers most of the Ogallala formation, according to Wyatt.

Three field tests conducted by the District and TDWR produced promising results. The first two were conducted near Slaton and the third near Idalou. The experiments near Slaton tested well construction techniques and developed methods of measuring and monitoring the results. After successful completion of these experiments, the researchers conducted a major field test near Idalou in June of 1982. They injected over 10 million cubic feet of air into the ground for six days, pressurizing more than 140 acres. Injection pressures reached as high as 160 pounds per square inch (psi).

Water levels began rising in wells around the area, and an estimated additional 406 acre-feet of water was available to wells 160 days after the test ended. Water levels continued to rise around the injection site for several months, reaching as much as nine feet in some areas.

"Water levels are starting to decline now," Wyatt says. "They reached a peak about a year after the test, but we're still seeing that mound of water almost two years after the air was injected even though two seasons of irrigation pumpage has occurred in the test site area."

Although the results are extremely positive, scientists have a difficult time explaining exactly how the technique worked.

"I'm convinced that they made something happen," says Don Reddell, a professor of agricultural engineering and an expert in groundwater modeling. "But I'm not sure why it worked. There are a lot of questions to be answered yet. We need to get into the lab and build some models so we can understand what's happening to the water. Then we can transfer this knowledge to the field." Reddell is working on a mathematical and physical model to help understand water movement in a medium when subjected to air pressure. His project is funded by the Texas Water Resources Institute.

"One of the problems with trying to explain water movement in this situation is the addition of air. With both water and air moving through the formation, the number of parameters which must be considered double," according to Reddell.

"Ultimately we want to be able to select injection sites. We need to know how far apart to drill the wells, what pressure to inject the air, and how long to inject it."

Although there are many questions remaining to be answered, capillary water recovery may be just the boost many farmers desperately need.

An economic analysis of the additional 406 acre-feet of water that was recorded 160 days after the test calculated the cost of recovery to be about $50 per acre-foot. "That's pretty cheap water," says Reddell. "We don't know how much pressure is necessary to get the results we want. If we could lower the pressure, we would automatically lower the costs."

Another field test by the High Plains District is under way west of Lubbock near Wolfforth. Air pressures there will only reach about 10 to 15 pounds per square inch instead of 160 psi, and the volume of air to be injected will be about 300 cubic feet per minute (cfm) instead of the previous 1,000 cfm. If this test is successful, according to Wyatt, the cost of recovery could be substantially reduced.

Secondary recovery is an exciting possibility for Panhandle farmers who see their well yields declining and their pumping costs escalating because of lower water levels. If successful, the technique may be used in other aquifers around the state, extending the life of rapidly diminishing groundwater supplies and insuring the continued economic prosperity of Texas.

Goundwater: The Unseen Crisis

A symposium entitled "Groundwater--The Unseen Crisis" is scheduled for San Antonio the last week in October. Jointly sponsored by the Texas A&M University System and the University of Texas at Austin, the symposium will address current groundwater issues and problems of particular concern to Texas.

The three-day meeting will be held at the Gunter Hotel in San Antonio Monday, October 29 through Wednesday, October 31.

Program topics arranged by the Texas Water Resources Institute, Texas A&M University System, and the Center for Research in Water Resources, the University of Texas at Ausin, include:

- **Overview and Current Perspective**
  A retrospective analysis focusing on the problems ahead, including the status of groundwater and legislative initiatives.
- **The Regional Aquifers--Their Unique Problems**
  The problems of regional aquifers, including the Edwards, the Ogallalla and the coastal aquifers as well as Texas' interstate and international aquifers.
- **Policies, Laws, and Institutions--Searching for Solutions**
  Public policy and legal issues in solving groundwater problems.
- **Groundwater Contamination--Monitoring, Analysis and Control**
  Groundwater quality issues associated with mining, toxic wastes, clean-up, and related problems.

Program details and registration materials are available from the: Center for Research in Water Resources, The University of Texas at Austin, Balcones Researcch Center, 10100 Burnet Road, Austin, TX 78758-4497, (512) 835-3112.