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WATER RESOURCES CENTER, TEXAS TECH UNIVERSITY, LUBBOCK

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Model Simulates Ogallala Aquifer Conditions over 50-year time period

Simulations project declines in saturated thickness for all scenarios

Researchers at Texas Tech University have completed efforts to model the Ogallala Aquifer in the Texas High Plains. The modeling effort was recognized as an integral part of the High Plains Ogallala Area Regional Water Management Plan, the purpose of which was to develop, promote, and implement water conservation and management strategies to provide and sustain adequate water resources in the Texas High Plains.

The model predicts the effects of pumpage on the aquifer throughout the region, and it provides a tool to estimate impacts of conservation measures and drought conditions. "We wanted to answer questions about actual recharge distribution in the region, projections of crop patterns and application rates, and incorporation of new hydrological information about the Ogallala aquifer," said Ken Rainwater, Ph.D., associate professor of civil engineering. This information can assist in planning and implementing water resource management strategies, such as those enumerated in Senate Bill 1.

The study was conducted by David Harkins, Ph.D., as his dissertation project; Jeff Stovall, doctoral candidate in civil engineering; Scott Frailey, Ph.D., assistant professor, petroleum engineering; Lloyd V. Urban, Ph.D., professor of civil engineering and director, Water Resources Center; and Dr. Rainwater.

The study area was limited to the High Plains Aquifer System in Texas, approximately 35,000 mi^2. The Ogallala aquifer was divided into two study areas, North and South, to simplify the modeling process.

All model simulations were performed on the North and South study areas and were divided into ten five-year increments for 1990-2040. One verification step in the modeling process was to run long-term simulations with no pumping. In this situation the storage volume for the study areas shows an increase or at least stays constant due to recharge and boundary flow. These simulations resulted in a 2 percent increase from 1990 to 2040 for the North area and a 16 percent increase in the South. Once the model was validated, six scenarios were developed to evaluate how the aquifer systems could react to changes in conservation measures and drought conditions.

In Scenario 1 (referred to as TWDB in figures, page 2) the predicted saturated thickness distributions were calculated by using the same irrigation, domestic/stock, and municipal/industrial pumpage projections produced by the TWDB's GWSIM-III program in its most recent Texas Water Plan efforts.

The second scenario or baseline (Baseline) case was based on pumpage demand numbers modified from TWDB projections, with assistance from local experts at the High Plains Underground Water Conservation District No. 1 and Texas Agricultural Experiment Station. The new pumpage values were then adjusted according to the type of delivery system used: furrow (65% delivery efficiency), surge (70%), side roll (67%), low pressure center pivot (85%), high pressure center pivot (75%), and low energy precision application

(See "Model," page 2)

Model complements regional water planning

(Cont. from page 1)

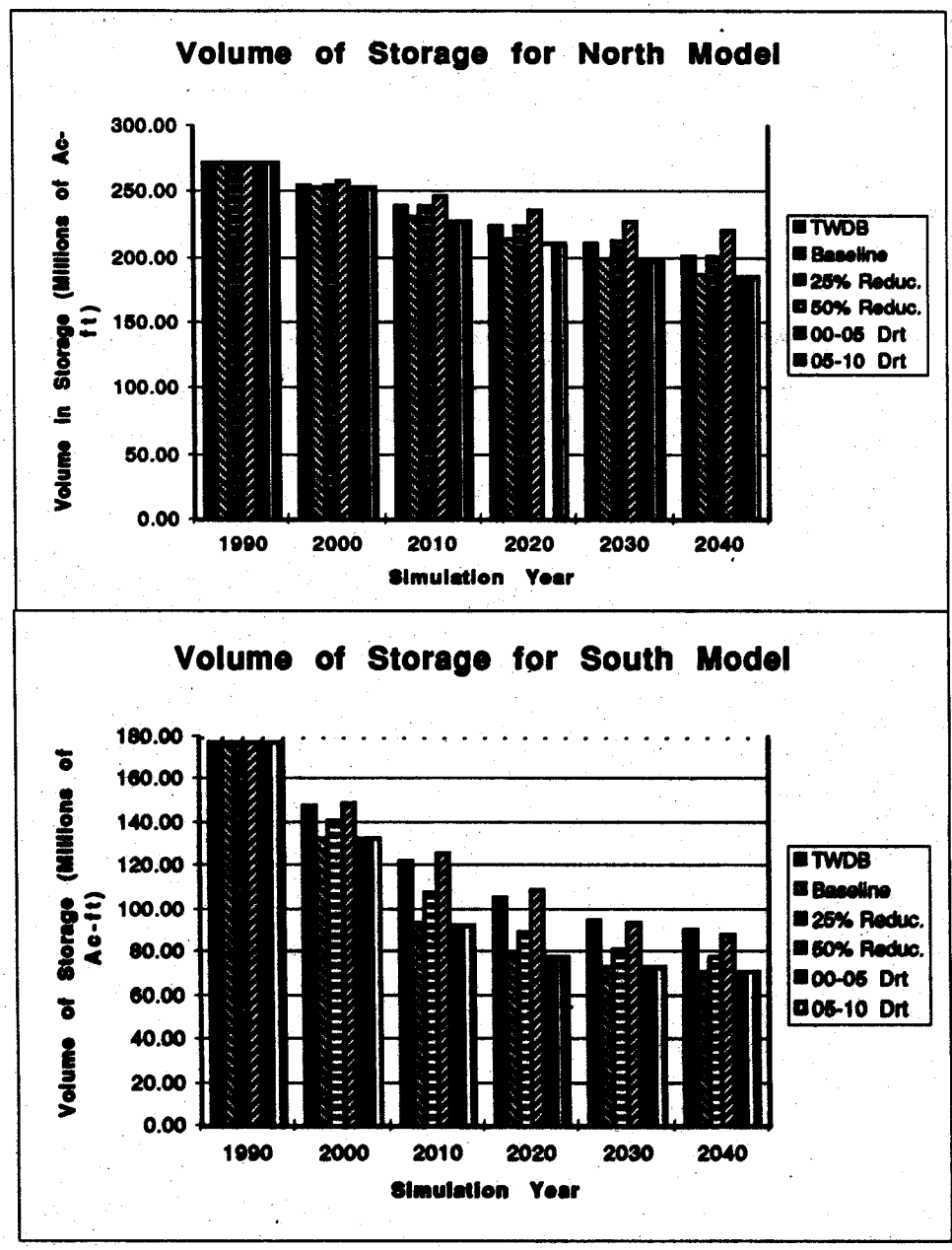
(95%).

In the first two scenarios, it was assumed that all irrigated acres received 100 percent of the irrigation application rate. This approach likely overestimates irrigation pumpage because many farmers choose to only pre-water their acreage prior to planting, which classifies the property as irrigated for record keeping but consumes much less water than the total estimated crop application rate. Scenario three (25% Reduc.) determined the effect of a 25 percent reduction of baseline irrigation pumpage rates on water levels of the aquifer system.

Scenario three determined the effect of a 50 percent reduction of baseline irrigation pumpage rates (50% Reduc.).

The final two scenarios examined the effects of increased water usage on the aquifer system caused by drought conditions. The drought of record, as determined from historical precipitation records, occurred in 1952-56, during which the annual rainfalls were 6.5 inches below normal average rainfall. It was assumed that the effect of the drought would be expressed as additional irrigation withdrawal of 6.5 inches per year for five years for all irrigated acreage combined with the Scenario 2 values. The droughts were placed in 1995-2000 (00-05 Drt) and 2005-2001 (05-10 Drt).

The results of the modeling efforts can be represented as contour maps of saturated thickness at various points in time for the two areas, or plotted as total storage



volume versus time for the two complete regions. The figures above show the regional storage totals for the North and South study areas. Scenario 1 matched the TWDB results within 1 percent. The pumpage reduction constraints severely reduced irrigation withdrawals by 2010 in the central counties of the South area, and in the western counties in the North. In Scenario 2, the higher application rates lead to greater predicted reduction in storage in both areas. Scenarios 3 in the North and 4 in the South more closely agreed with Scenario 1 results. Scenarios 5 and 6 gave almost identical re-sults, since the most severe declines occurred early in the simulation period and the pumpage values were controlled by the model reduction constraints.

Dr. Rainwater said that the research team hopes to use the model to assist the Llano Estacado Regional Water Planning Group in its

(See "Ogallala model," page 3)

WRC supports study of hydrologic mechanics of playa lakes

David Thompson, assistant professor of civil engineering, will complete his research on "Hydrology and Water Balance of Playa Systems" at the end of this fiscal year. The objectives were to collect hydrologic and meteorologic data relevant to estimating the water budget of six urban playa lakes located in Lubbock, Texas; use collected data to compute the water balance for the playa lakes chosen for study; and use results of the study to prepare a proposal for the U.S. Environmental Protection Agency for use of playa lakes to study urban stormwater runoff quantity and quality.

Many watersheds of the South High Plains region of Texas are small closed basins containing a playa lake; no stream outlet is present from the watershed. This physiographic feature allows runoff to collect from the contributing watershed in the playa lake, where chemical constituents are concentrated by surface flow in the playa, and limits the only outlets for surface runoff to evaporation and to infiltration through playa bed sediments. Therefore, chemical constituents cannot be flushed by the surface-flow system, so such constituents are either bound to playa sediments, treated naturally in playa waters, or transported to the groundwater flow system by infiltration through playa sediments. Understanding the fate of chemical constituents (pollutants or others) requires knowledge of the hydrologic mechanics of playa lakes and their contributing watershed.

Six playa lakes have been instrumented for this project. During the past three years, time series of stage data were collected. In addition, records were assembled from the National Climatic Data Center and from the local National Weather Service office. These were supplemented with data collected by Texas A&M Agricultural Research Extension Office, Lubbock.

The stage-volume relation for each study playa was used to translate stage measurements into volumetric estimates of change in playa storage. Lake evaporation was estimated by using the FAO-24 Penman method, which couples an energy balance approach to an advective term.

For the period of record, the average evaporation rate from study playas was estimated to be 5.0 mm/d. During summer, evaporation rates were higher, in the 8.0-10.0 mm/d range. During winter, evaporation rates were reduced and about 2.0 mm/d. Infiltration rates for the six study playa lakes ranged from 1.2 to 14.0 mm/d. The median value is approximately 6.5 mm/d. These values seem reasonable because lake levels tend to be reduced during summer months but are relatively stable during winter months.

For comparison, infiltration rates for five Pantex Plant playa lakes (these are relatively undisturbed rural lakes) ranged from about 0.25 to 2.8 mm/d. That these values are less than those derived during the current study is justified because the urban playas are excavated as part of the development process. Therefore, bottom sediments are removed and higher infiltration rates can be expected. In addition, NRCS published values of saturated hydraulic conductivity for playa sediments range from 30.5 to 183 mm/d.

In conclusion, infiltration and evaporation are approximately equal for the six Lubbock study playa lakes. This is in contrast to early studies that postulated that most water evaporated from playa lakes. Clearly, playa lake bed infiltration is a source of recharge to the underlying aquifer.

The project report on this study is being finalized. For additional information, contact David Thompson, Ph.D., at the Water Resources Center.

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Ogallala model

(Cont. from page 2)

task to develop a regional water plan. Project support was provided by the TWDB to the High Plains Ogallala Area Regional Water Management Plan and the Water Resources Center.

Dan Wells recipient studies applications for biosolids

Doctoral candidate Ricardo Mata-Gonzalez is the recipient of the 1998-1999 Dan M. Wells Memorial Endowed Scholarship. Mr. Mata-Gonzalez is a doctoral candidate in range science at Texas Tech's Department of Range, Wildlife and Fisheries Management. The Dan Wells Scholarship supports his doctoral research entitled "Biosolids Effects on Photosynthesis and Water Use of Two Desert Grasses."

Mr. Mata-Gonzalez is conducting his experiments in Sierra Blanca, Texas, with the final objective of recycling and introducing biosolids (sewage sludge) as a soil amendment to provide nutrients and reduce soil water evaporation in desert grasslands. His doctoral research is being supervised by Ron Sosebee, Ph.D., professor, Department of Range, Wildlife and Fisheries Management at Texas Tech. Mr. Mata-Gonzalez is scheduled to graduate in December 1998.

Biosolids are a nutrient-rich byproduct of wastewater treatment plants that can be beneficially used as soil amendment in rangelands. Since 1992 biosolids have been surface-applied to semiarid rangelands on the Sierra Blanca Ranch in far West Texas. Studies have consistently found that application of biosolids results in increasing the productivity of native grasses, which is beneficial for the livestock industry. This study was designed to provide explanations about the physiological mechanisms underlying the positive response of grasses to biosolids applications.

Plants of blue grama and tobosagrass, two important desert grasses, were transplanted into pots and kept under a rain-out shelter in Sierra Blanca, Texas, during summer 1997. Biosolids were surface-applied to the pots at rates of 0, 3, 8, 15, and 40 dry tons/acre, and plants were irrigated at 40 and 80% field capacity. Photosynthesis, transpiration, and soil water content were measured. Leaf area was estimated and the content of soil nitrates was analyzed.

Both species had an increase in leaf area as biosolids rate increased, partly due to higher soil water retention that resulted from the mulching effect of surface-applied biosolids. Photosynthesis rates were slightly affected by biosolids, nonetheless with increases in leaf area, total photosynthesis per plant was positively affected. Water use efficiency (photosynthesis/transpiration) was higher in plants treated with biosolids when plants were in short supply of water. This response may be associated to the higher availability of nitrates for plants treated with biosolids. The experiment is being repeated during summer 1998 and the dissertation is to be ready by July 1999.

Additional information may be obtained by contacting Mr. Mata-Gonzalez through the Department of Range, Wildlife and Fisheries Management at 806-742-2841.

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