THE Cross SECTION

Published monthly by High Plains Underground Water Conservation District No. 1, 2930 Avenue Q, Lubbock, Texas 79405—Ph. 762-0181

Volume 35—No. 1 Publication Number USPS 564-920, Second Class Postage paid at Lubbock, Texas January 1989

District field staff are taking 1988 depth to water measurements

HOW DEEP TO WATER?—Keith Whitworth lowers a chalk-coated, weighted measuring tape into an observation well to obtain its depth-to-water measurement. High Plains Underground Water Conservation District No. 1 field staff measure the depth to water in these wells each year, and the data collected is compared with that of previous years to determine any changes in the water levels of the Ogallala Aquifer.

During the cold of January and February, many farmers wind down from their busy harvest and spend more time working indoors. High Plains Underground Water Conservation District No. 1 field personnel are using this time between growing seasons to obtain depth to water level measurements for 1988.

Annual water level measurements are taken from a network of about 1,010 privately-owned irrigation wells. Measurements are taken during these two months because few irrigation wells are being pumped, and water levels are static as a result. The observation wells are spaced throughout the Water District's 15-county service area at a density of about one well per nine square miles.

Depth to water measurements are taken by dropping a weighted steel tape measure coated with blue carpenter's chalk into the well. The chalk turns a darker shade of blue when it comes in contact with water, and District personnel measure the distance from land surface to the point where the chalk changes color. After the depth to water measurement is determined, a sticker showing the well number, the depth to water, and the date of measurement is affixed at the well site.

The same observation wells are measured each year, and the depths to water are compared to measurements taken in previous years to note any changes in the water levels of the Ogallala Aquifer. This data is used to construct various maps showing District area water level changes and the saturated thickness of the Ogallala Aquifer. Annual depth to water measurements are also important for determining the amount of decline which is used to

See DEPTH Page Four

Irrigators may claim IRS cost-in-water income tax deduction

Persons owning land from which groundwater is used in the business of irrigation farming may claim a tax deduction on their federal income tax return for the cost of the water used during 1988. Persons wishing to claim this cost-in-water income tax depletion allowance should request water depletion information as soon as possible to avoid the last-minute April tax deadline rush.

For more than 20 years, the High Plains Underground Water Conservation District No. 1 has been providing water level decline data, saturated thickness information and cost-in-water guidelines required by the Internal Revenue Service for landowners to claim the federal income tax allowance within the Water District's 15-county service area.

According to Bobbie Bramblett, High Plains Water District Cost-In-Water Depletion Coordinator, an estimated 10,000 landowners request cost-in-water depletion allowance information each year which allows them collectively to save millions of dollars on their federal income tax returns.

Determining the Cost-In-Water

The amount of water in storage under the land tract at the time of land acquisition, the value of the water in storage at the time of purchase and the annual amount of water depleted by irrigation use are required data for filing a first-time claim.

Each year, professional land appraisers document land sales and survey property improvements to determine cost-in-water guidelines for the Water District. They subtract the value of any property improvements from the sales price to obtain the raw land cost. The difference between the average sales price of irrigated land and dryland property in the county is considered to be the cost the landowner paid for the underground water. To establish a cost for water, the landowner must have paid more for land with underground water reserves than land with little or no groundwater. When the IRS-approved guidelines are used, the cost attributed to groundwater in a land tract purchase price may not exceed the average price paid for groundwater as listed on the approved guidelines.

For example, if the average sales price for land with little or no groundwater is $200 per acre and the average price paid for irrigated land is $500 per acre, the price paid for water may not exceed $300 per acre.

The saturated thickness is determined by subtracting the depth to water below land surface from the depth to the formation base. The Water District constructs saturated thickness maps for each county in its service area every three to five years to aid landowners in establishing the amount of water in storage below their land tract at the time of land acquisition.

Groundwater declines, if any have occurred, are noted by annual depth to water level measurements conducted by the Water District in an observation well network of about 1,010 privately-owned wells. Water level changes are recorded for each observation well and are plotted on county maps. Water level changes are then noted for each land tract for which cost-in-water depletion information was requested the previous year.

IRS engineers must review and approve Water District records annually before water depletion requests are processed. In mid-December, Engineers Jack Page and Lorinda Busby met with District staff members and approved the water decline information for tax year 1988.

Claiming a Deduction

Landowners may either use the data available through the Water District or their own records to substantiate the cost-in-water depletion allowance.

Landowners requesting cost-in-water depletion allowance data from the Water District for the first time need to supply their name; address; social security or federal identification number; a complete legal description of the land tract on which the income tax allowance will be claimed; the number of acres in the land tract; and the land acquisition date. The distance in miles from the nearest town should also be indicated. First time depletion requests will receive the saturated thickness, water decline and cost-in-water guidelines for a $25 fee.

Landowners who have previously requested cost-in-water income tax depletion allowance information and need only water level decline data to support this year's tax claim should supply their name and address, the permanent reorder number from last year's request form and their accountant's name and address. If the taxpayer is using a different tax preparer

See COST Page Four

District co-sponsors statewide center pivot irrigation conference

The Texas Agricultural Extension Service (TAEX) is sponsoring a statewide Center Pivot Conference to be held January 18-19, 1989, at the Lubbock Plaza Hotel and Conference Center, 3201 South Loop 289, in Lubbock. Anyone interested in learning more about center pivot irrigation is invited to attend.

The Conference begins January 18th with a trade show at 5 p.m. and a shrimp boil/hospitality hour at 7 p.m. The trade show will feature 30 companies which are associated with center pivots and center pivot products. These exhibitors include manufacturers of chemigation equipment, center pivot nozzles and irrigation scheduling equipment.

The High Plains Underground Water Conservation District No. 1 is co-sponsoring the event, and several District representatives will be among those discussing facets of center pivot use during seminars on January 19th. Topics of discussion will include the economics of operating a center pivot, LEPA systems, how to choose a center pivot, chemigation and financing of the center pivot system.

Lunch will be provided, and the Conference will conclude that afternoon.

Pre-registration is requested. Registration fees for the Center Pivot Conference are $15 at the door or $10 for those who register in advance. Additional information on the conference is available by contacting your local County Extension Office, or Joe Henggeler, Irrigation Engineer at the Texas Agricultural Extension Service, P.O. Box 1298, Fort Stockton, TX 79735. His phone number is (915) 336-8585.

Grubb resigns from TWDB

Dr. Herbert W. Grubb, director of the Texas Water Development Board's Water Data Collection, Studies, and Planning Division, resigned from the state agency November 30th.

He will serve as director of water resource planning at HDR Engineering, Inc., a nationwide consulting firm based in Omaha, Nebraska. HDR has branch offices in several cities, including Austin.

Dr. Grubb has been director of the planning division at the Texas Water Development Board and its predecessor agencies since 1976.

Throughout his tenure with state water agencies, Dr. Grubb played a key role in water resource planning for Texas. He directed the creation of the 1984 Texas Water Plan, which is to serve as the state government's guide to the development of water supplies and wastewater treatment facilities for the next 50 years.

Prior to joining the Texas Water Development Board, Dr. Grubb served the state for eight years in the Planning Division of the Governor's Office. He has also been a member of the faculty at Texas Tech University and the South Plains Research and Extension Center, Texas A&M University in Lubbock.

At their December meeting, the High Plains Underground Water Conservation District No. 1 Board of Directors adopted a resolution commending Dr. Grubb for his role in Texas water resource planning and expressing great appreciation for his assistance to the Water District in implementing sound water conversation programs on the Texas High Plains.

Bombenger joins District staff

The High Plains Underground Water Conservation District No. 1 announces the addition of Marla Bombenger as the staff bookkeeper/cost accountant.

Marla was born and raised in Azle, Texas, which is northwest of Fort Worth. She has served as bookkeeper and accountant for several businesses, including a construction company, a certified public accountant and two restaurants. She has also taken accounting and business courses at Tarrant County Junior College in Fort Worth.

"I like working at the Water District because this position is all my other jobs combined into one. It involves general accounting and other bookkeeping activities that I enjoy," comments Marla.

Since she has previously lived on a farm, Marla says work at the Water District has been interesting. "The farming operation here on the High Plains is on a larger scale than what I'm used to. I've been learning about different irrigation systems," she says.

In her spare time, Marla enjoys cooking and needlepoint. Her husband, Mark, is a law student at Texas Tech University. The Bombenger household also includes two dachshunds, "Sniffles" and "Missy," and a golden retriever/labrador mix named "Bear."

Last month, Marci Wright resigned as the staff bookkeeper/cost accountant. She and her husband, David, have moved to Wheeler, Texas, where they will operate Wright Funeral Home.

Marla Bombenger

THE Cross SECTION

THE CROSS SECTION (USPS 564-920)

A MONTHLY PUBLICATION OF THE HIGH PLAINS UNDERGROUND WATER CONSERVATION DISTRICT NO. 1
2930 Avenue Q, Lubbock, Texas 79405
Telephone (806) 762-0181

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DIRECTOR, INFORMATION/EDUCATION

Second Class Postage Paid at Lubbock, Texas
District Office at Lubbock

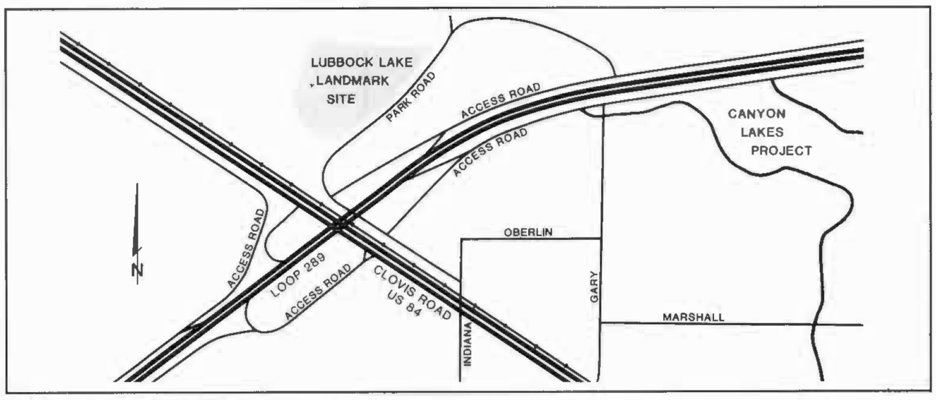
Abundant water supplies drew early Man to Lubbock Lake

For more than 10,000 years, men and animals have depended upon a reliable water source found in an old meander bend of Yellowhouse Draw, a tributary of the Double Mountain Fork of the Brazos River. Next year, visitors will be able to learn more about this water source and the life it sustained when the Lubbock Lake Landmark opens as Texas' newest historical state park.

• First In A Two-Part Series

On November 14th, dignitaries used archaeologist's trowels to break ground for a 10,000 square-foot interpretive center/headquarters building and a 4,000 square-foot research laboratory.

The Texas Parks and Wildlife Commission has authorized $2.48 million in state funds to construct these facilities at the lake site, just northeast of the intersection of Loop 289 and U.S. Highway 84 inside the Lubbock city limits. Along with the interpretive center, several picnic sites, overlook areas, and self-guided interpretive trails are planned for the enjoyment of visitors.



PAST MEETS PRESENT—The Lubbock Lake Landmark is located just northeast of the intersection of Loop 289 and U.S. Highway 84 inside the Lubbock city limits.

Archaeological Importance Was First Noted in the Late 1930s

Until the 1920s, a 10-acre lake existed at the Landmark site. Springs located on the west side of the lake kept water levels constant until the water table began dropping.

As a Works Progress Administration (WPA) project, the draw was dredged in an attempt to rejuvenate the spring. A semi-circular channel 40 to 50 feet wide and 20 feet deep was cut into the lake bottom. As a result, water stood to the top of the channel. Several boys who used the channel as a swimming hole reportedly drowned at the site.

In 1936, the bones of several extinct animals and a Folsom point were discovered. These finds were taken to Dr. William Curry Holden, Professor of History from 1929 to 1968 and the first director of the Museum of Texas Tech University. He realized the significance of the find and began to take steps to protect the lake site.

Research in the 1940s was hampered by high water table levels, but enough material was recovered to indicate the site's importance.

By the early 1950s, the water table had dropped enough to allow exploration of the dredged lake bottom. A Folsom period bison kill, along with several points and butchering tools, were found.

Further excavations followed in the 1950s and 1960s which yielded evidence of man's occupation of the site from all periods up to historic times beginning 300 to 500 years ago.

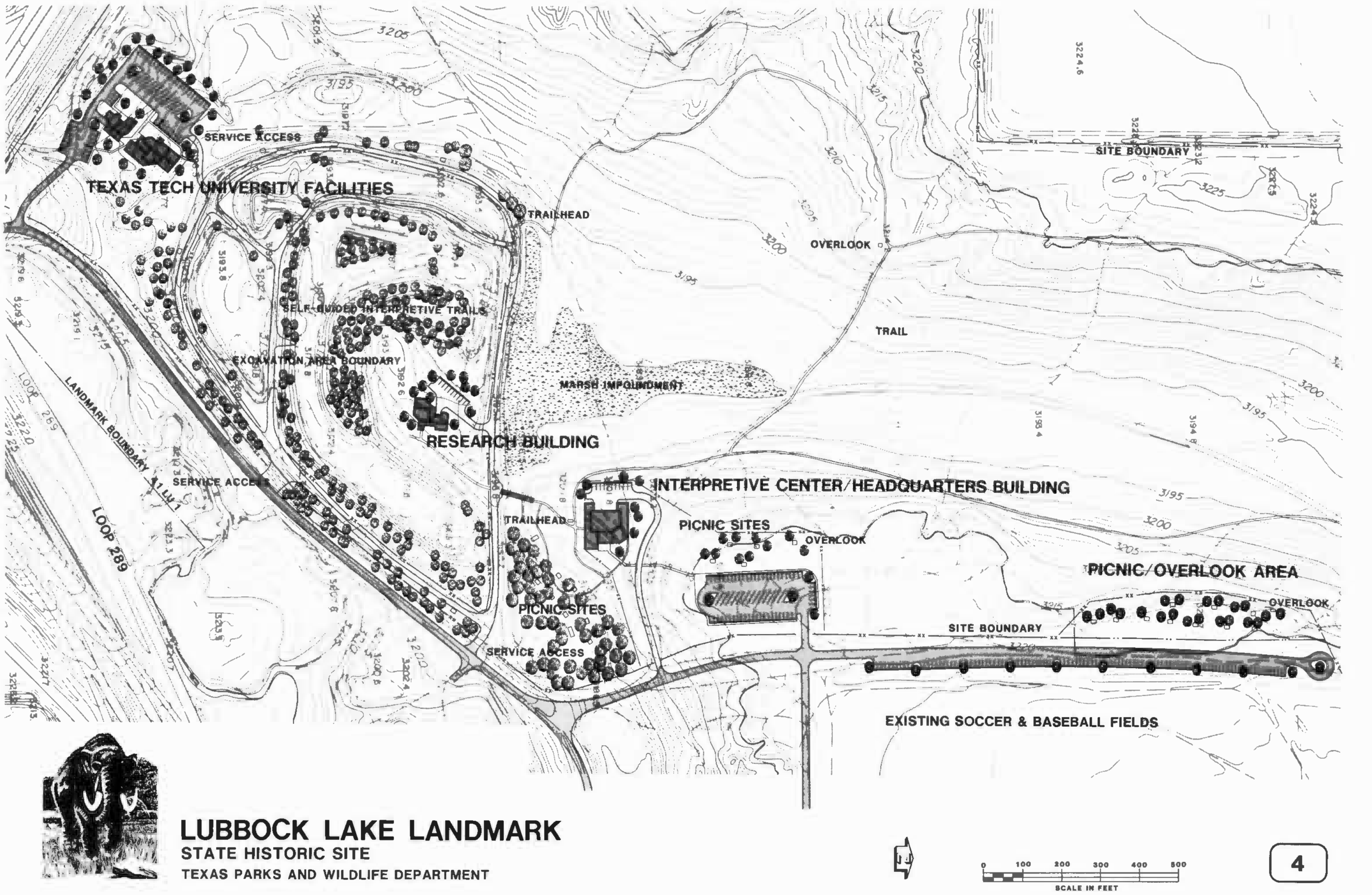
Texas Tech archaeologists note that the importance of the Lubbock Lake Landmark is that there are few sites in North America which have as complete a cultural sequence from the Clovis period to current time. The stratigraphy, or arrangement of various strata, are separated and sealed with sterile layers. Researchers say this is quite uncommon, since at most sites, cultural levels are mixed and difficult to distinguish.

Cultural and Geologic Sequences

The bedrock in the Lubbock Lake Site area is the Blanco Formation. It is younger than the Ogallala Formation and is composed of lake sediments dating back about 2 million years.

Yellowhouse Draw developed about 50,000 years ago and began cutting into the Blanco Formation. By 12,000 years ago, the draw had cut a meander bend about 50 feet deep in the Landmark area. The draw then began filling up with a variety of sediments.

See MAN'S Page Four



THE FUTURE LAKE SITE—Visitors to Lubbock will be able to learn about Man's occupation of the High Plains area when the Lubbock Lake Landmark State Historic Site opens in October 1989. An interpretive center, several picnic areas and many self-guided trails are planned for the newest state historic site. **Map courtesy of the Texas Parks and Wildlife Department.**

Depth to water data will reveal any aquifer water level changes

Continued From Page One

figure a cost-in-water income tax depletion allowance to be claimed on federal income tax returns.

Maps showing the location and well number of observation wells in each county or portion of a county served by the Water District are published annually in the April issue of *The Cross Section*. Tables listing observation wells in each county served by the District and the depth to water at one, five and 10-year intervals, along with the water level change in feet at one, five and 10-year intervals, are also printed.

After decades of declining water levels, recent trends indicate a stabilization of water levels in the Ogallala Aquifer within the Water District's service area.

The 10-year average annual water level change from 1978-1988 over the Water District's service area was a decline of 0.48 of a foot. However, the five-year average annual change from 1983-1988 was a rise of 0.07 of a foot over the Water District's service area. In 1985, the Water District recorded a zero net change in water levels over its service area, and in 1986, a net rise of about one-half foot was noted. The 1987 measurements showed a net rise in water levels of nine-tenths of a foot, which represents an increase of about 702,000 acre-feet of water in storage.

Cost-in-water income tax depletion allowance data now available

Continued From Page One

from the previous year, it would be helpful if the names and addresses of both the old and new accountants were supplied.

There is a $5 charge if a water decline was recorded for the property. There will be no charge if a water decline was not indicated during 1988 for that land tract and the taxpayer has no claim for depletion.

Landowners may file an amended tax return to claim the deduction for the past three years, provided they owned the land during that time. Also, groundwater must have been used in the business of irrigation farming and a depletion of that groundwater must have occurred during this time. Depletion requests for amended returns should indicate that the decline for the past one, two or three years is needed. There is a $5 charge for each requested year in which a decline was recorded.

All requests for income tax depletion information should be in writing. Phone requests will not be processed until they are confirmed in writing by the tax preparer. Requests are handled on a first-come, first-served basis.

"Beginning this year, taxpayers requesting cost-in-water income tax depletion allowance information will receive a new form which is similar to the form filed with the landowner's federal income tax return. The new form provides both the saturated thickness and the water decline amount. In the past, this information was supplied on two different forms, and taxpayers had to refer to old records to fill in the saturated thickness for the IRS forms," Bramblett notes.

Cost-in-water income tax depletion allowance information requests should be directed to Bobbie Bramblett, High Plains Underground Water Conservation District No. 1, 2930 Avenue Q, Lubbock, Texas 79405, (806) 762-0181.

Man's dependence on groundwater evident at lake site

Continued From Page Three

The oldest deposit consists of stream gravels with overlying sands and clays. This deposit dates back to 11,000 years ago and represents the Clovis cultural period. Remains of extinct bison, camels, a short-faced bear and a giant armadillo have been found in this sand and gravel layer. At the end of the Clovis period, the stream quit flowing, and up until 10,000 years ago, deep clear lakes that deposited layers of diatomite occupied the draw.

From 10,000 until 8,500 years ago, the floor of the draw filled with about three and a half feet of organic mud. It was from this Paleoindian cultural period that researchers found artifacts relating to bison kills and butchering locations at the edge of the marshy area. Materials found here include discarded tools, projectile points, burned rocks and small animal remains.

From 8,500 years ago until 6,500 years ago, the filling in of the draw halted, and a marshy soil developed. Between 6,500 and 5,500 years ago, the Archaic period began. An alkaline lake existed in the lower portions of the draw while sands blew in on the west side of the draw. The filling halted again between 5,500 and 5,000 years ago. A soil formed, and there was once again spring flow in the area.

From 5,000 to 4,500 years ago, blowing dust once again accumulated in the draw. It abruptly halted about 4,500 years ago, and a stable landscape then existed in the draw until about 1,000 years ago. From this Archaic period, bone beds of bison and pronghorn antelope were found along the edge of the stream bed. A large oval pit used for a cooking oven was discovered from the Middle Archaic sequence. Radiocarbon dating determined the pit to be about 5,000 years old.

Pueblo pottery, dating back to 1,000 years ago, was found in the Ceramic cultural period. Among the artifacts found in this layer were stone tools, flakes, and broken bones. Several food processing stations were found, along with the remains of modern bison, coyotes, wolves and pronghorn antelope.

Modern Indian occupation of the Plains is also noted during the Protohistoric period. Tribes of Apache were known to be in the area from 1500 to 1700 A.D.. From the 1700s to the 1870s, the Comanche roamed the Southern High Plains and forced the Apache from the area. Radiocarbon dating of artifacts at the Landmark site and the discovery of a trade bead above the numerous levels of Apache occupation have verified this.

The most recent archaeological cultural sequence is the Historic period. Exploration of the "Llano Estacado" was occurring during this time, and artifacts from this period include metal and glass.

Additional artifacts, consisting of rifle cartridges, metal hardware, square nails, and buttons probably came from the later part of the 1800s.

The Lubbock Lake National and State Archaeological Landmark is expected to be open to the public in October 1989. Visitors will be able to view artifacts taken from the site and can learn more about early man's life on the High Plains of Texas.

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SECOND CLASS PERMIT

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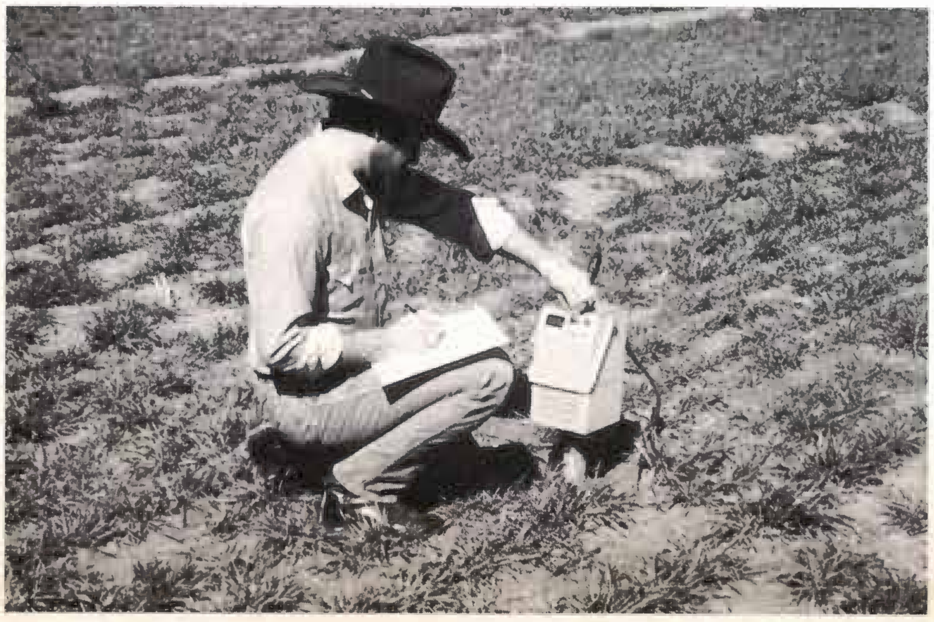
Volume 35—No. 2 Publication Number USPS 564-920, Second Class Postage paid at Lubbock, Texas *February 1989*

Drier than normal conditions revealed in soil moisture survey



HOW DRY IS IT? — Agricultural Engineer Jerry Funck uses a neutron moisture meter to obtain soil moisture readings at one of the 250 soil moisture monitoring sites maintained by the High Plains Underground Water Conservation District No. 1.

A four-month absence of significant rainfall has caused soil conditions to be drier than normal across the 15-county High Plains Underground Water Conservation District No. 1 service area. It appears that irrigators will need to pump more water than they have in several years to fill the root zone soil profile prior to planting. Historically, above-average crop yields are produced in our area when the root zone of the soil profile is wet prior to planting.

"Our last significant rains came in September when Hurricane Gilbert broke up. The below-average fall rainfall, continued plant growth into late fall, and a relatively late freeze date combined to produce four to eight-inch soil moisture deficits over most of the District's service area," says Mike Risinger, soil scientist with the USDA-Soil Conservation Service (USDA-SCS) in Lubbock.

Soil Moisture Deficits Noted Across District

Soil moisture conditions were measured at 250 neutron tube sites scattered throughout the District in November and December 1988. The selection of soil moisture monitoring sites is based upon the soil type, the crop grown and the saturated thickness of the Ogallala Aquifer, which indicates well yield variations. Soil moisture monitoring sites represent typical field conditions near their locations.

According to data collected by Water District and USDA-SCS staff at these sites, most areas will need four to eight inches of water to fill the five-foot soil profile to field capacity.

"Only about three percent of the sites show moisture deficits of less than two inches," says Risinger.

See DRY Page Two

Durable garden hose finds new role in irrigated farming

Eugene Tannahill says he got some strange looks when he ordered 15,000 feet of garden hose and told people that he was going to water cotton, corn and wheat with it. However, the Lockney producer has discovered that heavy duty garden hose is just the right material to use for flexible, long-lasting LEPA (low energy precision application) center pivot droplines.

Tannahill had tried several hose materials as droplines before deciding upon the garden hose.

"The first systems used metal droplines which weren't too good. Then I tried plastic, but it was brittle and would break when the weather got cold. I also tried heater hose, but it just wouldn't stand the weather. I finally thought about the garden hose that I had had at the house for years. It's flexible and does well in all weathers," he says.

Tannahill first bought a small roll of garden hose, attached the hose to a few drops on one of his pivots and tested it for a year. When he saw that his idea worked, he replaced all the drops on two of his systems with garden hose in 1983 and equipped two others in 1984. He says that the garden hose has been installed on the pivots for five years and that it still works well with very little maintenance.

He uses Gates Flexigan™ hose which easily withstands the 9-15 pounds per square inch (psi) water pressure required by his pivots. Garden hoses in most cities have to withstand water pressures ranging from 35 to 90 psi.

Although the hose is relatively lightweight, Tannahill says the wind has not caused major problems with his irrigation. "The water adds weight to the hose. The wind will move the hose somewhat, but it hasn't been a problem."

Tannahill also likes the hose's pliability, noting that he can tie the hose in a knot for a long time and it will straighten out when water flows through it. "It is easy to unplug the nozzles because you can bend the hose up and stop the water," he adds.

He says that it is important to get a good quality garden hose that will be flexible in cold weather. "The initial cost is more expensive, but in the end, it is a cheaper investment. A disadvantage is the higher cost (over other drop line materials). The price has increased from 27 cents per foot four years ago to 35 cents per foot now," he says.

Tannahill says using the garden hose LEPA drops to irrigate his cotton, wheat and corn is not without a few minor problems. "Sometimes the nozzle will hang on the corn ears and cause the drop to break off at the top of the pivot. If the clamp is not tight enough, a drop or nozzle may be pulled off," he says.

He attaches the garden hose LEPA drops to gooseneck pipes connected to the pivot span. A hose barb screws into the gooseneck, and the garden hose fits over the hose barb. The hose works better when attached to the gooseneck than when added on to a partial dropline, he says. Another hose barb connects the hose to the nozzle. Clamps help hold the barbs and hoses together.

He says that attaching the garden hose is easy, but time consuming. One person atop the pivot attaches the hose to the gooseneck and then drops it down to another person on the ground, who cuts the hose at the desired length. The

See LOCKNEY Page Four

FLEXIBILITY IS THE KEY — Eugene Tannahill says unplugging center pivot nozzles is much easier since he replaced his original droplines with Gates Flexigan™ garden hose.

Dry field conditions noted across Water District service area

Continued From Page One

"Two to four inches are needed at about 20 percent of these sites, while a four to six-inch deficit exists at about 34 percent of the sites. Six to eight inches of water will be needed at 33 percent of the sites, and the remaining 10 percent will need eight inches of water or more," he adds.

The map on page two indicates the moisture deficit which currently exists in the Water District. The deficit indicates the amount of moisture that needs to be added to the five-foot crop root zone to bring the soil profile to field capacity prior to planting.

The map on page three illustrates the amount of moisture currently available for plant use in the five-foot soil profile within the Water District. Risinger commented that the map illustrates that most of the area in the Water District service area has from two to six inches of plant available water stored in the root zone. The soil moisture is fairly uniform throughout the soil profile, except for the top six inches of soil, the plow layer, which is very dry in most of the area.

Producers Should Check Individual Moisture Conditions

Risinger adds that it is important for producers to check their individual field soil moisture conditions. The maps indicate general trends over the Water District service area and should not be used to predict exact soil moisture conditions on any given farm.

"Soil moisture conditions vary from field to field. For example, a fallow field in Hockley County showed a 1.8 inch soil moisture deficit, while across the road, the soil moisture deficit in a cotton field was 6.2 inches," he says.

Furrow Dikes and Crop Residues Can Help Save Moisture

Furrow dikes offer producers a cost-effective method to collect any precipitation which might fall prior to planting and keep it in place in the soil.

Historical precipitation averages for the months of January, February, March and April for the years 1976 to 1986 were 3.36 inches at Amarillo and 3.05 inches at Lubbock.

"Furrow dikes can really make a difference with regard to soil moisture. We checked the soil moisture at one site with furrow dikes still in place and found that the soil had three and a half inches more moisture than surrounding fields without furrow dikes," Risinger says.

Crop residues can also help keep soil moisture in place. By keeping the residue on the soil surface as long as possible, producers can reduce evaporation losses. Without crop residues acting as an insulation layer, the soil profile's top six inches will air-dry which requires nearly twice as much water to wet.

Water Application Efficiency Important

Irrigators should consider their irrigation application efficiencies before pre-plant irrigation begins. The amount of water pumped compared to the amount of water stored in the plant root zone at the completion of the irrigation application is defined as the *"irrigation application efficiency."*

An example of poor irrigation application efficiency would be an irrigator who needs to add four inches of water per acre to the plant root zone to bring it to field capacity and is losing 50 percent of the pumped water during application. He would need to pump eight inches of water per acre to get four inches of moisture into the soil.

Various Application Efficiencies Noted

If an irrigator is using open, unlined ditches to move water across the field, water losses of 10 to 30 percent per 1,000 feet can be expected.

With conventional furrow irrigation, water losses caused by evapora-

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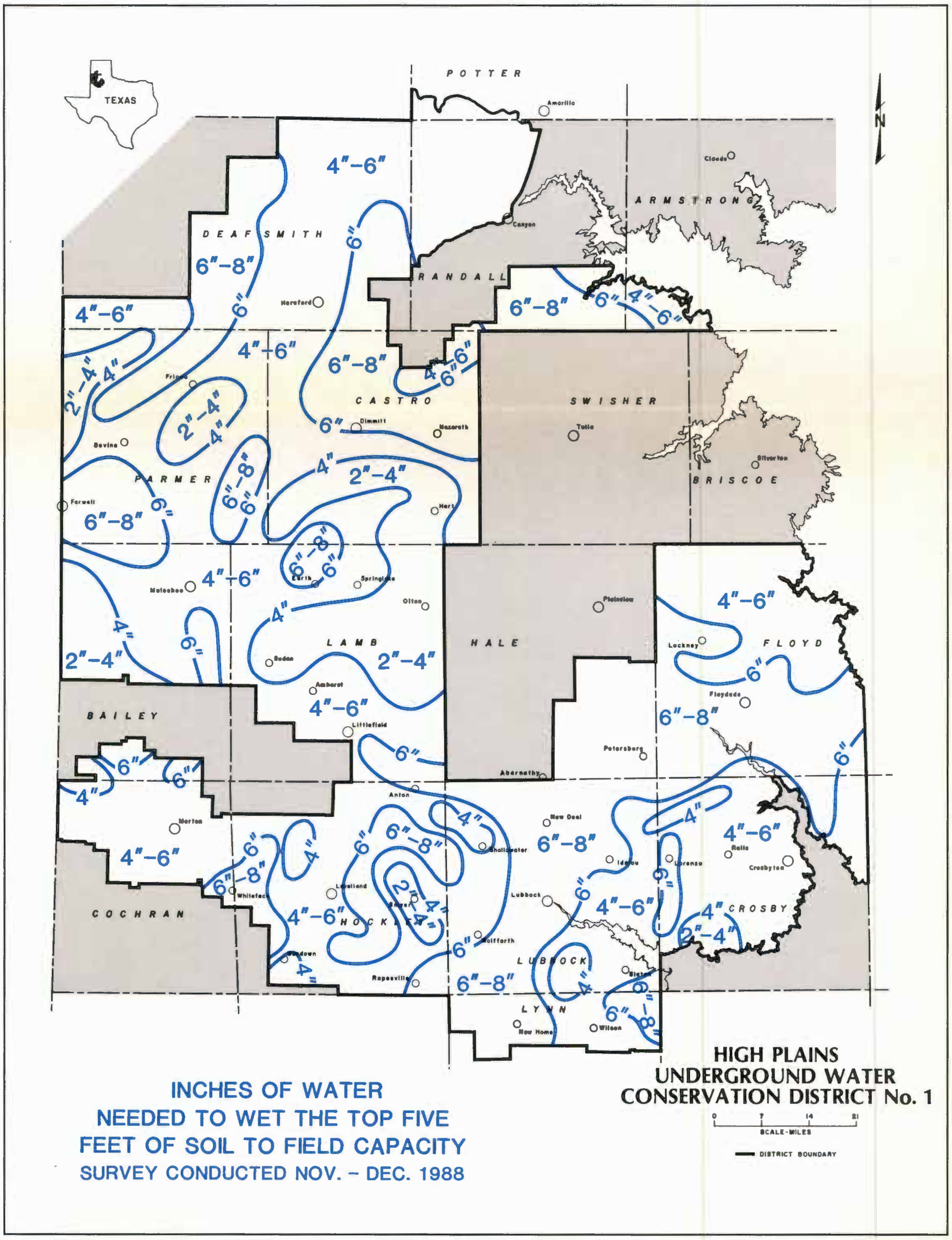


INCHES OF WATER NEEDED TO WET THE TOP FIVE FEET OF SOIL TO FIELD CAPACITY
SURVEY CONDUCTED NOV. – DEC. 1988

Pre-plant irrigation safety important

The Water District reminds irrigators to use extreme care when handling aluminum pipe during pre-plant irrigation. Before moving the pipe, irrigators should look to see if there are power lines overhead. Also, center pivot sprinklers should be inspected for broken wires or other damage caused by livestock and rodents before the system is operated.

Producers should consider irrigation application efficiencies

Continued From Page Two

tion and deep percolation can be as high as 40 percent. Furrow irrigators should also take special care to avoid uneven water distribution in their fields. With open ditches and siphon tubes, there is a greater likelihood that the upper and lower portions of the field will be over-irrigated while the center is unevenly watered.

Use of surface or underground pipe to convey the water from the well to the field, combined with the use of surge valves, will cut water losses at least 50 percent over conventional furrow irrigation using open, unlined ditches.

Surge valves used with a closed irrigation system will increase water use efficiency from 10 to 40 percent. Irrigators with a limited water supply can generally achieve a much more uniform application of water using surge valves.

Irrigators using sideroll sprinklers usually have a 47 percent water application efficiency rating. High pressure sprinklers will give producers about a 60 percent water application efficiency, while center pivots with partial droplines offer 80 percent efficiency ratings. Center pivots modified with LEPA drops are the most efficient sprinkler system to date and can provide up to a 98 percent efficiency rating.

Cut Irrigation Fuel Costs

It is important to have irrigation pumps operating at maximum energy use efficiencies to reduce fuel costs. *Irrigation pump plant efficiency* is a term used to describe the energy use of a pump and motor to produce water. A pump and motor in good repair designed to produce the quantity of water being pumped from the depth it is being lifted should have an energy use efficiency of 70 percent or more. A worn pump improperly designed to produce the quantity of water the well is yielding from the depth it is being lifted may have an energy use efficiency of no more than 35 percent. Comparing the two examples, the worn pump would use twice the amount of fuel to pump the same quantity of water. There are several private businesses which will conduct pump plant tests, or irrigators may conduct the test themselves using formulas in brochures available from the Water District.

Also, District personnel are available to conduct pump plant efficiency tests. These tests are scheduled on a first-come, first-served basis. Irrigators may call (806) 762-0181 to schedule a testing time.

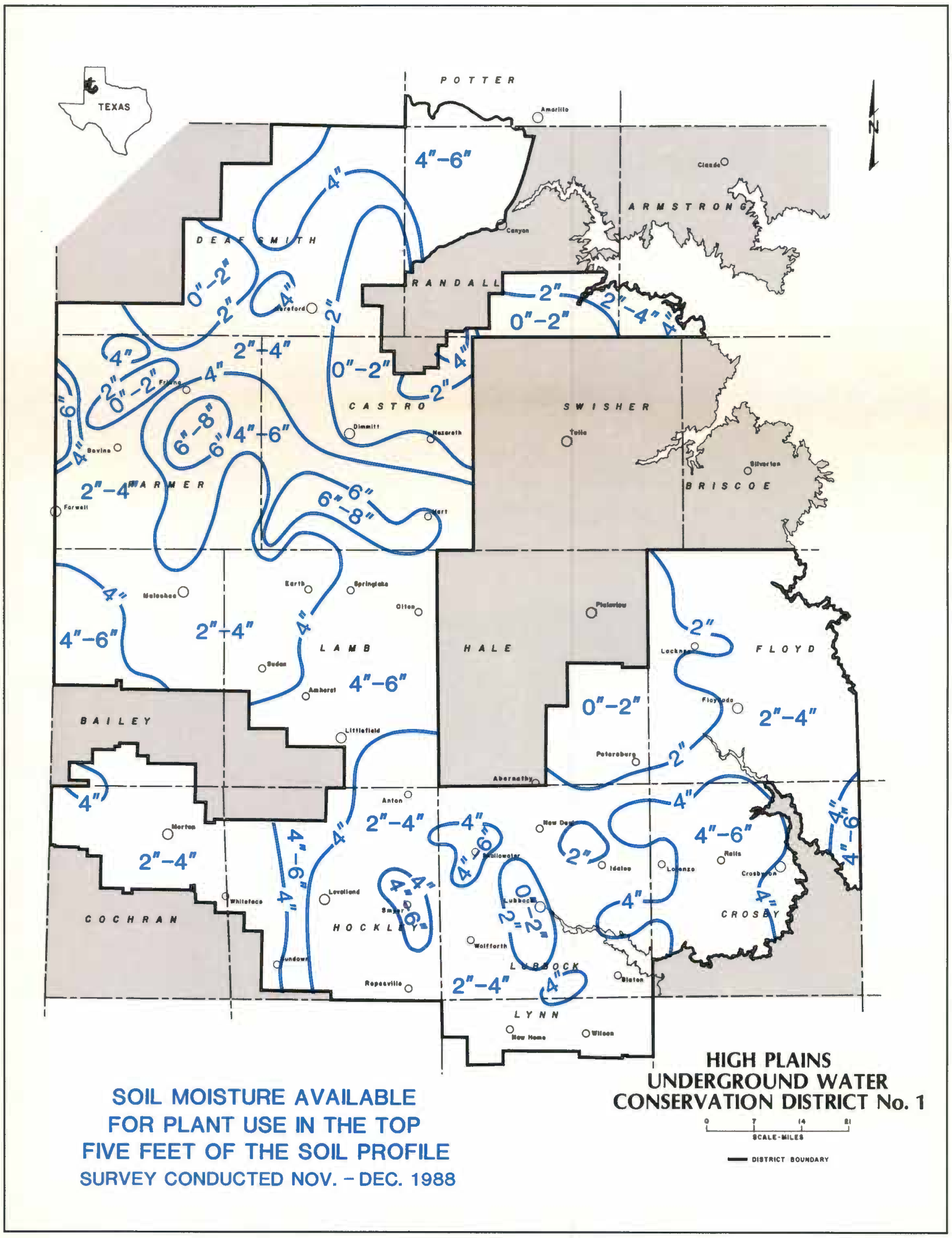
Soil Fertility Important Consideration

Plant water use efficiency can be improved as much as 50 percent with a balanced water management and soil fertility program.

It is recommended that producers collect soil samples and have them analyzed for fertility levels. Laboratories can make fertilizer recommendations based upon the soil analysis, the crop to be grown, and the producer's yield goal.

"A small application of nitrogen following the pre-plant irrigation will help get a cotton crop off to a healthy start," says Risinger. "Producers should then side-dress additional nitrogen when the crop begins to fruit. This is assuming that there is significant rainfall or the crop is irrigated. Five pounds of nitrogen per inch of stored soil moisture in addition to five pounds of nitrogen per inch of rainfall or irrigation should result in a maximum yield potential," he says.

Grain sorghum and corn require 10 to 12 pounds of nitrogen and two to three pounds of phosphorus (4-6 pounds of P_2O_5) per inch of water.



SOIL MOISTURE AVAILABLE FOR PLANT USE IN THE TOP FIVE FEET OF THE SOIL PROFILE
SURVEY CONDUCTED NOV. - DEC. 1988

Water legislation in 71st session

The 71st session of the Texas Legislature convened January 10, 1989. As of January 30th, 24 water-related bills had been introduced in the House and the Senate, along with one House Joint Resolution, one Senate Joint Resolution and one Senate Resolution. Watch future issues of *The Cross Section* for descriptions of these bills and their impact on Texas' water management if passed.

Lockney producer uses garden hose for LEPA droplines

Continued From Page One

person on the ground must then toss the hose back up to the man on the pivot so that it can be attached to the next gooseneck. The hose installation process for one pivot system takes Tannahill and his son about a day.

Tannahill uses five-eighths-inch diameter garden hose, purchased in 125-foot lengths. The hose and hose barbs are available in most hardware stores. It takes about 2,200 feet of hose to equip one of Tannahill's quarter-mile sprinklers with 196 drops spaced 80 inches apart. The orifices next to the pivot base are 5/64 of an inch in diameter and gradually widen to one-fourth of an inch diameter at the machine's outer edge. The pivot operates at 15 psi on the inside circle and eight to nine psi at the end, running at 500 gallons of water per minute. Two end hoses are attached without goosenecks to the underside of the pivot span, and they continually flush sand out of the system, Tannahill says.

Tannahill waters two half circles of 60 acres of corn and 60 acres of cotton, and two full circles of 120 acres each of wheat. He irrigates with three sprinklers which are moved between pads on five quarter-sections. He starts seven or eight wells when he begins irrigating in the spring, but usually has to turn on the ninth well in August to maintain water pressure on these three pivots.

Conserving as much water as possible is important to Tannahill. When he first started using high impact center pivots in 1976, he pumped 900 gallons per minute through the sprinkler. "Now, the water is getting weaker. The sprinklers run about 500 gallons per minute," he notes.

The Lockney irrigator began with a high pressure impact center pivot and then converted his system to droplines. Tannahill was an early user of the LEPA system, and he is convinced of its advantages. "LEPA is as near to 100 percent efficient as you can get," he says.

Tannahill's LEPA system has also eased maintenance chores and the splash plates are easy to check for trash and blocked orifices. "I'm getting to the age where it's nice not to have to climb up on the center pivot. With the drop lines, I can just put on rubber boots, walk up to the pivot and unplug the nozzle. I don't get wet, and I don't have to stoop over as much," he says.

Tannahill says he is sold on the LEPA system's water use efficiency. "You get 25 percent more water on the ground with LEPA drops than with high pressure impact spray. If you're watering with a LEPA system and the wind is blowing, you'll be standing in the dry 10-15 feet downwind. In comparision, I was driving about 100 yards from one of my pivots with mid-level drops, and water was splattering on the windshield."

Texas Tech researchers hope to dewater archaeological site

The same abundance of water that sustained life in Lubbock's Yellowhouse Draw for more than 10,000 years is causing problems for researchers wishing to learn more about the men and animals that frequented this dependable water source.

• Second In A Two-Part Series

Texas Tech University researchers are working to dewater the Lubbock Lake National and State Archaeological Landmark in order to expose potential artifact excavation sites now covered by the rising water.

"There are about a dozen water wells located in the Lubbock Lake Landmark area. When these wells are not being used, a section in the middle of the Landmark becomes covered with four to five feet of water," says Dr. Ken Rainwater, Assistant Professor of Civil Engineering at Texas Tech University in Lubbock. "The archaeologists working at the site suspect that some of the best artifacts could be located in this area, so they contacted Dr. Bill Claborn and me to develop a cost-effective means of dewatering the Landmark site."

Continuous groundwater flow from beneath the City of Lubbock toward the Landmark causes problems for the dewatering effort. "Pumping groundwater for a short period of time does not keep the water levels lowered. There has to be continuous pumpage since the flow rate is about 150 feet per year on a gradient of 10 feet per mile. This poses an interesting situation for operation of the Landmark. The City of Lubbock owns the actual property, the Texas Parks and Wildlife Department leases it from the City, and Texas Tech University operates the site. It will be interesting to see who will ultimately pay for this annual pumping cost," says Rainwater.

The Texas Tech researchers began their groundwater study by drilling a test well to a depth of 128 feet to determine the parameters of the Ogallala Aquifer.

"The test well was able to sustain a pumping rate of only 150 gallons per minute. The water pumped from it is not of drinking water quality without expensive treatment, since it has natural fluoride and selenium levels above the limits imposed by the Environmental Protection Agency's Safe Drinking Water Standards," says Rainwater.

Data collected from the test well has been used in computer models at Texas Tech to determine the number and location of water wells needed to effectively dewater the archaeological site. Graduate Students Brian Moore and Lanny Buck, as well as Technician Brad Thornhill, have assisted Rainwater with the Landmark groundwater study.

The Lubbock Lake Landmark groundwater study is sponsored by the Museum of Texas Tech University and funded by the Texas Parks and Wildlife Department. It began in July 1988 and will continue through early 1989.

"This is not an unusual project. Dewatering is done all the time with construction and mining projects. However, dewatering to preserve a historical site does make it unusual. While the Lubbock Lake Landmark is still relatively young in its archaeological development, we need to work to preserve this 'library under the ground'," he says.

RISING WATER floods a portion of the Lubbock Lake Landmark site. Photo courtesy of the Texas Tech University Museum.

THE CROSS SECTION (USPS 564-920)
HIGH PLAINS UNDERGROUND WATER CONSERVATION DISTRICT NO. 1
2930 AVENUE Q
LUBBOCK, TEXAS 79405

SECOND CLASS PERMIT

THE Cross SECTION

Published monthly by High Plains Underground Water Conservation District No. 1, 2930 Avenue Q, Lubbock, Texas 79405—Ph. 762-0181

Volume 35—No. 3 Publication Number USPS 564-920, Second Class Postage paid at Lubbock, Texas March 1989

For better pump energy use efficiencies

District submits energy conservation grant program proposal

On February 14, 1989, High Plains Underground Water Conservation District No. 1 representatives visited the Energy Management Center in the Governor's Office of Budget and Planning in Austin to deliver a proposal that the Water District serve as supervising agency for the oil overcharge funded Agricultural Energy Conservation Competitive Grant Program. If the proposal is accepted, the Water District will develop, manage and administer this competitive grant program under contract to the Governor's office.

The Water District proposes to establish an advisory board to help identify and assess the needs of the target areas and to develop the program plan. The advisory board would consist of representatives from the Water District Board of Directors, Texas A&M University, Texas Tech University, Texas Agricultural Experiment Stations, Texas Agricultural Extension Service, Texas Department of Agriculture, USDA-Soil Conservation Service, Texas State Soil and Water Conservation District Board, Texas Groundwater Management Districts Association, Texas Water Development Board, Texas Water Commission and the major agricultural producer groups. The advisory board would assist in soliciting projects, as well as review and rank proposals for funding.

The Water District proposes to establish a revolving loan fund to help producers upgrade their energy use efficiency of irrigation pumps and motors. The Water District, the USDA-Soil Conservation Service, the Texas Agricultural Extension Service, Rural Electric Co-ops and other organizations have conducted more than 1,000 pump plant energy use efficiency tests of irrigation pumps and motors in the High Plains since 1978.

These tests reveal that the average pump plant energy use efficiency is less than 50 percent of what it should be on wells tested. One of the many reasons for the inefficient use of energy is the number of pumps still being used that were designed to produce more water than the aquifer will currently yield from a lesser depth than it is now being lifted.

Guidelines prohibit paying of administrative costs associated with serving as supervising agency from the oil overcharge funds. Therefore, the Water District proposes to loan the money at a four percent rate to recover the cost for administering the program. A pump plant efficiency test would be required before and after repairs to validate that the pump and motor needed to be repaired and that the repairs had been made which improved the energy use efficiency to industry standards before the loan would be final.

Model farms demonstrating maximum water and energy use efficiency would be established throughout the area with some of the money. Cooperators would have first option to purchase the state-of-the-art equipment after three years based on a ten-year depreciation schedule. Equipment not purchased by the cooperators would be sold at a public auction. Funds from the sale of this equipment would be used to pay for the cost of operation and maintenance of the projects, with any remaining proceeds going to the funding of additional model farms.

Solons introduce water-related legislation during current session

Several water-related bills have been filed for consideration since the 71st Texas Legislative Session convened in Austin on January 10, 1989. As a service to our *Cross Section* readers, we present a synopsis of some of the proposed water-related legislation.

TEXAS STATE LEGISLATURE HOUSE BILLS

HB 49

This bill, sponsored by Representative Juan Hinojosa of McAllen, would create the Economically Depressed Area Residential Water and Sewer Service Development Act. This Act would allow the Texas Water Development Board to provide funds to counties, municipalities and conservation and reclamation districts in economically depressed areas for water and sewer facilities.

HB 178

This bill, sponsored by Representative Dudley Harrison of Sanderson, would create the Pecos County Underground Water Conservation District No. 4 with all the powers, privileges and authority allowed under Chapters 50 and 52 of the Texas Water Code.

HB 183

Representative Nolan (Buzz) Robnett of Lubbock has introduced this bill relating to the licensing of underground storage tank installers. This legislation would require testing prior to the licensing of all new tank installers after January 1, 1990. Those persons operating as of that date would be "grandfathered" under this legislation. The Texas Water Commission would be given the power to deny, suspend or revoke any licenses under this law.

HB 213

This legislation, sponsored by Representative Bill Hammond of Dallas, would amend Section 11.184 of the Texas Water Code. This bill addresses the exemption from cancellation of certain water rights permits and certificates of adjudication of surface water.

TEXAS LAWMAKERS IN SESSION—Several water-related bills have been introduced by Texas lawmakers since the 71st Texas Legislative session convened at the State capitol building (above) in Austin on January 10, 1989.

HB 214

This legislation sponsored by Representative Phyllis Robinson of Gonzales, would amend Section 2, Chapter 126, Acts of the 55th Legislature, to extend the powers of the Plum Creek Conservation District to include regulation of groundwater under Chapter 52 (Underground Water Conservation Districts).

HB 216

Representative Jerry Yost of Longview is sponsoring this legislation which requires the Texas Water Commission to prepare and distribute election information on the creation of a water district or authority to the temporary board of directors before a creation election is held.

HB 228

This bill by Representative Robinson would amend Section 4, Chapter 186, Acts of the 50th Legislature, to allow two of the

See TEXAS Page Two

Texas lawmakers sponsor water legislation during session

Continued From Page One

District's employees, as designated by the Board of Directors, to sign checks for the Lavaca-Navidad River Authority.

HB 234

House Bill 234 by Representative Glenn Repp of Duncanville would amend Section 5.052 of the Texas Water Code relating to the membership of the Texas Water Commission. Nine members would be appointed by the Governor for six-year terms, staggered at two-year intervals. Eight commission districts would be established, with one commissioner appointed from each district, plus one at-large who would serve as chairman of the commission.

HB 422

This bill by Representative Terral Smith of Austin would amend Chapter 52 of the Texas Water Code by adding Subchapter L. The Texas Water Commission would have the authority to assume jurisdiction within designated boundaries of a critical groundwater area in which the creation of an underground water conservation district or annexation to an existing underground water conservation district is defeated in an election.

HB 423

This legislation by Representative Terral Smith would amend Section 50.377 of the Texas Water Code to define a "financially dormant district" and allows a financially dormant district to elect to submit an annual financial dormancy affidavit instead of an annual audit to the Texas Water Commission.

HB 528

This legislation by Representative Stan Schlueter of Killeen proposes to change the membership of the Fox Crossing Water District board of directors from three to five members and provides for all five to be elected at large, rather than from individual counties as before.

HB 533

HB 533 by Representative Lena Guerrero of Austin would amend the Natural Resources Code, Chapter 202 Environmental Protection for Caves and Associated Territory, to include definitions of caves, significant cave recharge areas, cave life, sinkhole, district, board, underground water and water pollution abatement plan. It would allow an underground water conservation district to require permits before the filling in, closing, destruction, or impediment of any flow of water into a cave, sinkhole, or cave recharge area. A detailed plan would have to be submitted at the time of permitting and the district would have to be satisfied that the information presented was sufficient to make a judgement that the change would not harm any part of the cave or recharge area.

HB 780

Representative Wilhelmina Delco of Austin has introduced this legislation which would create the Northeast Growth Corridor Water, Sewer, Irrigation and Drainage District No. 2 in Travis County, Texas. It establishes the powers, duties, finances and operations of the district and defines its territory.

HB 781

This legislation by Representative Delco creates the Northeast Growth Corridor Water, Sewer, Irrigation and Drainage District No. 1 in Travis County, Texas. It establishes the powers, duties, finances and operations of the district and defines its territory.

HB 847

This legislation by Representative Tom Craddick of Midland would amend Section 325.002, Government Code, to establish set dates for review of river authorities as if they were to be abolished on that date. The bill also requires submission of river authority policies and audits to the Texas Water Commission and provides for penalties for failure to do so or on violation of commission rules or order to implement this section.

HB 932

HB 932 by Representative Terral Smith relates to the water quality permit limitations in certain watersheds.

HB 933

This legislation, also by Representative Terral Smith, is related to the exploration and drilling for and production, mining, and storage of oil and gas, and other mineral resources in the areas of lakes, reservoirs, and basins.

HB 961

This bill by Representative Robert Saunders of LaGrange relates to the creation of the Texas Rivers Protection System.

HJR 45

This joint resolution introduced by Representative Bruce Gibson of Cleburne would authorize an exemption from ad valorem taxation of property owned by a nonprofit water supply or wastewater service corporation.

TEXAS STATE LEGISLATURE SENATE BILLS

SB 2

This legislation by Senators H. Tati Santiesteban of El Paso and Hector Uribe of Brownsville, is the Senate companion bill for HB 49.

SB 32

This bill by Senator Bill Sims of San Angelo would amend Section 30.05 of the Texas Penal Code as related to the creation of the offense of criminal trespass onto property or buildings from a state-owned river.

SB 61

Senator John T. Montford of Lubbock introduced this bill to amend Section 16.001 of the Texas Water Code to include a Section 49-d-7 of the Texas Constitution and amend Section 17.011 to include water development bonds not to exceed $500 million pursuant to Article III, Section 49-d-7 of the Texas Constitution. (This bill enables SJR5.)

SB 62

This bill by Senator Sims is the Senate companion bill for HB 178.

SB 113

This legislation by Senator Don Henderson of Houston would amend Section 50.4662 of the Texas Water Code so that a confirmation election for certain regional water districts may be held only once, according to the provisions of 54.026-54.029, which apply to confirmation elections.

SB 167

This legislation by Senator Sims relates to an appropriation for the Pecos River Compact Commission to pay for certain services.

SB 285

SB 285 by Senator Santiesteban would amend Section 26.177 of the Texas Water Code as related to the establishment of a water pollution control and abatement program by certain cities.

SB 333

This legislation by Senator Carlos Truan of Corpus Christi would delete Chapter 20 from the Texas Water Code and provisions in Chapters 15 and 17, relating to Chapter 20, which pertain to the Texas Water Resources Finance Authority.

SB 370

Introduced by Senator Santiesteban, this bill would create the Texas River Protection System.

SB 383

This legislation by Senator Judith Zaffirini of Laredo would forbid the use or possession of a glass container within 300 yards of a river, lake or stream.

SB 422

This bill by Senator Kenneth Armbrister of Victoria relates to the regulation of underground storage tank installers.

SB 423

Senator Bob McFarland of Arlington has introduced this legislation to amend Section 26 of the Texas Water Code to add above-ground storage tanks to the regulations dealing with leaking underground storage tanks. The bill also would establish a groundwater protection cleanup program and a petroleum storage tank remediation fund for the cleanup of releases from certain petroleum storage tanks.

SR 17

This Senate resolution by Senator Chet Brooks of Pasadena relates to the continuation of the Task Force on Waste Management Policy.

SJR 5

This joint resolution, introduced by Senator Montford, proposes a constitutional amendment to authorize the issuance of an additional $500 million in Texas Water Development Bonds, of which $250 million would be used for water supplies; $200 million for water quality; and $50 million for flood control purposes.

TWCA honors McCleskey

Lubbock lawyer George W. McCleskey has been named the Water Person of 1989 by the Texas Water Conservation Association in recognition of his long-term contributions to Texas water resources development and management.

The presentation was made by TWCA president Owen H. Ivie during the organization's 45th annual convention in Austin, which was dedicated to McCleskey.

McCleskey served as lead counsel for the 1962 landmark case, *Marvin Shurbet, Et Ux vs. United States of America,* which established the cost-in-water income tax depletion allowance for landowners. This has allowed taxpayers within the High Plains Underground Water Conservation District No. 1 to collectively save from three to five million dollars each year on their federal tax returns.

McCleskey has just completed two six-year terms as a member of the Texas Water Development Board (TWDB). During his service, many area towns and cities were able to obtain low interest water supply and waste water treatment loans from the TWDB. McCleskey has also been credited with causing changes in TWDB rules to allow loans for the purchase and development of groundwater by Texas towns and cities.

THE CROSS SECTION

THE CROSS SECTION (USPS 564-920)

A MONTHLY PUBLICATION OF THE HIGH PLAINS UNDERGROUND WATER CONSERVATION DISTRICT NO. 1
2930 Avenue Q, Lubbock, Texas 79405
Telephone (806) 762-0181

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Second Class Postage Paid at Lubbock, Texas
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High water losses are common with open ditch irrigation

Farmers who transport water to their fields in open, unlined irrigation ditches face water losses of 10 to 30 percent per 1,000 feet of ditch due to evaporation and deep percolation. This practice wastes limited ground-water supplies and causes producers to pay for pumping water which will not be available for plant use.

In an Amarillo fine sandy loam soil, which is common in the southern portion of the High Plains Underground Water Conservation District No. 1 service area, unlined irrigation ditches can lose 5,372 gallons of water per ditch foot during a 2,000-hour irrigation season. According to a Water District study, this amounts to 21.76 acre-feet of water lost from one-quarter mile of open, unlined irrigation ditch during the growing season.

Open ditches installed in the more clayey Pullman clay loam soils commonly found in the northern areas of the District can lose 1,819 gallons of water per foot of ditch during a 2,000-hour irrigation season, or 7.37 acre-feet of water from one-quarter mile of open ditch, to evaporation and infiltration.

The 21.76 acre-feet of water lost from an open ditch in the Amarillo fine sandy loam soil could be used to irrigate 65 additional crop acres with about a four-inch application. In a Pullman clay loam soil, 22 crop acres could receive about a four-inch irrigation with the 7.37 acre-feet of water normally lost from open ditches.

Alternatives to open, unlined ditches include underground pipe to transport water to the field and gated pipe to apply water in the furrows. By eliminating evaporation and deep percolation losses, these devices provide more water to the crops and save producers the cost of pumping water that will not get to the crop.

In addition, underground pipe is not dependent upon gravity flow for water transportation as open irrigation ditches are. Underground pipelines allow water to be transported up gradients as well as across level ground or downhill.

Underground pipelines may be damaged by ground movement and should be checked regularly for leaks, especially older concrete pipelines with mortar joints. Flow meters are a practical method to check for water losses from underground pipe. Differences between meter readings at the pump and at the discharge point indicate a water loss in the pipeline.

Some farmers use underground pipe to transport water from the well to the field, then use open ditches and siphon tubes to apply water in the furrows. Aluminum or PVC gated pipe can be an alternative in this case. In addition to preventing evaporation and seepage losses, gated pipe also reduces the labor associated with constructing and maintaining open ditches. Also, gated pipe allows the implementation of surge irrigation, which can improve furrow irrigation application efficiency 10 to 40 percent.

Surge irrigation consists of time-controlled valves placed between two sets of gated pipe. The system alternately waters the two sets of furrows in a series of timed "surges." Surge irrigation can eliminate tail-water losses while obtaining a more uniform wetting of the soil root zone profile throughout the length of the field.

Aluminum gated pipe is commonly used on the Texas High Plains. However, an increased price per pound for scrap aluminum has caused pipe theft problems in some areas. Producers have increased PVC gated pipe use because it is durable, light-weight, and less likely to be stolen from the field.

A variation of gated pipe is disposable polyethylene tubing. The tubing is designed for low pressure applications where the ground is level or has a downhill gradient from the well for gravity water flow. Although the polyethylene tubing generally becomes too brittle for dependable irrigation use after one season, it is relatively inexpensive at 10 to 42 cents per foot. It is normally sold in rolls containing a quarter-mile length of collapsed tubing.

Polyethylene pipelines require little labor for use. They are placed alongside the field and cut or spliced to the desired length. Holes are then punched in the tubing to correspond with the furrows. These holes may be plugged later by simply inserting a rolled leaf into the hole.

Farmers within the Water District's service area may qualify to borrow money from the District to replace open unlined irrigation ditches through the Agricultural Water Conservation Equipment Pilot Loan Program. Concrete-lined ditches, underground pipe, gated pipe, surge valves and sprinkler systems are among the items eligible for loan funds. The current interest rate is 7.22 percent and a one-time service fee of 2.5 percent of the loan amount is charged for administrative costs.

Surge valves improve furrow irrigation application efficiencies

EDITOR'S NOTE — Since 1983, surge irrigation has become widely accepted on the Texas High Plains and has been proven to be a valuable water conservation tool. The first of this two-part series examines the problems involved with conventional furrow irrigation and how surge irrigation can be beneficial to irrigators wishing to improve their furrow irrigation application efficiencies. Part Two of this series will be printed in the May 1989 *Cross Section* — **CEM.**

Since their introduction on the Texas High Plains less than a decade ago, surge valves have provided farmers with a cost-effective means to improve furrow irrigation application efficiencies. Through proper management, more uniform water applications are possible with surge irrigation, and this reduces deep percolation as well as tailwater losses.

The main objective of furrow irrigation is to wet a predetermined portion of the soil plant root zone uniformly throughout the length of the field with the least possible amount of waste. However, it is difficult to achieve this objective with continuous flow irrigation.

Generally, the infiltration rate of the soil is very rapid when the water is first applied in the furrow, and this rate decreases through time as a continuous stream of water is added to the furrow. If the soil infiltration rate did not decrease, the water would move down the furrow only a short distance to the point where the soil infiltration rate equals the water flow rate, and the water would move no further.

Even with a decreasing infiltration rate, the soil will continue to absorb water as long as it is present. Any water applied in excess of the infiltration rate of the length of the wetted furrow will move down the furrow and wet the soil as it goes. The quantity of water being injected into each furrow must exceed the infiltration rate for the length of the furrow to be wet and must account for the decreasing infiltration rate as the water travels through the field.

If an irrigator only wanted to wet the top foot of the soil plant root zone using a continuous flow of water down the furrow, he would have several options. However, none of them would achieve the desired objective.

If the irrigator stops the flow of water before it can reach the end of the furrow in an attempt to allow only enough water down the furrow to reach the end of the row, he likely has wet the soil in a wedge-shaped pattern that extends about three feet deep at the top end of the field and thins to a few inches at the end of the field.

The irrigator might allow the flow to continue down the furrow and then stop it when it reaches the end of the field. He may build a border to back the water up into the furrow, and this would give the soil time to absorb the water. Using this method of irrigation, the wetted soil area will be three feet thick or more at the upper end of the field and thin to a few inches in the center of the field. The wetted area will thicken to about a foot in depth at the end of the field.

The irrigator may let the water flow out of the end of the rows for three to four hours to allow time for the end of the field to wet to a one-foot depth. In this instance, the soil wetting pattern would again be in a wedge shape. This area would be wet to a depth of four or more feet at the upper end of the field and narrow to about a foot at the end of the field. Considerable tailwater waste and water waste due to deep percolation would occur.

Through the use of soil moisture monitoring devices installed at intervals through the field, the irrigation pattern can be easily seen. The producer can then make changes in the irrigation distribution to avoid undesirable over-irrigation or under-irrigation.

Crop appearances also tell the producer about watering patterns. An uneven water application causes water-stressed areas or "hot spots" to appear.

Researchers and irrigators have searched for ways to overcome these undesirable, uneven furrow irrigation patterns.

Through trial and error, many producers discovered that water could be moved to the end of the furrow with less total irrigation time by using a technique they called "bumping." Water flow within the furrow was temporarily interrupted and then allowed to flow. This "on-off" application of irrigation water was the primitive forerunner of today's modern surge irrigation.

Surge irrigation offers several benefits. For example, when pre-plant irrigation begins, furrows are usually rough with clods or contain stubble from the previous crop if the producer uses minimum tillage. After each surge cycle, soil particles and leaves settle to the bottom of the furrow. A large percentage of this material settles out, and the next wetting cycle does not pick it up. This allows producers to get the water through the furrows better during the next cycle. Subsequent irrigations during the growing season will consequently be through smoother furrows, which speeds up the advance rate.

Surge irrigation also allows greater flexibility in the amount of water that can be applied to crops. As little as two to three inches of water can be applied uniformly.

Careful management of surge irrigation improves irrigation distribution patterns. Once the furrows are wet, the irrigation flow time should be cut back to match the infiltration rate of the soil in the furrows as closely as possible. The surge valve controller should be programmed to switch watering cycles to the alternate side just before water reaches the furrow end to prevent tailwater. Remaining surges will be used to fill the root zone soil profile to the depth desired by the producer.

Water District management manual nears completion

The fear of state control of underground water and a desire to retain local control has prompted the creation of numerous underground water conservation districts during the past two regular sessions of the Texas Legislature, and more are expected to be created during the current session.

Most directors and managers of the newly created districts are overwhelmed by the vast array of legal, technical and/or procedural requirements facing them as they begin to try to meet their responsibilities.

The Texas Water Code provides that an underground water conservation district perform many functions and follow certain procedures in all its activities. Also, the Election Code, the Tax Code, the Open Meetings Act, the Open Records Act and other laws that must be complied with can be downright intimidating.

The Water Resources Center at Texas Tech University, the Texas Water Commission and the High Plains Water District have joined in a cooperative effort to develop a manual designed to assist in the operation of new or existing underground water conservation districts. The manual includes information on routine procedures, programs and operations, including budget and financial accounting procedures, as well as descriptions of the duties and responsibilities of district managers and directors.

A review committee comprised of legislators, the Texas Water Commission, the Texas Water Development Board, water district managers, representatives of the Texas Farm Bureau, the League of Women Voters, the Texas Water Alliance and the Texas Sierra Club met in Austin during the week of February 12, 1989, for a final review of the manual. Minor revisions were suggested and should be completed in the next 30 days.

Copies of the manual will be available from the Texas Water Commission in Austin, Texas, Bill Klemt, Ground Water Conservation Section, P.O. Box 13087, Capitol Station, Austin, Texas 78711-3087 (512) 463-7969 and through the Water Resources Center, Texas Tech University, Dr. Lloyd Urban, Director, P.O. Box 4630, Lubbock, Texas 79409 (806) 742-3597.

Producers can use furrow dikes to reduce rainfall runoff losses

Each year, producers look toward the skies in anticipation of rains to wet the soil profile prior to planting time. To make the most of these precipitation events, producers might consider installing furrow dikes in their fields to capture the free moisture provided by Mother Nature.

Special farm implements are used to create furrow dikes at periodic intervals down the furrow. These small earthen dams and the basins in front of them keep water in place until it can soak into the soil.

Annual precipitation averages 18 inches at Lubbock and 20 inches at Amarillo. Approximately 65 percent of this precipitation is likely to fall between April and the end of the growing season.

As much as two-thirds of the average annual rainfall occurs during precipitation events of less than one inch of moisture. Most High Plains soils can absorb this quantity of rainfall without any significant runoff. However, the remaining precipitation falls during short, intense thunderstorms. The downpour is usually faster than the soil infiltration rate, and runoff occurs. Furrow dike installation allows producers to capture rainfall and prevent it from running down the furrow and out of the field.

HARVESTING RAINFALL — These furrow dikes are holding rainfall in place to soak into the soil profile.

Research conducted by the Texas Agricultural Experiment Station in Lubbock has determined the relationship of runoff to the land slope. On level loamy soils, no runoff occurs, while the average annual runoff is about 1.74 inches on loamy soils with a 0.2 percent slope, or a slope of two inches per 100 feet. Runoff is about 2.51 inches annually from loamy soils with a 0.5 percent slope, 3.08 inches from loamy soils with a 0.9 percent slope and 3.61 inches from loamy soils with a 1.2 percent slope. The researchers also noted an average annual runoff of 2.73 inches per acre on loamy soils from all plots without furrow dikes. On a 160-acre farm with similar slopes, the average annual runoff without furrow dikes would be approximately 437 acre-inches.

With furrow dikes, this water is kept available for crop use. For each inch of water per acre harvested by furrow dikes, a producer saves about $3 per acre-inch in fuel cost as compared to the cost of producing the water from a well pumping 500 gallons per minute with a pumping lift of 200 feet. Equally important, each acre-inch of water obtained from another source extends the life of the Ogallala Aquifer.

For each inch of water available to plants over and above the requirements for developing stalks, stems and leaves, a cotton crop can produce as much as 30 pounds of lint per acre, or a grain sorghum crop can produce as much as 350 pounds of grain per acre.

Furrow diking equipment costs range from $140 to $300 per row. This investment can usually be recovered in the first year of use through reduced pumping costs and increased yields. No extra tillage costs are added since the dikes can be put in during other field operations.

Additional furrow diking information may be found in the Water Management Note, *"Furrow Dikes: Small Reservoirs of Yield Potential."* Residents of the District's 15-county service area may obtain free copies of this publication by contacting the High Plains Underground Water Conservation District No. 1, 2930 Avenue Q, Lubbock, TX 79405, or by calling (806) 762-0181.

THE CROSS SECTION (USPS 564-920)
HIGH PLAINS UNDERGROUND WATER
CONSERVATION DISTRICT NO. 1
2930 AVENUE Q
LUBBOCK, TEXAS 79405

SECOND CLASS PERMIT

THE Cross SECTION

Published monthly by High Plains Underground Water Conservation District No. 1, 2930 Avenue Q, Lubbock, Texas 79405—Ph. 762-0181

Volume 35—No. 4 Publication Number USPS 564-920, Second Class Postage paid at Lubbock, Texas *April 1989*

Three-year trend reversed

Ogallala Aquifer groundwater levels show slight decline

After a three-year upward trend, depth to water measurements have revealed a slight decline in the groundwater levels of the Ogallala Aquifer within the High Plains Underground Water Conservation District No. 1 from 1988 to 1989.

The average annual change in groundwater levels from 1988 to 1989 was a decline of about one-half foot within the 5.5 million-acre Water District service area. Of the 15 counties surveyed, nine counties showed an average decline in their depth to water measurements. Groundwater levels in six of the nine counties had an average rise from 1988 to 1989.

Dry pre-plant soil conditions and below average rainfall across most of the District during the growing season caused producers to apply larger and more frequent irrigations than usual. The increased pumpage caused a reversal of the three-year trend in rising aquifer levels.

Groundwater levels in the Ogallala Aquifer stabilized for the first time in the Water District's history during 1985; rose 0.50 of a foot in 1986; and rose 0.90 of a foot in 1987. During the ten-year period from 1979 to 1989, groundwater levels showed an average annual decline of 0.39 of a foot per year. However, during the five-year period from 1984 to 1989, groundwater levels rose an average of 0.07 of a foot per year.

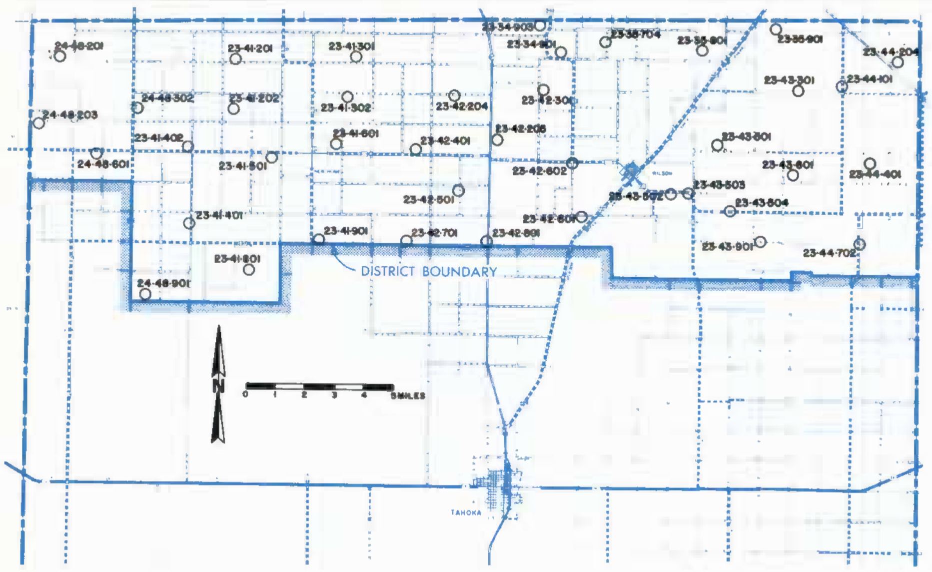
Depth to water measurements are taken from a network of 1,012 observation water wells scattered across the 15-county Water District service area and are used to determine the annual change in the quantity of water stored in the Ogallala Aquifer. District Technical Division staff members take these measurements during January and February, so that water levels can stabilize from the previous irrigation season.

The following table denotes the average annual depth to water changes for each county within the High Plains Water District during the past 10 years, the past five years and the past year.

Also, individual maps will help readers locate groundwater observation water wells in their respective county. Each map is accompanied by 1979, 1984, 1988 and 1989 depth to water measurements for each observation well in that specific county.

Average Changes In Depths to Water In Feet For Observation Wells - 1989

	Number Of Observation Wells Maintained	Past 10 Years Average Annual Change (1979 to 1989)	Past 5 Years Average Annual Change (1984 to 1989)	Past Year Average Change (1988 to 1989)
ARMSTRONG	9	-0.16	+0.33	+0.46
BAILEY	78	-0.47	+0.11	+0.13
CASTRO	89	-1.48	-0.77	-1.45
COCHRAN	52	+0.36	+0.63	+0.53
CROSBY	74	+0.10	+1.41	+0.14
DEAF SMITH	88	-0.82	-0.48	-1.42
FLOYD	98	-0.64	-0.18	-1.08
HALE	27	-0.54	+0.60	-1.48
HOCKLEY	88	+0.48	+0.72	+0.86
LAMB	99	-1.42	-0.64	-0.75
LUBBOCK	117	+0.52	+0.74	-0.23
LYNN	40	+1.27	+1.69	+0.45
PARMER	97	-1.42	-0.79	-1.24
POTTER	6	-0.41	+0.01	-1.03
RANDALL	50	-0.14	+0.03	-0.31
District	**1,012**	**-0.39**	**+0.07**	**-0.51**



LYNN COUNTY

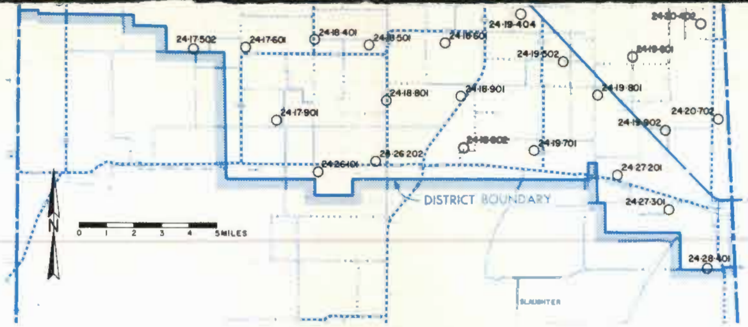
Well Number	Depth to Water Below Land Surface In Feet 1979	1984	1988	1989	Total Change In Water Levels In Feet 1979 to 1989	1984 to 1989	1988 to 1989
23-34-901	146.90	141.64	136.69	138.27	+ 8.63	+ 3.37	- 1.58
23-34-903	154.18	154.81	149.52	150.93	+ 3.25	+ 3.88	- 1.41
23-35-704	135.00	135.65	130.76	132.27	+ 2.73	+ 3.38	- 1.51
23-35-801	87.69	88.65	85.39	83.54	+ 4.15	+ 5.11	+ 1.85
23-35-901	90.90	89.61	87.81	85.69	+ 5.21	+ 3.92	+ 2.12
23-41-201	107.15	100.98	93.49	93.45	+ 13.70	+ 7.53	+ 0.04
23-41-202	N/A	N/A	105.85	104.31	N/A	N/A	+ 1.54
23-41-301	N/A	132.46	127.64	127.40	N/A	+ 5.06	+ 0.24

LYNN COUNTY

Well Number	Depth to Water Below Land Surface In Feet 1979	1984	1988	1989	Total Change In Water Levels In Feet 1979 to 1989	1984 to 1989	1988 to 1989
23-41-302	N/A	N/A	106.72	104.90	N/A	N/A	+ 1.82
23-41-401	94.45	92.07	82.67	79.26	+ 15.19	+ 12.81	+ 3.41
23-41-402	N/A	102.49	93.40	91.43	N/A	+ 11.06	+ 1.97
23-41-501	72.84	68.08	59.45	60.17	+ 12.67	+ 7.91	- 0.72
23-41-601	N/A	103.74	101.47	100.79	N/A	+ 2.95	+ 0.68
23-41-801	N/A	62.15	60.66	61.20	N/A	+ 0.95	- 0.54
23-41-901	127.78	121.06	113.49	111.16	+ 16.62	+ 9.90	+ 2.33
23-42-204	N/A	118.81	115.30	114.60	N/A	+ 4.21	+ 0.70
23-42-205	N/A	N/A	91.29	89.78	N/A	N/A	+ 1.51
23-42-301	109.89	107.55	102.69	101.82	+ 8.07	+ 5.73	+ 0.87
23-42-401	114.29	109.69	103.92	102.28	+ 12.01	+ 7.41	+ 1.64
23-42-501	103.42	96.39	85.30	88.08	+ 15.34	+ 8.31	- 2.78
23-42-601	43.72	38.34	30.23	33.63	+ 10.09	+ 4.71	- 3.40
23-42-602	89.51	84.33	81.28	82.19	+ 7.32	+ 2.14	- 0.91
23-42-701	98.95	87.32	79.08	78.60	+ 20.35	+ 8.72	+ 0.48
23-42-801	66.27	60.42	49.02	46.03	+ 20.24	+ 14.39	+ 2.99
23-43-301	31.80	23.48	12.46	17.79	+ 14.01	+ 5.69	- 5.33
23-43-501	70.91	68.88	61.71	N/A	N/A	N/A	N/A
23-43-502	78.54	76.39	70.38	69.29	+ 9.25	+ 7.10	+ 1.09
23-43-503	85.48	83.43	78.11	76.10	+ 9.38	+ 7.33	+ 2.01
23-43-504	76.26	74.78	66.25	65.86	+ 10.40	+ 8.92	+ 0.39
23-43-601	N/A	35.97	27.96	29.30	N/A	+ 6.67	- 1.34
23-43-901	57.74	52.00	45.47	47.00	+ 10.74	+ 5.00	- 1.53
23-44-101	63.60	55.13	28.24	31.65	+ 31.95	+ 23.48	- 3.41
23-44-204	N/A	143.40	113.97	114.68	N/A	+ 28.72	- 0.71
23-44-401	43.86	38.65	30.03	31.56	+ 12.30	+ 7.09	- 1.53
23-44-702	27.40	23.60	17.71	18.12	+ 9.28	+ 5.48	- 0.41
24-48-201	101.26	97.70	90.70	87.95	+ 13.31	+ 9.75	+ 2.75
24-48-203	N/A	89.59	80.40	77.34	N/A	+ 12.25	+ 3.06
24-48-302	111.91	102.42	87.70	87.01	+ 24.90	+ 15.41	+ 0.69
24-48-601	89.77	86.81	71.40	67.58	+ 22.19	+ 19.23	+ 3.82
24-48-901	N/A	N/A	108.59	102.10	N/A	N/A	+ 6.49

NOTE: N/A Denotes data not available

24-09-901	107.40	109.46	105.20	104.19	+ 3.21	+ 5.27	+ 1.01
24-10-501	95.17	93.75	91.75	91.45	+ 3.72	+ 2.30	+ 0.30
24-10-503	N/A	104.87	103.21	102.70	N/A	+ 2.17	+ 0.51
24-10-601	93.15	92.37	89.97	N/A	N/A	N/A	N/A
24-10-702	112.55	111.78	112.35	112.05	+ 0.50	– 0.27	+ 0.30
24-10-902	N/A	N/A	111.44	110.16	N/A	N/A	+ 1.28
24-11-402	N/A	126.77	124.37	N/A	N/A	N/A	N/A
24-11-701	127.07	125.22	124.70	123.95	+ 3.12	+ 1.27	+ 0.75
24-11-802	115.79	114.69	111.74	110.98	+ 4.81	+ 3.71	+ 0.76
24-11-803	N/A	130.82	128.01	126.60	N/A	+ 4.22	+ 1.41
24-17-101	N/A	134.29	132.22	128.89	N/A	+ 5.40	+ 3.33
24-17-202	N/A	140.84	136.62	135.50	N/A	+ 5.34	+ 1.12
24-17-301	148.86	145.62	141.16	141.35	+ 7.51	+ 4.27	– 0.19
24-17-502	158.89	155.04	152.58	149.25	+ 9.64	+ 5.79	+ 3.33
24-17-601	152.42	150.56	147.77	146.50	+ 5.92	+ 4.06	+ 1.27
24-17-901	168.97	165.99	N/A	N/A	N/A	N/A	N/A
24-18-101	146.84	146.00	143.96	N/A	N/A	N/A	N/A
24-18-102	156.86	153.56	150.25	147.68	+ 9.18	+ 5.88	+ 2.57
24-18-201	180.55	178.23	175.65	172.90	+ 7.65	+ 5.33	+ 2.75
24-18-202	138.98	138.18	136.25	135.82	+ 3.16	+ 2.36	+ 0.43
24-18-301	135.23	136.44	134.61	133.47	+ 1.76	+ 2.97	+ 1.14
24-18-306	N/A	N/A	165.10	165.71	N/A	N/A	– 0.61
24-18-401	154.65	154.80	149.70	148.90	+ 5.75	+ 5.90	+ 0.80
24-18-501	198.63	198.39	194.95	193.97	+ 4.66	+ 4.42	+ 0.98
24-18-601	177.09	176.60	171.78	172.97	+ 4.12	+ 3.63	– 1.19
24-18-801	195.14	193.52	187.97	187.15	+ 7.99	+ 6.37	+ 0.82
24-18-901	114.55	114.08	110.85	111.89	+ 2.66	+ 2.19	– 1.04
24-18-902	N/A	139.45	137.37	138.50	N/A	+ 0.95	– 1.13
24-19-201	149.44	150.85	148.03	148.10	+ 1.34	+ 2.75	– 0.07
24-19-203	N/A	N/A	125.23	126.05	N/A	N/A	– 0.82
24-19-301	170.04	170.54	161.67	161.47	+ 8.57	+ 9.07	+ 0.20
24-19-404	N/A	N/A	143.58	144.07	N/A	N/A	– 0.49
24-19-502	176.43	173.79	169.99	170.88	+ 5.55	+ 2.91	– 0.89
24-19-601	161.52	161.33	158.99	158.60	+ 2.92	+ 2.73	+ 0.39
24-19-701	153.19	150.55	N/A	N/A	N/A	N/A	N/A
24-19-801	169.89	166.53	164.99	167.20	+ 2.69	– 0.67	– 2.21
24-19-902	129.80	130.49	129.65	129.17	+ 0.63	+ 1.32	+ 0.48



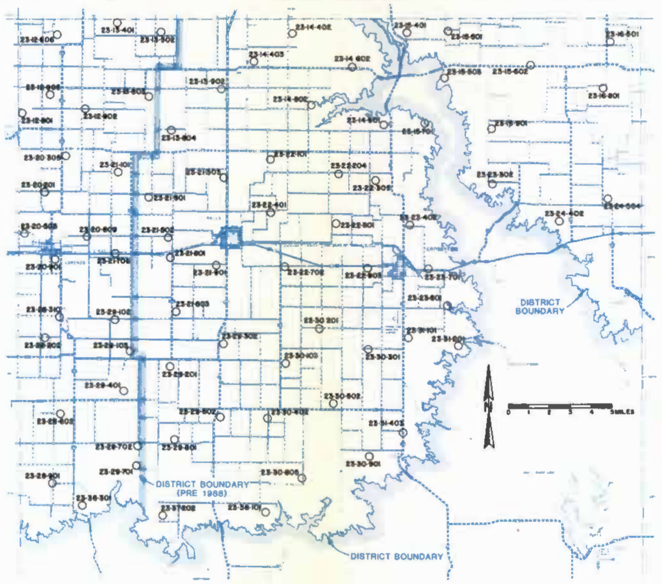
COCHRAN COUNTY

Well Number	Depth to Water Below Land Surface In Feet				Total Change In Water Levels In Feet		
	1979	1984	1988	1989	1979 to 1989	1984 to 1989	1988 to 1989
24-20-103	147.92	145.71	142.12	141.77	+ 6.15	+ 3.94	+ 0.35
24-20-402	152.08	157.60	157.76	156.60	– 4.52	+ 1.00	+ 1.16
24-20-702	153.39	155.46	154.26	153.10	+ 0.29	+ 2.36	+ 1.16
24-26-101	N/A	151.25	149.96	149.01	N/A	+ 2.24	+ 0.95
24-26-202	162.48	159.74	156.92	158.34	+ 4.14	+ 1.40	– 1.42
24-27-201	182.76	181.20	179.25	178.65	+ 4.11	+ 2.55	+ 0.60
24-27-301	180.45	180.82	179.67	179.05	+ 1.40	+ 1.77	+ 0.62
24-28-401	187.41	189.20	187.90	187.32	+ 0.09	+ 1.88	+ 0.58
25-16-602	79.78	79.91	75.49	N/A	N/A	N/A	N/A
25-16-901	92.12	94.13	90.25	89.08	+ 3.04	+ 5.05	+ 1.17
25-16-902	N/A	109.57	108.35	107.69	N/A	+ 1.88	+ 0.66
25-24-601	N/A	140.77	137.65	137.40	N/A	+ 3.37	+ 0.25

NOTE: N/A Denotes data not available

23-25-401	148.44	145.49	140.67	140.75	+ 7.69	+ 4.74	– 0.08
23-25-704	133.59	129.56	125.03	125.06	+ 8.53	+ 4.50	– 0.03
23-25-801	N/A	111.51	108.39	108.09	N/A	+ 3.42	+ 0.30
23-25-904	85.87	71.59	59.20	56.54	+ 29.33	+ 15.05	+ 2.66
23-26-101	56.54	50.84	50.62	51.82	+ 4.72	– 0.98	– 1.20
23-26-103	N/A	N/A	40.26	40.89	N/A	N/A	– 0.63
23-26-301	93.47	91.04	86.35	85.81	+ 7.66	+ 5.23	+ 0.54
23-26-603	13.82	11.11	9.12	N/A	N/A	N/A	N/A
23-26-604	50.87	47.93	45.97	48.08	+ 2.79	– 0.15	– 2.11
23-26-802	N/A	67.92	59.31	60.59	N/A	+ 7.33	– 1.28
23-27-102	N/A	81.15	76.17	76.04	N/A	+ 5.11	+ 0.13
23-27-201	95.48	90.47	85.82	85.28	+ 10.20	+ 5.19	+ 0.54
23-27-204	94.82	90.94	86.39	86.08	+ 8.74	+ 4.86	+ 0.31
23-27-207	109.06	97.38	87.79	91.06	+ 18.00	+ 6.32	– 3.27
23-27-302	82.67	77.38	67.15	66.91	+ 15.76	+ 10.47	+ 0.24
23-27-402	75.23	71.38	67.58	66.54	+ 8.69	+ 4.84	+ 1.04
23-27-601	87.42	82.66	73.94	75.15	+ 12.27	+ 7.51	– 1.21
23-27-603	N/A	85.23	78.21	78.08	N/A	+ 7.15	+ 0.13
23-27-701	N/A	61.42	52.40	59.19	N/A	+ 2.23	– 6.79
23-27-801	N/A	125.68	121.55	119.98	N/A	+ 5.70	+ 1.57
23-28-203	N/A	162.39	143.94	151.16	N/A	+ 11.23	– 7.22
23-28-501	N/A	87.61	80.94	78.56	N/A	+ 9.05	+ 2.38
23-28-701	62.62	58.45	41.69	45.39	+ 17.23	+ 13.06	– 3.70
23-33-201	130.64	128.81	126.81	126.02	+ 4.62	+ 2.79	+ 0.79
23-33-301	N/A	99.81	95.62	96.35	N/A	+ 3.46	– 0.73
23-33-401	106.17	105.68	102.65	101.89	+ 4.28	+ 3.79	+ 0.76
23-33-501	110.95	110.51	108.89	107.97	+ 2.98	+ 2.54	+ 0.92
23-33-601	106.92	104.94	101.31	100.48	+ 6.44	+ 4.46	+ 0.83
23-33-801	99.64	98.33	94.02	93.33	+ 6.31	+ 5.00	+ 0.69
23-33-901	121.00	118.35	114.96	114.38	+ 6.62	+ 3.97	+ 0.58
23-34-101	115.97	111.87	106.97	107.31	+ 8.66	+ 4.56	– 0.34
23-34-202	N/A	92.23	83.92	84.07	N/A	+ 8.16	– 0.15
23-34-402	117.93	115.27	112.93	112.21	+ 5.72	+ 3.06	+ 0.72
23-34-502	140.49	140.03	136.95	136.39	+ 4.10	+ 3.64	+ 0.56
23-34-503	123.18	119.67	115.12	115.56	+ 7.62	+ 4.11	– 0.44
23-34-601	128.31	128.02	126.35	125.64	+ 2.67	+ 2.38	+ 0.71
23-34-801	149.84	145.94	142.17	141.18	+ 8.66	+ 4.76	+ 0.99
23-34-805	145.89	140.96	137.65	136.43	+ 9.46	+ 4.53	+ 1.22
23-34-902	137.47	137.20	134.76	134.42	+ 3.05	+ 2.78	+ 0.34
23-35-101	81.79	76.61	70.85	70.83	+ 10.96	+ 5.78	+ 0.02
23-35-301	110.39	110.97	106.76	105.35	+ 5.04	+ 5.62	+ 1.41
23-35-502	98.76	96.88	94.45	93.22	+ 5.54	+ 3.66	+ 1.23
23-35-503	129.10	127.36	123.41	123.31	+ 5.79	+ 4.05	+ 0.10
23-35-701	132.23	131.36	128.84	128.82	+ 3.41	+ 2.54	+ 0.02
23-35-703	136.85	136.35	131.35	131.39	+ 5.46	+ 4.96	– 0.04
23-35-706	131.05	130.28	126.93	127.69	+ 3.36	+ 2.59	– 0.76
23-35-707	N/A	131.50	128.90	129.26	N/A	+ 2.24	– 0.36
23-35-802	118.63	117.88	113.72	N/A	N/A	N/A	N/A
23-35-902	148.73	142.24	138.81	138.64	+ 10.09	+ 3.60	+ 0.17
23-35-903	151.25	148.87	134.62	136.48	+ 14.77	+ 12.39	– 1.86
23-36-201	N/A	77.43	70.77	71.45	N/A	+ 5.98	– 0.68
23-36-401	103.19	101.89	100.01	99.24	+ 3.95	+ 2.65	+ 0.77
23-36-701	119.52	116.35	115.17	116.49	+ 3.03	– 0.14	– 1.32
23-36-702	217.46	212.10	202.38	203.96	+ 13.50	+ 8.14	– 1.58
23-36-703	205.77	199.74	192.43	189.34	+ 16.43	+ 10.40	+ 3.09
24-16-601	133.01	135.93	132.84	131.92	+ 1.09	+ 4.01	+ 0.92
24-16-901	171.53	169.96	168.84	168.47	+ 3.06	+ 1.49	+ 0.37
24-24-201	70.45	69.91	65.30	61.25	+ 9.20	+ 8.66	+ 4.05
24-24-301	136.93	135.41	131.80	130.75	+ 6.18	+ 4.66	+ 1.05
24-24-602	86.50	85.69	80.89	80.33	+ 6.17	+ 5.36	+ 0.56
24-24-901	171.33	171.64	N/A	N/A	N/A	N/A	N/A
24-24-903	N/A	N/A	132.48	131.63	N/A	N/A	+ 0.85
24-32-201	N/A	103.27	102.68	102.14	N/A	+ 1.13	+ 0.54
24-32-303	N/A	119.75	118.52	117.87	N/A	+ 1.88	+ 0.65
24-32-304	145.15	146.52	143.31	143.61	+ 1.54	+ 2.91	– 0.30
24-32-305	N/A	N/A	N/A	123.89	N/A	N/A	N/A
24-32-502	N/A	121.09	116.73	115.83	N/A	+ 5.26	+ 0.90
24-32-601	134.80	134.52	132.49	131.75	+ 3.05	+ 2.77	+ 0.74
24-40-201	138.65	133.99	129.98	129.62	+ 9.03	+ 4.37	+ 0.36
24-40-301	148.21	146.19	143.39	142.17	+ 6.04	+ 4.02	+ 1.22
24-40-601	129.03	126.29	124.46	124.79	+ 4.24	+ 1.50	– 0.33
24-40-603	87.03	87.54	85.82	85.91	+ 1.12	+ 1.63	– 0.09
24-40-901	70.86	66.24	62.45	62.38	+ 8.48	+ 3.86	+ 0.07

NOTE: N/A Denotes data not available



CROSBY COUNTY

Well Number	Depth to Water Below Land Surface In Feet				Total Change In Water Levels In Feet		
	1979	1984	1988	1989	1979 to 1989	1984 to 1989	1988 to 1989
23-12-606	189.83	205.92	202.46	204.67	– 14.84	+ 1.25	– 2.21
23-12-801	207.13	211.87	205.00	207.36	– 0.23	+ 4.51	– 2.36
23-12-902	228.74	240.04	231.25	231.03	– 2.29	+ 9.01	+ 0.22
23-12-905	214.28	218.85	217.68	218.30	– 4.02	+ 0.55	– 0.62
23-13-401	206.08	216.53	214.83	217.22	– 11.14	– 0.69	– 2.39
23-13-502	224.54	232.27	231.27	233.27	– 8.73	– 1.00	– 2.00
23-13-803	238.73	252.68	246.60	246.33	– 7.60	+ 6.35	+ 0.27
23-13-804	N/A	N/A	N/A	241.03	N/A	N/A	N/A
23-13-902	N/A	N/A	N/A	255.07	N/A	N/A	N/A
23-14-402	N/A	N/A	N/A	N/A	N/A	N/A	N/A
23-14-403	N/A	N/A	N/A	259.56	N/A	N/A	N/A
23-14-602	N/A	N/A	N/A	266.22	N/A	N/A	N/A
23-14-802	N/A	N/A	N/A	266.78	N/A	N/A	N/A
23-14-901	N/A	N/A	N/A	N/A	N/A	N/A	N/A
23-15-401	N/A	N/A	N/A	N/A	N/A	N/A	N/A
23-15-501	N/A	N/A	N/A	301.25	N/A	N/A	N/A
23-15-503	N/A	N/A	N/A	308.00	N/A	N/A	N/A
23-15-602	N/A	N/A	N/A	280.10	N/A	N/A	N/A
23-15-701	N/A	N/A	N/A	286.91	N/A	N/A	N/A
23-15-901	N/A	N/A	N/A	257.70	N/A	N/A	N/A
23-16-501	N/A	N/A	N/A	286.03	N/A	N/A	N/A
23-16-801	N/A	N/A	N/A	259.79	N/A	N/A	N/A
23-20-201	N/A	192.06	187.23	186.67	N/A	+ 5.39	+ 0.56
23-20-305	N/A	224.96	215.52	218.96	N/A	+ 6.00	– 3.44
23-20-503	213.68	213.81	205.23	206.43	+ 7.25	+ 7.38	– 1.20
23-20-609	N/A	N/A	216.73	218.35	N/A	N/A	– 1.62
23-20-901	214.01	220.22	202.41	202.94	+ 11.07	+ 17.28	– 0.53
23-21-101	N/A	245.52	241.32	238.69	N/A	+ 6.83	+ 2.63
23-21-303	N/A	N/A	N/A	188.75	N/A	N/A	N/A
23-21-501	N/A	N/A	N/A	244.12	N/A	N/A	N/A
23-21-502	N/A	N/A	N/A	241.98	N/A	N/A	N/A
23-21-706	211.10	211.80	204.35	207.45	+ 3.65	+ 4.35	– 3.10
23-21-801	N/A	N/A	N/A	221.24	N/A	N/A	N/A
23-21-803	N/A	N/A	N/A	185.44	N/A	N/A	N/A
23-21-901	N/A	N/A	N/A	227.29	N/A	N/A	N/A
23-22-101	N/A	N/A	N/A	262.60	N/A	N/A	N/A
23-22-204	N/A	N/A	N/A	267.09	N/A	N/A	N/A
23-22-305	N/A	N/A	N/A	281.32	N/A	N/A	N/A
23-22-401	N/A	N/A	N/A	270.68	N/A	N/A	N/A
23-22-501	N/A	N/A	N/A	260.83	N/A	N/A	N/A
23-22-702	N/A	N/A	N/A	268.06	N/A	N/A	N/A
23-22-903	N/A	N/A	N/A	268.50	N/A	N/A	N/A
23-23-302	N/A	N/A	N/A	266.51	N/A	N/A	N/A
23-23-402	N/A	N/A	N/A	274.01	N/A	N/A	N/A
23-23-701	N/A	N/A	N/A	265.21	N/A	N/A	N/A
23-23-801	N/A	N/A	N/A	N/A	N/A	N/A	N/A
23-24-402	N/A	N/A	N/A	248.80	N/A	N/A	N/A
23-24-504	N/A	N/A	N/A	291.47	N/A	N/A	N/A
23-28-202	142.23	137.25	117.49	120.05	+ 22.18	+ 17.20	– 2.56
23-28-310	N/A	177.55	169.50	169.60	N/A	+ 7.95	– 0.10
23-28-602	N/A	N/A	109.19	100.86	N/A	N/A	+ 8.33
23-28-901	N/A	96.10	87.77	84.51	N/A	+ 11.59	+ 3.26
23-29-102	N/A	184.30	176.91	174.75	N/A	+ 9.55	+ 2.16
23-29-103	N/A	206.64	193.61	193.46	N/A	+ 13.18	+ 0.15
23-29-201	N/A	N/A	N/A	177.04	N/A	N/A	N/A
23-29-302	N/A	N/A	N/A	180.84	N/A	N/A	N/A
23-29-401	210.25	208.35	196.52	193.04	+ 17.21	+ 15.31	+ 3.48
23-29-602	N/A	N/A	N/A	194.17	N/A	N/A	N/A
23-29-701	N/A	114.05	111.62	112.55	N/A	+ 1.50	– 0.93
23-29-702	N/A	N/A	189.75	185.25	N/A	N/A	+ 4.50
23-29-801	N/A	N/A	N/A	142.42	N/A	N/A	N/A
23-30-103	N/A	N/A	N/A	208.61	N/A	N/A	N/A
23-30-201	N/A	N/A	N/A	237.98	N/A	N/A	N/A
23-30-301	N/A	N/A	N/A	200.74	N/A	N/A	N/A
23-30-402	N/A	N/A	N/A	206.16	N/A	N/A	N/A
23-30-502	N/A	N/A	N/A	221.31	N/A	N/A	N/A
23-30-805	N/A	N/A	N/A	211.22	N/A	N/A	N/A
23-30-901	N/A	N/A	N/A	249.55	N/A	N/A	N/A
23-31-101	N/A	N/A	N/A	230.58	N/A	N/A	N/A
23-31-201	N/A	N/A	N/A	263.98	N/A	N/A	N/A
23-31-403	N/A	N/A	N/A	277.13	N/A	N/A	N/A
23-36-301	N/A	152.60	149.08	148.27	N/A	+ 4.33	+ 0.81
23-37-202	N/A	N/A	N/A	184.45	N/A	N/A	N/A
23-38-101	N/A	N/A	N/A	194.90	N/A	N/A	N/A

NOTE: N/A Denotes data not available

NOTE: Only one depth to water measurement was considered in determining 1989 groundwater conditions within that portion of Crosby County annexed into the High Plains Underground Water Conservation District No. 1 in 1988.

10-25-701	289.49	307.48	295.07	297.10	– 7.61	+ 10.38	– 2.03
10-25-801	N/A	254.35	256.32	256.45	N/A	– 2.10	– 0.13
10-26-102	N/A	N/A	293.77	292.67	N/A	N/A	+ 1.10
10-26-201	N/A	289.92	290.70	290.62	N/A	– 0.70	+ 0.08
10-26-301	350.94	369.10	374.31	374.56	– 23.62	– 5.46	– 0.25
10-26-402	N/A	327.42	323.09	322.74	N/A	+ 4.68	+ 0.35
10-26-502	N/A	349.25	355.98	359.28	N/A	– 10.03	– 3.30
10-26-603	N/A	N/A	341.78	343.81	N/A	N/A	– 2.03
10-26-702	231.17	243.00	245.01	246.92	– 15.75	– 3.92	– 1.91
10-26-802	245.47	261.80	265.62	267.42	– 21.95	– 5.62	– 1.80
10-27-102	294.39	311.70	308.93	N/A	N/A	N/A	N/A
10-27-103	N/A	396.35	406.29	405.05	N/A	– 8.70	+ 1.24
10-27-301	335.55	347.83	353.27	361.06	– 25.51	– 13.23	– 7.79
10-27-501	373.74	392.37	398.72	400.69	– 26.95	– 8.32	– 1.97
10-27-601	N/A	370.25	369.38	369.18	N/A	+ 1.07	+ 0.20
10-27-702	N/A	303.22	305.24	306.42	N/A	– 3.20	– 1.18
10-27-901	280.09	N/A	296.51	298.25	– 18.16	N/A	– 1.74
10-28-102	N/A	344.05	348.96	349.28	N/A	– 5.23	– 0.32
10-28-202	307.39	321.14	324.54	328.60	– 21.21	– 7.46	– 4.06
10-28-501	333.91	352.40	359.68	N/A	N/A	N/A	N/A
10-28-703	N/A	285.28	293.41	294.44	N/A	– 9.16	– 1.03
10-28-801	N/A	313.40	318.52	320.27	N/A	– 6.87	– 1.75
10-33-103	N/A	319.15	326.74	328.77	N/A	– 9.62	– 2.03
10-33-310	N/A	283.10	283.22	285.80	N/A	– 2.70	– 2.58
10-33-501	292.99	311.65	N/A	N/A	N/A	N/A	N/A
10-33-502	N/A	340.30	345.32	348.35	N/A	– 8.05	– 3.03
10-33-603	N/A	322.62	328.74	329.90	N/A	– 7.28	– 1.16
10-33-801	N/A	274.04	282.69	284.25	N/A	– 10.21	– 1.56
10-33-802	227.89	246.88	256.49	257.20	– 29.31	– 10.32	– 0.71
10-33-902	224.40	242.17	249.58	251.89	– 27.49	– 9.72	– 2.31
10-34-102	236.39	253.00	259.77	261.02	– 24.63	– 8.02	– 1.25
10-34-202	N/A	289.88	293.14	294.88	N/A	– 5.00	– 1.74
10-34-302	234.72	248.57	253.34	256.77	– 22.05	– 8.20	– 3.43
10-34-403	N/A	309.54	313.42	315.05	N/A	– 5.51	– 1.63
10-34-404	303.97	319.70	323.33	325.20	– 21.23	– 5.50	– 1.87
10-34-602	N/A	289.47	N/A	N/A	N/A	N/A	N/A
10-34-801	233.01	250.72	257.36	258.70	– 25.69	– 7.98	– 1.34
10-34-802	261.13	276.40	282.31	283.52	– 22.39	– 7.12	– 1.21
10-35-304	233.06	244.77	250.51	252.25	– 19.19	– 7.48	– 1.74
10-35-401	264.95	283.25	291.59	293.81	– 28.86	– 10.56	– 2.22
10-35-501	255.59	269.02	274.29	273.75	– 18.16	– 4.73	+ 0.54
10-35-603	N/A	227.98	236.76	238.45	N/A	– 10.47	– 1.69
10-35-702	247.81	259.17	265.74	267.46	– 19.65	– 8.29	– 1.72
10-35-802	N/A	270.80	279.22	280.95	N/A	– 10.15	– 1.73
10-35-901	273.05	286.10	292.12	292.67	– 19.62	– 6.57	– 0.55
10-35-902	268.95	285.75	291.08	293.62	– 24.67	– 7.87	– 2.54
10-36-102	230.94	244.50	249.15	250.12	– 19.18	– 5.62	– 0.97
10-36-401	N/A	200.53	209.89	208.52	N/A	– 7.99	+ 1.37
10-36-602	N/A	N/A	246.35	246.85	N/A	N/A	– 0.50
10-36-702	N/A	235.73	245.20	246.10	N/A	– 10.37	– 0.90
10-36-801	214.06	229.43	237.20	239.03	– 24.97	– 9.60	– 1.83
10-41-209	210.25	228.40	231.43	235.05	– 24.80	– 6.65	– 3.62
10-41-301	198.68	216.45	222.58	226.69	– 28.01	– 10.24	– 4.11
10-41-403	N/A	200.56	205.53	207.81	N/A	– 7.25	– 2.28
10-42-104	N/A	N/A	212.10	215.79	N/A	N/A	– 3.69
10-42-202	221.78	237.57	242.52	244.61	– 22.83	– 7.04	– 2.09
10-42-302	N/A	N/A	210.60	212.24	N/A	N/A	– 1.64
10-42-506	176.70	192.18	199.00	202.30	– 25.60	– 10.12	– 3.30
10-43-203	217.29	232.22	240.12	242.32	– 25.03	– 10.10	– 2.20
10-44-102	211.37	229.20	234.77	236.70	– 25.33	– 7.50	– 1.93
10-44-202	223.19	239.69	244.63	N/A	N/A	N/A	N/A
10-44-203	N/A	239.30	247.66	249.92	N/A	– 10.62	– 2.26

NOTE: N/A Denotes data not available

10-53-803	N/A	72.94	77.71	80.02	N/A	– 7.08	– 2.31
10-54-205	134.71	147.19	151.63	152.25	– 17.54	– 5.06	– 0.62
10-54-301	192.68	N/A	211.35	211.41	– 18.73	N/A	– 0.06
10-54-404	N/A	120.93	125.17	125.64	N/A	– 4.71	– 0.47
10-54-502	126.95	137.98	141.23	142.16	– 15.21	– 4.18	– 0.93
10-54-701	N/A	102.11	114.12	116.83	N/A	– 14.72	– 2.71
10-54-801	83.81	98.71	113.02	117.32	– 33.51	– 18.61	– 4.30
10-55-203	198.88	215.63	219.36	219.67	– 20.79	– 4.04	– 0.31
10-55-301	222.36	234.35	237.83	239.25	– 16.89	– 4.90	– 1.42
10-55-404	201.08	207.55	N/A	N/A	N/A	N/A	N/A
10-55-701	101.40	114.44	119.62	120.42	– 19.02	– 5.98	– 0.80
10-55-802	108.86	125.95	132.48	135.76	– 26.90	– 9.81	– 3.28
10-55-902	172.59	194.00	198.41	199.87	– 27.28	– 5.87	– 1.46
10-55-904	170.84	181.77	185.91	185.99	– 15.15	– 4.22	– 0.08
10-56-102	229.08	242.06	245.28	245.20	– 16.12	– 3.14	+ 0.08
10-56-403	213.40	238.01	238.55	239.99	– 26.59	– 1.98	– 1.44
10-56-404	226.22	244.86	252.56	255.08	– 28.86	– 10.22	– 2.52
10-60-103	143.18	142.32	140.24	N/A	N/A	N/A	N/A
10-60-304	95.15	109.91	110.11	110.41	– 15.26	– 0.50	– 0.30
10-60-401	125.03	123.32	118.99	118.38	+ 6.65	+ 4.94	+ 0.61
10-60-604	N/A	96.49	92.71	91.62	N/A	+ 4.87	+ 1.09
10-60-904	134.86	133.99	N/A	N/A	N/A	N/A	N/A
10-61-101	95.68	113.96	117.74	118.05	– 22.37	– 4.09	– 0.31
10-61-105	N/A	93.40	96.03	98.57	N/A	– 5.17	– 2.54
10-61-201	69.17	79.31	85.24	86.59	– 17.42	– 7.28	– 1.35
10-61-402	153.22	163.78	168.21	169.77	– 16.55	– 5.99	– 1.56
10-61-602	111.98	127.19	136.42	139.33	– 27.35	– 12.14	– 2.91
10-61-701	142.05	150.71	148.64	149.34	– 7.29	+ 1.37	– 0.70
10-62-101	67.26	79.89	N/A	N/A	N/A	N/A	N/A
10-62-207	N/A	N/A	136.48	N/A	N/A	N/A	N/A
10-62-304	N/A	N/A	107.89	111.09	N/A	N/A	– 3.20
10-62-402	140.39	149.69	154.79	155.26	– 14.87	– 5.57	– 0.47
10-62-603	N/A	115.12	117.27	117.44	N/A	– 2.32	– 0.17
10-63-102	N/A	101.24	107.75	N/A	N/A	N/A	N/A
10-63-202	N/A	119.99	124.48	129.15	N/A	– 9.16	– 4.67
10-63-306	N/A	152.67	156.92	157.90	N/A	– 5.23	– 0.98
10-63-404	N/A	134.70	138.97	139.11	N/A	– 4.41	– 0.14
10-63-601	133.34	145.09	147.94	148.60	– 15.26	– 3.51	– 0.66
10-63-702	147.46	152.98	154.34	155.70	– 8.24	– 2.72	– 1.36
10-63-801	N/A	132.86	132.25	133.10	N/A	– 0.24	– 0.85
10-64-103	N/A	166.74	167.46	168.44	N/A	– 1.70	– 0.98
10-64-701	132.95	146.85	N/A	N/A	N/A	N/A	N/A
24-04-301	55.10	63.25	53.83	51.74	+ 3.36	+ 11.51	+ 2.09
24-05-102	N/A	55.06	52.02	51.47	N/A	+ 3.59	+ 0.55
24-05-303	130.39	145.13	150.80	153.10	– 22.71	– 7.97	– 2.30
24-05-502	74.73	71.84	67.99	67.28	+ 7.45	+ 4.56	+ 0.71
24-06-101	N/A	142.23	144.45	144.65	N/A	– 2.42	– 0.20
24-06-203	N/A	N/A	145.54	N/A	N/A	N/A	N/A
24-06-402	87.97	88.49	85.29	84.98	+ 2.99	+ 3.51	+ 0.31
24-06-507	N/A	82.53	80.85	80.51	N/A	+ 2.02	+ 0.34
24-06-604	142.90	151.30	149.39	149.07	– 6.17	+ 2.23	+ 0.32
24-06-902	100.91	102.35	101.49	100.99	– 0.08	+ 1.36	+ 0.50
24-07-101	N/A	143.97	144.08	144.21	N/A	– 0.24	– 0.13
24-07-202	160.50	164.34	N/A	N/A	N/A	N/A	N/A
24-07-301	139.27	141.05	140.80	140.31	– 1.04	+ 0.74	+ 0.49
24-07-602	N/A	147.28	149.22	N/A	N/A	N/A	N/A
24-07-701	145.00	146.98	147.05	147.58	– 2.58	– 0.60	– 0.53
24-07-901	124.98	128.03	127.65	127.21	– 2.23	+ 0.82	+ 0.44
24-08-402	N/A	158.05	157.81	157.53	N/A	+ 0.52	+ 0.28
24-08-701	139.08	144.60	146.06	145.76	– 6.68	– 1.16	+ 0.30
24-14-301	N/A	58.19	57.48	56.77	N/A	+ 1.42	+ 0.71
24-15-201	120.98	120.55	119.88	122.30	– 1.32	– 1.75	– 2.42
24-15-506	81.78	81.95	77.83	77.22	+ 4.56	+ 4.73	+ 0.61
24-15-609	137.31	138.36	135.41	135.03	+ 2.28	+ 3.33	+ 0.38
24-16-101	N/A	165.85	166.32	165.86	N/A	– 0.01	+ 0.46

NOTE: N/A Denotes data not available

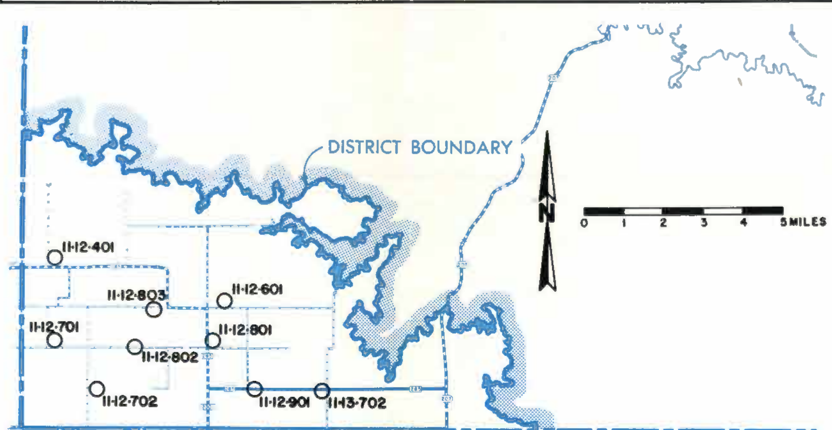
11-60-902	218.94	224.61	225.57	227.00	– 8.06	– 2.39	– 1.43
11-61-110	N/A	N/A	233.38	233.27	N/A	N/A	+ 0.11
11-61-204	219.01	228.50	224.85	224.95	– 5.94	+ 3.55	– 0.10
11-61-406	239.46	246.09	245.70	246.38	– 6.92	– 0.29	– 0.68
11-61-407	240.15	247.00	246.78	246.75	– 6.60	+ 0.25	+ 0.03
11-61-603	89.51	90.20	87.90	87.10	+ 2.41	+ 3.10	+ 0.80
11-61-801	238.93	248.47	248.28	251.20	– 12.27	– 2.73	– 2.92
11-61-901	230.91	243.18	246.04	248.00	– 17.09	– 4.82	– 1.96
11-62-201	145.37	145.02	142.54	141.40	+ 3.97	+ 3.62	+ 1.14
11-62-301	N/A	155.60	155.38	154.90	N/A	+ 0.70	+ 0.48
11-62-401	64.35	62.85	58.67	58.27	+ 6.08	+ 4.58	+ 0.40
11-62-601	151.09	150.94	149.20	149.24	+ 1.85	+ 1.70	– 0.04
11-62-602	156.96	156.15	156.08	155.92	+ 1.04	+ 0.23	+ 0.16
11-62-701	131.26	133.40	N/A	N/A	N/A	N/A	N/A
11-62-702	108.04	109.94	108.25	107.70	+ 0.34	+ 2.24	+ 0.55
11-62-801	118.06	115.35	105.47	104.41	+ 13.65	+ 10.94	+ 1.06
11-63-401	N/A	157.10	156.48	155.40	N/A	+ 1.70	+ 1.08
11-63-501	236.16	238.55	237.05	235.34	+ 0.82	+ 3.21	+ 1.71
11-63-801	211.42	213.07	212.73	213.28	– 1.86	– 0.21	– 0.55
11-63-901	N/A	248.85	249.15	249.40	N/A	– 0.55	– 0.25
11-64-101	246.77	249.72	250.23	249.90	– 3.13	– 0.18	+ 0.33
11-64-403	N/A	N/A	251.94	252.01	N/A	N/A	– 0.07
11-64-803	N/A	267.09	267.60	267.75	N/A	– 0.66	– 0.15
23-04-301	N/A	209.40	211.13	214.30	N/A	– 4.90	– 3.17
23-04-504	N/A	214.73	215.75	220.56	N/A	– 5.83	– 4.81
23-04-602	212.49	221.64	222.38	239.10	– 26.61	– 17.46	– 16.72
23-04-603	211.05	219.66	221.85	228.18	– 17.13	– 8.52	– 6.33
23-04-802	202.75	212.71	214.39	217.35	– 14.60	– 4.64	– 2.96
23-05-202	223.95	238.60	242.40	246.75	– 22.80	– 8.15	– 4.35
23-05-301	N/A	N/A	250.48	251.34	N/A	N/A	– 0.86
23-05-502	N/A	242.62	246.59	252.43	N/A	– 9.81	– 5.84
23-05-602	249.16	267.45	261.01	261.32	– 12.16	+ 6.13	– 0.31
23-05-603	N/A	265.41	265.80	266.64	N/A	– 1.23	– 0.84
23-05-701	N/A	224.92	225.35	229.26	N/A	– 4.34	– 3.91
23-05-802	233.24	240.68	240.34	N/A	N/A	N/A	N/A
23-06-302	193.56	194.56	193.48	192.43	+ 1.13	+ 2.13	+ 1.05
23-06-502	261.56	265.10	261.36	263.05	– 1.49	+ 2.05	– 1.69
23-06-503	N/A	286.30	284.42	284.34	N/A	+ 1.96	+ 0.08
23-06-601	N/A	281.08	277.32	277.62	N/A	+ 3.46	– 0.30
23-06-704	N/A	263.67	261.56	262.37	N/A	+ 1.30	– 0.81
23-07-103	262.42	261.05	268.12	267.05	– 4.63	– 6.00	+ 1.07
23-07-202	N/A	288.00	286.59	287.70	N/A	+ 0.30	– 1.11
23-07-401	295.11	295.98	294.59	294.85	+ 0.26	+ 1.13	– 0.26
23-07-501	296.83	297.25	295.31	295.44	+ 1.39	+ 1.81	– 0.13
23-07-503	N/A	N/A	292.14	293.30	N/A	N/A	– 1.16
23-07-601	301.91	302.45	301.47	302.07	– 0.16	+ 0.38	– 0.60
23-07-702	N/A	211.70	214.77	215.26	N/A	– 3.56	– 0.49
23-07-801	N/A	N/A	N/A	N/A	N/A	N/A	N/A
23-07-901	N/A	285.00	284.03	287.17	N/A	– 2.17	– 3.14
23-08-201	272.15	275.64	277.44	279.60	– 7.45	– 3.96	– 2.16
23-08-401	291.31	292.99	292.68	N/A	N/A	N/A	N/A
23-08-502	277.94	277.85	278.39	279.58	– 1.64	– 1.73	– 1.19
23-08-701	286.40	289.00	289.90	290.74	– 4.34	– 1.74	– 0.84
23-12-301	213.09	218.35	219.46	220.53	– 7.44	– 2.18	– 1.07
23-13-101	206.19	211.44	212.74	214.76	– 8.57	– 3.32	– 2.02
23-13-302	249.45	258.30	254.64	260.35	– 10.90	– 2.05	– 5.71
23-13-303	N/A	240.07	237.89	N/A	N/A	N/A	N/A
23-14-101	262.55	265.19	262.03	263.53	– 0.98	+ 1.66	– 1.50
23-14-301	245.47	253.85	253.75	254.72	– 9.25	– 0.87	– 0.97
23-15-203	N/A	N/A	N/A	N/A	N/A	N/A	N/A
23-15-302	N/A	308.90	305.50	308.62	N/A	+ 0.28	– 3.12
23-16-101	318.71	319.55	319.18	320.12	– 1.41	– 0.57	– 0.94
23-16-202	N/A	N/A	304.18	308.16	N/A	N/A	– 3.98

NOTE: N/A Denotes data not available

ARMSTRONG COUNTY

Well Number	Depth to Water Below Land Surface In Feet				Total Change In Water Levels In Feet		
	1979	1984	1988	1989	1979 to 1989	1984 to 1989	1988 to 1989
11-12-401	126.37	129.52	131.05	130.88	– 4.51	– 1.36	+ 0.17
11-12-601	117.78	120.78	120.19	119.89	– 2.11	+ 0.89	+ 0.30
11-12-701	145.30	148.11	146.80	145.91	– 0.61	+ 2.20	+ 0.89
11-12-702	155.30	157.07	154.49	153.35	+ 1.95	+ 3.72	+ 1.14
11-12-801	150.38	151.53	150.01	149.29	+ 1.09	+ 2.24	+ 0.72
11-12-802	160.17	162.04	161.12	161.03	– 0.86	+ 1.01	+ 0.09
11-12-803	139.02	145.51	145.75	144.87	– 5.85	+ 0.64	+ 0.88
11-12-901	132.18	135.34	134.89	134.37	– 2.19	+ 0.97	+ 0.52
11-13-702	N/A	124.88	119.60	120.13	N/A	+ 4.75	– 0.53

NOTE: N/A Denotes data not available



THE Cross SECTION

THE CROSS SECTION (USPS 564-920)

A MONTHLY PUBLICATION OF THE HIGH PLAINS UNDERGROUND WATER CONSERVATION DISTRICT NO. 1

Second Class Postage Paid at Lubbock, Texas
District Office at Lubbock

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CARMON McCAIN, Editor
DIRECTOR, INFORMATION/EDUCATION

10-43-707	107.17	117.80	117.44	116.96	– 9.79	+ 0.84	+ 0.48
10-43-807	N/A	116.84	117.43	117.98	N/A	– 1.14	– 0.55
10-43-903	124.89	137.56	141.95	141.52	– 16.63	– 3.96	+ 0.43
10-43-905	112.00	126.58	127.23	128.33	– 16.33	– 1.75	– 1.10
10-49-104	N/A	N/A	94.92	96.63	N/A	N/A	– 1.71
10-49-303	62.57	81.20	86.67	N/A	N/A	N/A	N/A
10-49-501	N/A	55.35	57.78	58.82	N/A	– 3.47	– 1.04
10-49-602	69.57	86.67	98.17	99.21	– 29.64	– 12.54	– 1.04
10-49-603	N/A	68.27	70.52	71.70	N/A	– 3.43	– 1.18
10-49-801	80.96	84.40	83.18	84.45	– 3.49	– 0.05	– 1.27
10-49-803	N/A	107.29	104.63	104.49	N/A	+ 2.80	+ 0.14
10-50-104	N/A	119.84	123.10	120.42	N/A	– 0.58	+ 2.68
10-50-508	N/A	N/A	113.49	N/A	N/A	N/A	N/A
10-50-602	N/A	82.94	81.04	81.80	N/A	+ 1.14	– 0.76
10-50-703	N/A	N/A	104.50	104.31	N/A	N/A	+ 0.19
10-50-801	68.54	68.75	65.25	63.75	+ 4.79	+ 5.00	+ 1.50
10-50-901	N/A	74.69	78.00	78.60	N/A	– 3.91	– 0.60
10-51-105	83.05	91.38	89.55	N/A	N/A	N/A	N/A
10-51-119	N/A	N/A	73.88	73.00	N/A	N/A	+ 0.88
10-51-311	N/A	104.14	105.23	102.89	N/A	+ 1.25	+ 2.34
10-51-403	65.07	72.94	73.88	75.68	– 10.61	– 2.74	– 1.80
10-51-406	N/A	71.20	N/A	N/A	N/A	N/A	N/A
10-51-501	70.68	87.20	85.10	84.87	– 14.19	+ 2.33	+ 0.23
10-51-507	N/A	85.63	85.88	N/A	N/A	N/A	N/A
10-51-602	79.39	95.80	97.25	N/A	N/A	N/A	N/A
10-51-609	N/A	N/A	113.25	113.55	N/A	N/A	– 0.30
10-51-703	100.03	103.65	102.45	100.99	– 0.96	+ 2.66	+ 1.46
10-51-704	N/A	N/A	86.32	86.51	N/A	N/A	– 0.19
10-51-808	N/A	N/A	103.35	100.90	N/A	N/A	+ 2.45
10-51-908	N/A	N/A	116.19	116.52	N/A	N/A	– 0.33
10-51-909	N/A	N/A	123.28	120.99	N/A	N/A	+ 2.29
10-51-910	N/A	N/A	117.52	117.67	N/A	N/A	– 0.15
10-51-911	N/A	N/A	126.88	126.67	N/A	N/A	+ 0.21
10-52-408	94.69	N/A	103.42	N/A	N/A	N/A	N/A
10-57-103	80.15	83.47	82.55	83.98	– 3.83	– 0.51	– 1.43
10-57-401	110.52	111.26	112.00	110.91	– 0.39	+ 0.35	+ 1.09
10-57-501	37.59	40.42	40.93	38.60	– 1.01	+ 1.82	+ 2.33
10-58-201	N/A	32.17	26.70	24.50	N/A	+ 7.67	+ 2.20
10-58-502	68.72	N/A	60.43	60.40	+ 8.32	N/A	+ 0.03
10-58-601	N/A	75.75	71.50	70.80	N/A	+ 4.95	+ 0.70
10-58-701	46.92	45.77	43.70	42.96	+ 3.96	+ 2.81	+ 0.74
10-58-801	24.00	27.08	17.95	17.37	+ 6.63	+ 9.71	+ 0.58
10-59-106	111.29	114.47	112.52	112.63	– 1.34	+ 1.84	– 0.11
10-59-107	98.25	102.55	100.35	100.30	– 2.05	+ 2.25	+ 0.05
10-59-302	112.83	112.83	111.39	111.01	+ 1.82	+ 1.82	+ 0.38
10-59-401	116.31	117.72	115.22	114.54	+ 1.77	+ 3.18	+ 0.68
10-59-402	N/A	N/A	126.90	126.97	N/A	N/A	– 0.07
10-59-501	96.19	95.61	92.99	94.30	+ 1.89	+ 1.31	– 1.31
10-59-601	134.24	132.65	127.57	124.25	+ 9.99	+ 8.40	+ 3.32
24-02-701	51.84	49.15	45.62	44.11	+ 7.73	+ 5.04	+ 1.51
24-02-702	N/A	N/A	50.72	49.90	N/A	N/A	+ 0.82
24-09-101	N/A	165.50	160.82	160.65	N/A	+ 4.85	+ 0.17
24-09-103	N/A	N/A	165.67	163.38	N/A	N/A	+ 2.29
24-09-302	N/A	86.52	85.28	84.53	N/A	+ 1.99	+ 0.75
24-10-201	116.15	113.79	108.71	105.48	+ 10.67	+ 8.31	+ 3.23
24-10-303	142.23	123.62	108.00	105.31	+ 36.92	+ 18.31	+ 2.69
24-11-201	103.05	96.32	90.32	92.68	+ 10.37	+ 3.64	– 2.36
24-11-202	N/A	85.25	83.52	83.10	N/A	+ 2.15	+ 0.42

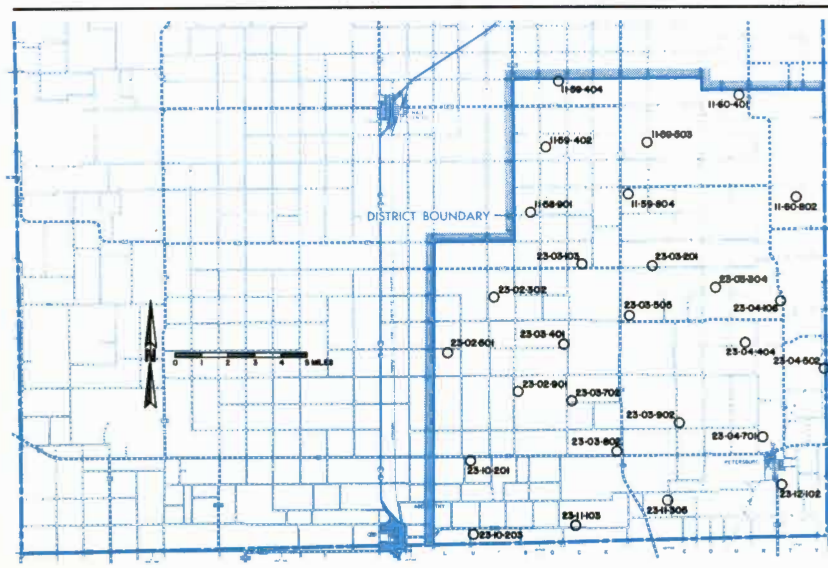
NOTE: N/A Denotes data not available

10-30-301	N/A	175.21	169.20	170.95	N/A	+ 4.26	– 1.75
10-30-401	277.44	290.02	293.05	292.68	– 15.24	– 2.66	+ 0.37
10-30-505	239.29	245.64	248.35	248.50	– 9.21	– 2.86	– 0.15
10-30-603	216.27	220.24	217.53	219.17	– 2.90	+ 1.07	– 1.64
10-30-604	268.91	277.29	276.73	275.56	– 6.65	+ 1.73	+ 1.17
10-30-701	N/A	251.87	256.55	N/A	N/A	N/A	N/A
10-30-802	227.98	248.61	255.88	254.65	– 26.67	– 6.04	+ 1.23
10-31-201	189.38	195.82	196.77	198.30	– 8.92	– 2.48	– 1.53
10-31-301	186.90	188.59	188.33	N/A	N/A	N/A	N/A
10-31-501	223.78	227.13	228.91	229.20	– 5.42	– 2.07	– 0.29
10-31-601	178.37	189.32	193.35	194.43	– 16.06	– 5.11	– 1.08
10-31-701	266.04	263.95	263.20	263.45	+ 2.59	+ 0.50	– 0.25
10-31-803	N/A	266.54	272.95	275.40	N/A	– 8.86	– 2.45
10-32-201	177.74	178.39	178.45	177.11	+ 0.63	+ 1.28	+ 1.34
10-32-301	N/A	178.54	175.16	174.10	N/A	+ 4.44	+ 1.06
10-32-501	141.19	144.14	145.70	146.02	– 4.83	– 1.88	– 0.32
10-32-601	N/A	131.39	133.89	134.34	N/A	– 2.95	– 0.45
10-32-703	257.23	268.75	269.60	271.96	– 14.73	– 3.21	– 2.36
10-32-801	217.82	218.18	217.73	218.82	– 1.00	– 0.64	– 1.09
10-36-301	N/A	226.30	230.40	233.67	N/A	– 7.37	– 3.27
10-37-301	N/A	210.82	217.40	222.22	N/A	– 11.40	– 4.82
10-37-403	N/A	N/A	207.98	210.80	N/A	N/A	– 2.82
10-37-501	N/A	200.50	206.41	207.06	N/A	– 6.56	– 0.65
10-37-601	176.20	191.80	198.50	202.88	– 26.68	– 11.08	– 4.38
10-37-801	N/A	188.83	195.66	200.40	N/A	– 11.57	– 4.74
10-37-901	172.14	188.63	195.47	198.05	– 25.91	– 9.42	– 2.58
10-38-101	196.28	209.43	214.70	217.92	– 21.64	– 8.49	– 3.22
10-38-201	N/A	204.40	208.72	212.89	N/A	– 8.49	– 4.17
10-38-401	190.29	203.84	209.88	212.10	– 21.81	– 8.26	– 2.22
10-38-603	176.62	199.50	199.74	200.62	– 24.00	– 1.12	– 0.88
10-38-802	181.59	199.63	203.21	204.98	– 23.39	– 5.35	– 1.77
10-39-101	223.69	241.28	246.92	249.85	– 26.16	– 8.57	– 2.93
10-39-201	N/A	264.44	269.31	272.95	N/A	– 8.51	– 3.64
10-39-302	253.13	271.90	285.10	286.10	– 32.97	– 14.20	– 1.00
10-39-402	N/A	N/A	219.99	221.14	N/A	N/A	– 1.15
10-39-501	203.69	220.72	220.15	221.51	– 17.82	– 0.79	– 1.36
10-39-702	168.88	183.36	189.52	192.78	– 23.90	– 9.42	– 3.26
10-39-801	184.03	198.61	202.20	202.75	– 18.72	– 4.14	– 0.55
10-39-901	N/A	193.56	199.61	203.40	N/A	– 9.84	– 3.79
10-40-301	N/A	N/A	173.96	174.94	N/A	N/A	– 0.98
10-40-402	N/A	228.38	232.09	233.65	N/A	– 5.27	– 1.56
10-40-502	237.27	256.65	261.38	265.50	– 28.23	– 8.85	– 4.12
10-40-601	N/A	237.83	245.38	246.54	N/A	– 8.71	– 1.16
10-40-803	211.89	231.72	235.54	238.50	– 26.61	– 6.78	– 2.96
10-44-601	N/A	198.30	204.66	N/A	N/A	N/A	N/A
10-45-102	186.25	202.90	208.95	210.50	– 24.25	– 7.60	– 1.55
10-45-301	193.94	211.47	216.95	219.65	– 25.71	– 8.18	– 2.70
10-46-101	172.53	194.13	193.75	N/A	N/A	N/A	N/A
10-46-302	163.69	179.64	187.55	189.71	– 26.02	– 10.07	– 2.16
10-46-303	N/A	N/A	195.04	195.63	N/A	N/A	– 0.59
10-46-405	194.29	207.52	N/A	N/A	N/A	N/A	N/A
10-47-101	158.84	179.47	184.18	186.37	– 27.53	– 6.90	– 2.19
10-47-201	195.83	210.37	214.70	217.10	– 21.27	– 6.73	– 2.40
10-47-302	180.51	196.62	200.36	202.95	– 22.44	– 6.33	– 2.59
10-48-103	N/A	N/A	200.07	202.26	N/A	N/A	– 2.19
10-48-302	N/A	194.40	199.04	201.32	N/A	– 6.92	– 2.28
10-48-303	N/A	214.56	216.03	217.88	N/A	– 3.32	– 1.85
10-48-603	178.73	199.29	202.82	205.70	– 26.97	– 6.41	– 2.88

NOTE: N/A Denotes data not available

24-22-201	73.74	75.65	70.16	70.15	+ 3.59	+ 5.50	+ 0.01
24-22-202	85.30	84.65	82.82	82.09	+ 3.21	+ 2.56	+ 0.73
24-22-402	N/A	N/A	65.39	65.01	N/A	N/A	+ 0.38
24-22-601	103.06	100.02	97.70	96.99	+ 6.07	+ 3.03	+ 0.71
24-22-701	180.38	177.32	173.90	173.47	+ 6.91	+ 3.85	+ 0.43
24-22-802	125.53	118.18	111.67	111.97	+ 13.56	+ 6.21	– 0.30
24-23-102	N/A	112.79	111.62	111.55	N/A	+ 1.24	+ 0.07
24-23-302	117.53	117.74	118.69	117.48	+ 0.05	+ 0.26	+ 1.21
24-23-304	N/A	127.00	125.30	125.00	N/A	+ 2.00	+ 0.30
24-23-501	108.67	107.59	105.46	105.53	+ 3.14	+ 2.06	– 0.07
24-23-701	108.36	108.70	107.53	107.57	+ 0.79	+ 1.13	– 0.04
24-24-402	159.16	156.17	153.05	149.74	+ 9.42	+ 6.43	+ 3.31
24-24-703	N/A	N/A	121.10	120.30	N/A	N/A	+ 0.80
24-28-103	143.87	143.32	133.99	131.76	+ 12.11	+ 11.56	+ 2.23
24-28-203	N/A	144.82	146.50	144.93	N/A	– 0.11	+ 1.57
24-28-303	N/A	N/A	122.24	122.28	N/A	N/A	– 0.04
24-28-501	154.32	155.95	152.51	151.43	+ 2.89	+ 4.52	+ 1.08
24-28-601	N/A	138.74	137.50	135.74	N/A	+ 3.00	+ 1.76
24-28-901	169.27	169.38	165.83	164.03	+ 5.24	+ 5.35	+ 1.80
24-29-308	152.67	153.55	150.24	148.29	+ 4.38	+ 5.26	+ 1.95
24-29-312	N/A	139.32	139.07	138.01	N/A	+ 1.31	+ 1.06
24-29-401	142.54	142.05	138.84	137.75	+ 4.79	+ 4.30	+ 1.09
24-29-603	N/A	134.14	134.74	131.48	N/A	+ 2.66	+ 3.26
24-29-901	193.54	188.97	183.70	181.99	+ 11.55	+ 6.98	+ 1.71
24-30-102	141.09	136.37	131.75	130.28	+ 10.81	+ 6.09	+ 1.47
24-30-304	110.38	109.24	107.35	106.23	+ 4.15	+ 3.01	+ 1.12
24-30-409	N/A	N/A	102.85	N/A	N/A	N/A	N/A
24-30-502	N/A	132.33	125.58	123.60	N/A	+ 8.73	+ 1.98
24-30-801	179.23	179.30	177.35	176.76	+ 2.47	+ 2.54	+ 0.59
24-30-901	160.65	157.28	154.83	154.32	+ 6.33	+ 2.96	+ 0.51
24-31-101	N/A	69.09	67.90	68.02	N/A	+ 1.07	– 0.12
24-31-304	N/A	N/A	104.21	103.20	N/A	N/A	+ 1.01
24-31-401	138.09	128.83	124.54	123.21	+ 14.88	+ 5.62	+ 1.33
24-31-501	79.66	77.57	71.55	70.31	+ 9.35	+ 7.26	+ 1.24
24-31-601	118.78	114.13	109.68	108.99	+ 9.79	+ 5.14	+ 0.69
24-31-801	149.67	149.02	147.81	147.24	+ 2.43	+ 1.78	+ 0.57
24-31-902	N/A	124.38	121.38	119.96	N/A	+ 4.42	+ 1.42
24-32-401	106.43	100.12	97.90	96.60	+ 9.83	+ 3.52	+ 1.30
24-32-702	N/A	N/A	126.01	125.60	N/A	N/A	+ 0.41
24-36-302	N/A	174.25	172.43	171.79	N/A	+ 2.46	+ 0.64
24-36-601	149.57	147.93	147.25	146.48	+ 3.09	+ 1.45	+ 0.77
24-37-101	155.16	157.06	156.28	154.41	+ 0.75	+ 2.65	+ 1.87
24-37-204	155.25	154.91	151.85	149.94	+ 5.31	+ 4.97	+ 1.91
24-37-308	147.16	148.15	146.29	145.61	+ 1.55	+ 2.54	+ 0.68
24-37-502	N/A	N/A	142.34	139.63	N/A	N/A	+ 2.71
24-38-201	177.09	175.63	174.30	172.98	+ 4.11	+ 2.65	+ 1.32
24-38-403	165.78	167.43	164.70	163.49	+ 2.29	+ 3.94	+ 1.21
24-38-501	N/A	N/A	159.52	158.30	N/A	N/A	+ 1.22
24-38-602	N/A	119.71	118.65	115.76	N/A	+ 3.95	+ 2.89
24-38-801	163.99	159.31	153.88	151.11	+ 12.88	+ 8.20	+ 2.77
24-39-101	157.49	151.33	147.63	147.32	+ 10.17	+ 4.01	+ 0.31
24-39-302	151.25	148.49	147.51	145.55	+ 5.70	+ 2.94	+ 1.96
24-39-501	135.84	134.04	132.10	131.50	+ 4.34	+ 2.54	+ 0.60
24-39-701	118.99	105.15	99.28	99.62	+ 19.37	+ 5.53	– 0.34
24-39-901	97.56	96.07	91.40	91.75	+ 5.81	+ 4.32	– 0.35
24-40-401	145.72	145.84	143.90	143.91	+ 1.81	+ 1.93	– 0.01
24-40-403	151.64	148.96	146.80	146.11	+ 5.53	+ 2.85	+ 0.69
24-40-702	N/A	113.16	110.10	109.06	N/A	+ 4.10	+ 1.04

NOTE: N/A Denotes data not available

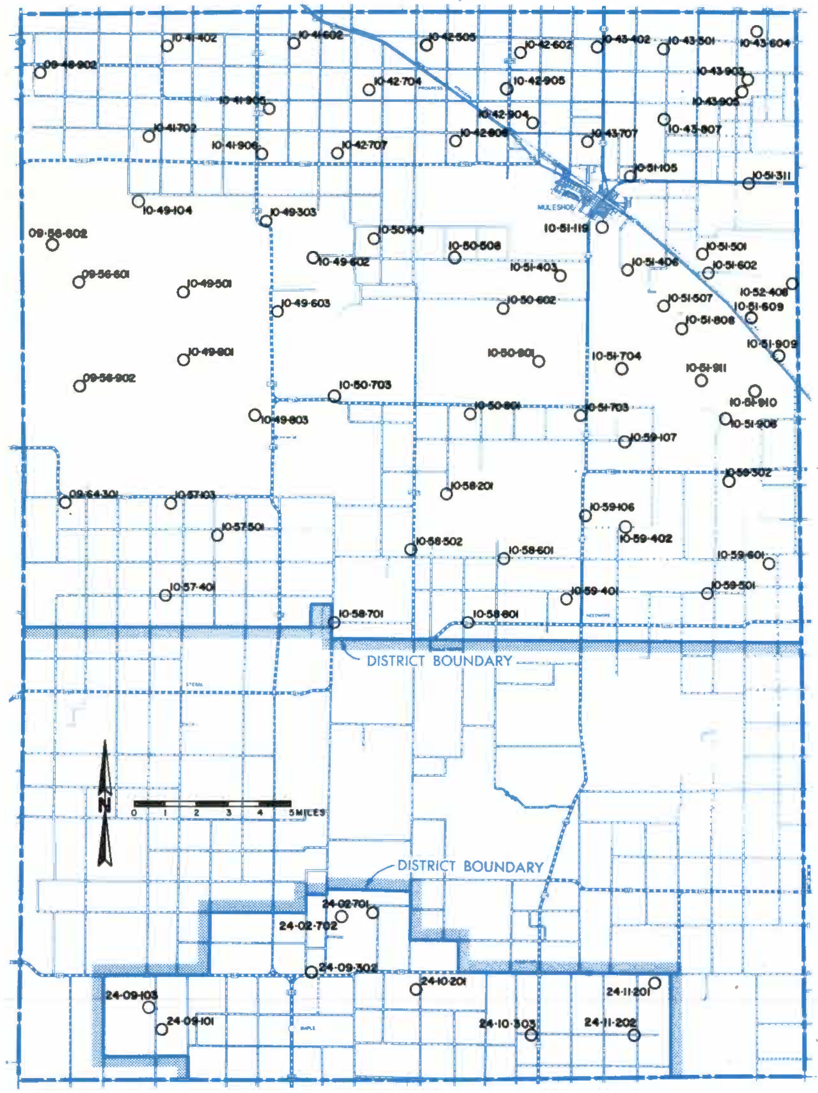


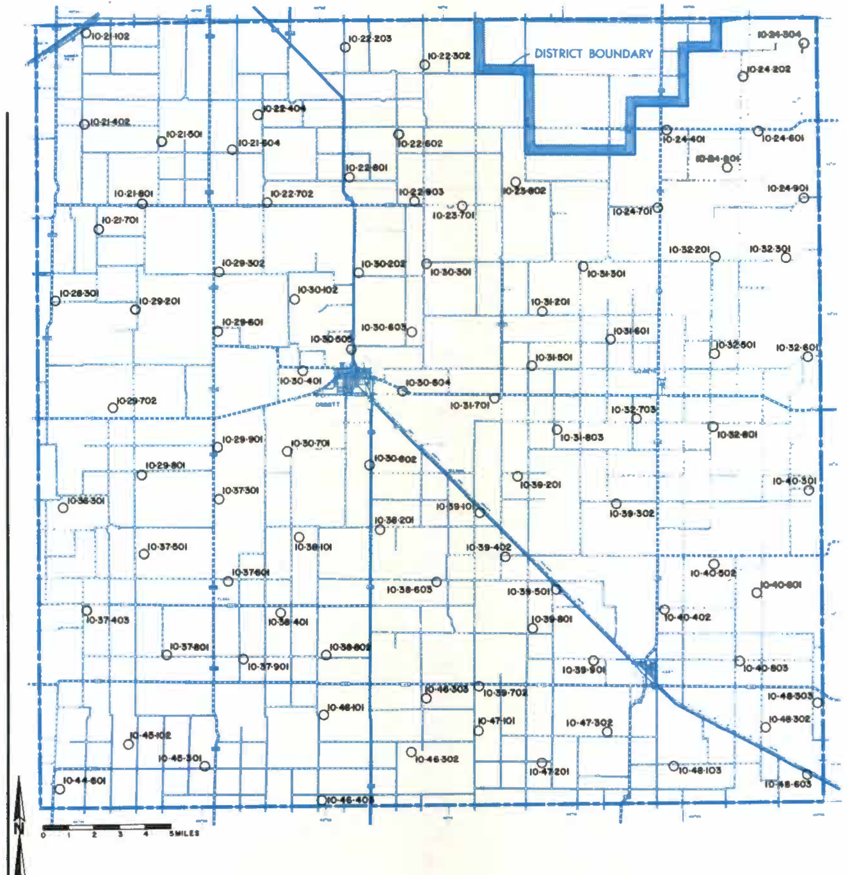
HALE COUNTY

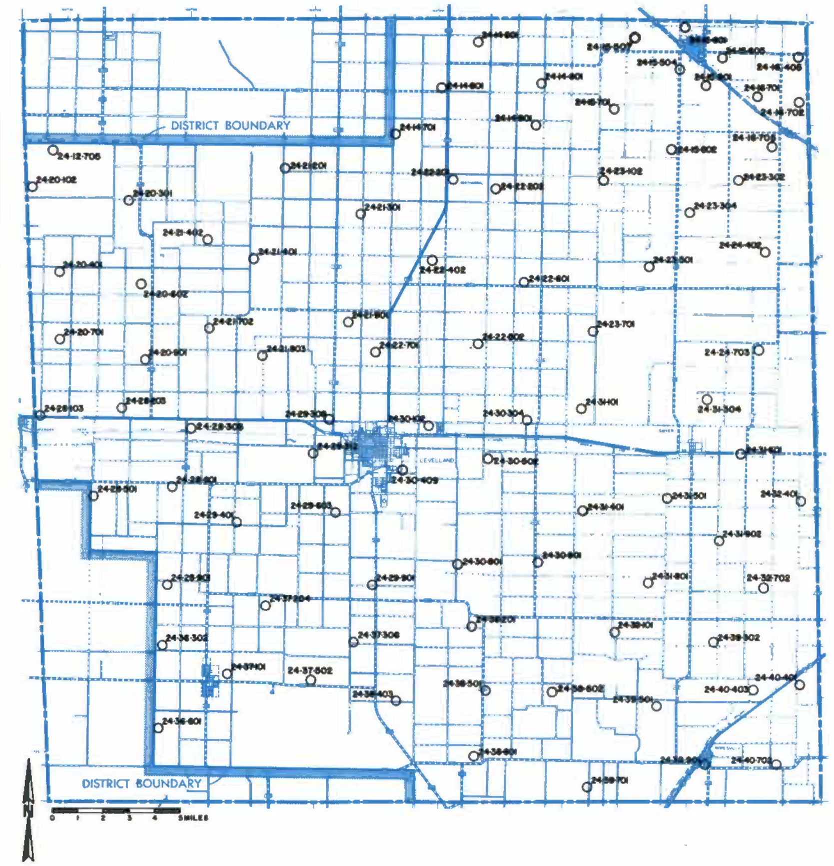
Well Number	Depth to Water Below Land Surface In Feet 1979	1984	1988	1989	Total Change In Water Levels In Feet 1979 to 1989	1984 to 1989	1988 to 1989
11-58-901	N/A	100.98	97.50	99.62	N/A	+ 1.36	– 2.12
11-59-402	93.32	90.87	75.65	N/A	N/A	N/A	N/A
11-59-404	N/A	193.70	196.00	197.76	N/A	– 4.06	– 1.76
11-59-503	86.14	88.02	79.52	82.71	+ 3.43	+ 5.31	– 3.19
11-59-804	N/A	105.50	92.43	92.55	N/A	+ 12.95	– 0.12
11-60-401	95.28	98.79	100.82	100.28	– 5.00	– 1.49	+ 0.54
11-60-802	N/A	183.44	177.18	178.76	N/A	+ 4.68	– 1.58
23-02-302	111.14	114.61	111.05	111.10	+ 0.04	+ 3.51	– 0.05
23-02-501	193.94	207.98	204.77	205.75	– 11.81	+ 2.23	– 0.98
23-02-901	N/A	192.38	189.25	190.83	N/A	+ 1.55	– 1.58
23-03-103	116.79	118.29	110.40	110.90	+ 5.89	+ 7.39	– 0.50
23-03-201	N/A	135.45	129.50	129.53	N/A	+ 5.92	– 0.03
23-03-304	N/A	137.07	130.89	130.29	N/A	+ 6.78	+ 0.60
23-03-401	N/A	109.30	105.43	105.54	N/A	+ 3.76	– 0.11

Well Number	Depth to Water Below Land Surface In Feet 1979	1984	1988	1989	Total Change In Water Levels In Feet 1979 to 1989	1984 to 1989	1988 to 1989
23-03-505	N/A	126.82	111.90	111.82	N/A	+ 15.00	+ 0.08
23-03-702	N/A	189.65	181.18	189.59	N/A	+ 0.06	– 8.41
23-03-802	192.31	203.13	205.45	208.64	– 16.33	– 5.51	– 3.19
23-03-902	N/A	187.58	186.44	189.33	N/A	– 1.75	– 2.89
23-04-106	N/A	210.05	207.68	209.27	N/A	+ 0.78	– 1.59
23-04-404	N/A	N/A	128.08	129.70	N/A	N/A	– 1.62
23-04-502	208.09	217.24	217.31	220.07	– 11.98	– 2.83	– 2.76
23-04-701	158.94	163.65	161.67	162.18	– 3.24	+ 1.47	– 0.51
23-10-201	N/A	168.95	155.73	155.59	N/A	+ 13.36	+ 0.14
23-10-203	N/A	172.25	166.95	167.08	N/A	+ 5.17	– 0.13
23-11-103	N/A	215.64	216.20	216.40	N/A	– 0.76	– 0.20
23-11-305	N/A	N/A	180.27	184.77	N/A	N/A	– 4.50
23-12-102	197.84	205.32	205.80	207.77	– 9.93	– 2.45	– 1.97

NOTE: N/A Denotes data not available







BAILEY COUNTY

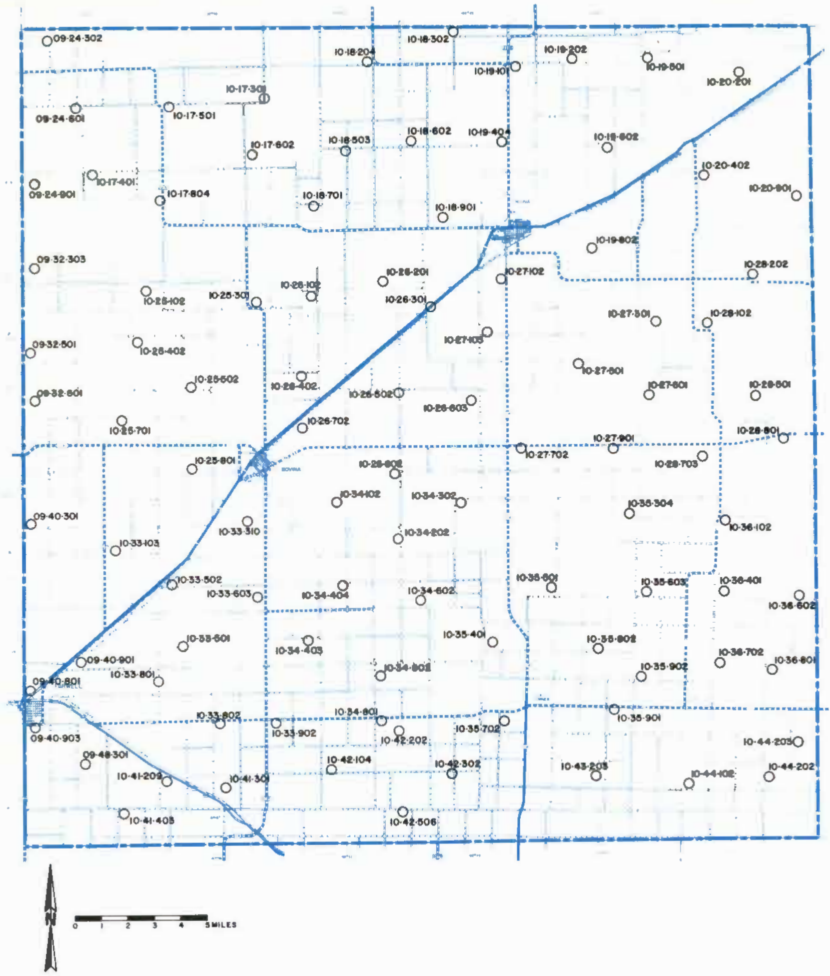
Well Number	Depth to Water Below Land Surface In Feet 1979	1984	1988	1989	Total Change In Water Levels In Feet 1979 to 1989	1984 to 1989	1988 to 1989
09-48-902	155.04	165.93	172.35	172.54	− 17.50	− 6.61	− 0.19
09-56-601	N/A	44.95	45.99	46.78	N/A	− 1.83	− 0.79
09-56-602	N/A	N/A	67.15	68.60	N/A	N/A	− 1.45
09-56-902	43.25	45.82	48.13	48.71	− 5.46	− 2.89	− 0.58
09-64-301	69.49	72.89	62.23	59.12	+ 10.37	+ 13.77	+ 3.11
10-41-402	167.94	176.82	178.11	178.60	− 10.66	− 1.78	− 0.49
10-41-602	N/A	N/A	173.22	173.55	N/A	N/A	− 0.33
10-41-702	113.85	122.38	124.95	125.15	− 11.30	− 2.77	− 0.20
10-41-905	126.89	138.75	135.20	136.53	− 9.64	+ 2.22	− 1.33
10-41-906	99.11	109.17	113.04	115.00	− 15.89	− 5.83	− 1.96
10-42-505	140.37	155.40	161.95	163.89	− 23.52	− 8.49	− 1.94
10-42-602	N/A	150.52	N/A	N/A	N/A	N/A	N/A
10-42-704	128.55	138.52	141.54	143.20	− 14.65	− 4.68	− 1.66
10-42-707	105.76	117.53	115.69	115.50	− 9.74	+ 2.03	+ 0.19
10-42-808	100.20	105.64	108.95	109.83	− 9.63	− 4.19	− 0.88
10-42-904	104.97	114.80	117.32	116.90	− 11.93	− 2.10	+ 0.42
10-42-905	N/A	N/A	128.70	130.25	N/A	N/A	− 1.55
10-43-402	142.26	157.79	162.48	164.90	− 22.64	− 7.11	− 2.42
10-43-501	N/A	149.01	156.72	155.60	N/A	− 6.59	+ 1.12
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

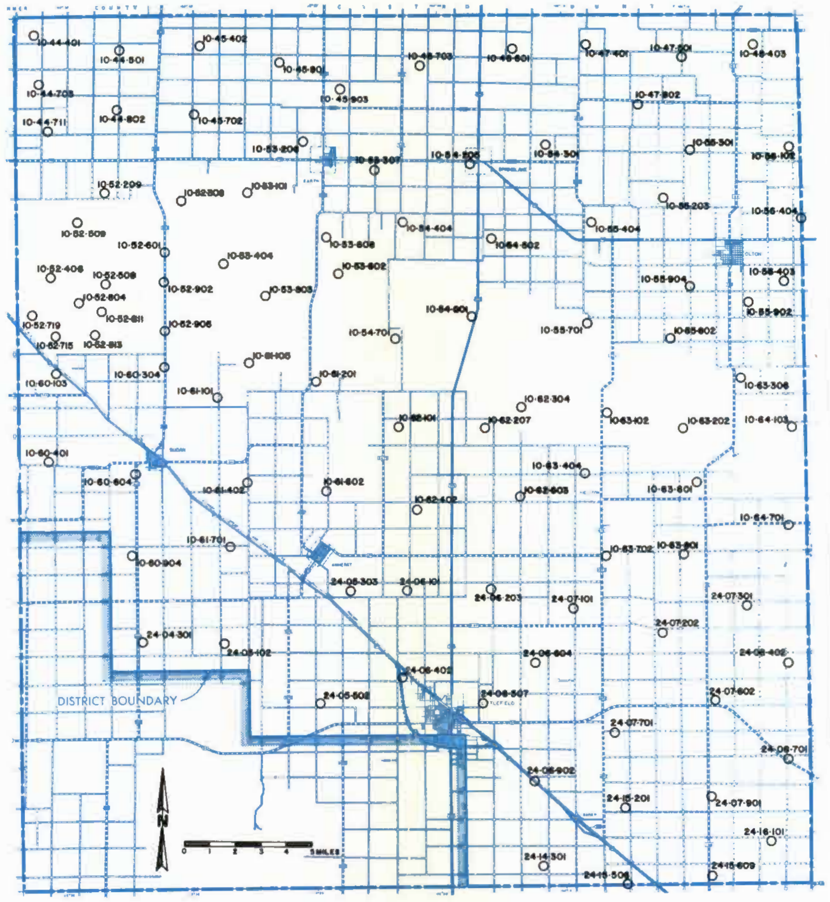
CASTRO COUNTY

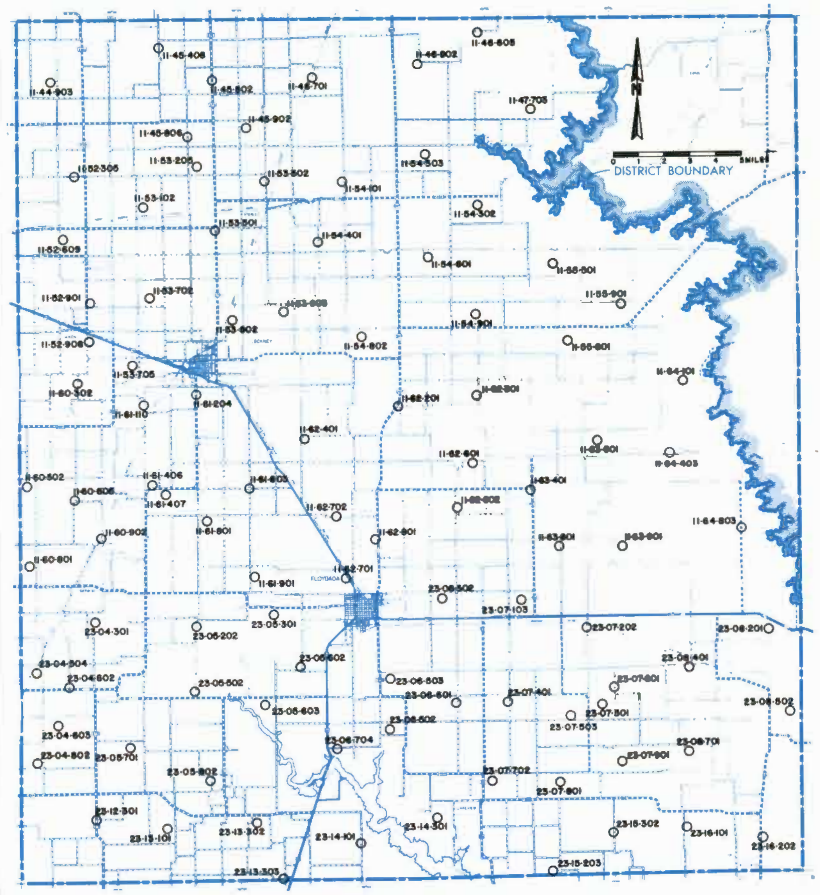
Well Number	Depth to Water Below Land Surface In Feet 1979	1984	1988	1989	Total Change In Water Levels In Feet 1979 to 1989	1984 to 1989	1988 to 1989
10-21-102	N/A	237.02	236.10	237.74	N/A	− 0.72	− 1.64
10-21-402	185.76	203.65	208.88	207.69	− 21.93	− 4.04	+ 1.19
10-21-501	172.51	187.00	189.05	188.71	− 16.20	− 1.71	+ 0.34
10-21-604	155.22	165.43	165.85	166.59	− 11.37	− 1.16	− 0.74
10-21-701	236.17	244.76	240.95	243.71	− 7.54	+ 1.05	− 2.76
10-21-801	226.91	238.24	241.07	242.47	− 15.56	− 4.23	− 1.40
10-22-203	178.51	191.69	189.38	192.74	− 14.23	− 1.05	− 3.36
10-22-302	106.54	108.46	105.73	105.37	+ 1.17	+ 3.09	+ 0.36
10-22-404	N/A	N/A	189.60	194.14	N/A	N/A	− 4.54
10-22-602	83.92	84.70	84.46	83.83	+ 0.09	+ 0.87	+ 0.63
10-22-702	181.09	195.81	197.15	203.94	− 22.85	− 8.13	− 6.79
10-22-801	173.00	179.99	183.49	182.31	− 9.31	− 2.32	+ 1.18
10-22-903	151.68	154.24	151.75	151.21	+ 0.47	+ 3.03	+ 0.54
10-23-701	116.81	116.70	109.63	108.87	+ 7.94	+ 7.83	+ 0.76
10-23-802	N/A	139.10	140.20	140.50	N/A	− 1.40	− 0.30
10-24-202	176.50	177.10	178.20	N/A	N/A	N/A	N/A
10-24-304	N/A	165.17	165.56	N/A	N/A	N/A	N/A
10-24-401	192.18	191.78	190.92	190.81	+ 1.37	+ 0.97	+ 0.11
10-24-601	162.42	161.54	161.26	161.90	+ 0.52	− 0.36	− 0.64
10-24-701	191.12	189.21	187.80	187.47	+ 3.65	+ 1.74	+ 0.33
10-24-801	186.73	185.93	184.75	184.30	+ 2.43	+ 1.63	+ 0.45
10-24-901	N/A	199.48	195.97	194.56	N/A	+ 4.92	+ 1.41
10-28-301	295.84	308.13	312.93	313.46	− 17.62	− 5.33	− 0.53
10-29-201	N/A	275.55	272.98	270.83	N/A	+ 4.72	+ 2.15
10-29-302	293.86	299.49	302.02	303.83	− 9.97	− 4.34	− 1.81
10-29-601	278.44	288.70	N/A	N/A	N/A	N/A	N/A
10-29-702	307.61	329.50	334.85	337.59	− 29.98	− 8.09	− 2.74
10-29-801	234.22	255.01	261.10	261.49	− 27.27	− 6.48	− 0.39
10-29-901	247.85	260.14	265.97	268.43	− 20.58	− 8.29	− 2.46
10-30-102	266.59	277.75	277.45	276.95	− 10.36	+ 0.80	+ 0.50
10-30-202	251.00	262.66	261.10	262.74	− 11.74	− 0.08	− 1.64

HOCKLEY COUNTY

Well Number	Depth to Water Below Land Surface In Feet 1979	1984	1988	1989	Total Change In Water Levels In Feet 1979 to 1989	1984 to 1989	1988 to 1989
24-12-705	N/A	142.03	138.98	138.10	N/A	+ 3.93	+ 0.88
24-14-501	105.00	100.18	95.36	93.50	+ 11.50	+ 6.68	+ 1.86
24-14-601	N/A	129.91	125.58	126.02	N/A	+ 3.89	− 0.44
24-14-701	N/A	44.60	33.12	31.22	N/A	+ 13.38	+ 1.90
24-14-801	52.61	51.99	43.46	40.45	+ 12.16	+ 11.54	+ 3.01
24-14-901	99.74	99.85	99.19	98.93	+ 0.81	+ 0.92	+ 0.26
24-15-504	71.33	71.58	68.17	67.62	+ 3.71	+ 3.96	+ 0.55
24-15-507	82.67	82.58	81.25	79.62	+ 3.05	+ 2.96	+ 1.63
24-15-601	111.39	112.68	111.90	112.18	− 0.79	+ 0.50	− 0.28
24-15-605	101.72	102.95	102.05	101.85	− 0.13	+ 1.10	+ 0.20
24-15-701	N/A	101.84	97.27	98.45	N/A	+ 3.39	− 1.18
24-15-802	183.64	180.23	174.72	174.02	+ 9.62	+ 6.21	+ 0.70
24-15-901	52.38	55.11	51.12	51.37	+ 1.01	+ 3.74	− 0.25
24-16-405	133.45	134.68	131.38	130.63	+ 2.82	+ 4.05	+ 0.75
24-16-701	71.66	75.18	73.63	73.56	− 1.90	+ 1.62	+ 0.07
24-16-702	101.91	102.78	98.87	98.52	+ 3.39	+ 4.26	+ 0.35
24-16-705	N/A	93.53	91.50	88.98	N/A	+ 4.55	+ 2.52
24-20-102	150.37	150.42	147.55	146.85	+ 3.52	+ 3.57	+ 0.70
24-20-301	137.95	139.36	137.75	137.36	+ 0.59	+ 2.00	+ 0.39
24-20-401	126.04	131.33	132.43	131.93	− 5.89	− 0.60	+ 0.50
24-20-602	155.79	157.58	158.92	158.93	− 3.14	− 1.35	− 0.01
24-20-701	148.98	151.29	151.40	152.60	− 3.62	− 1.31	− 1.20
24-20-901	152.95	154.27	153.20	152.17	+ 0.78	+ 2.10	+ 1.03
24-21-201	46.02	45.04	42.28	43.65	+ 2.37	+ 1.39	− 1.37
24-21-301	94.96	93.66	92.48	91.21	+ 3.75	+ 2.45	+ 1.27
24-21-401	158.09	156.25	154.71	154.65	+ 3.44	+ 1.60	+ 0.06
24-21-402	N/A	140.51	139.12	139.50	N/A	+ 1.01	− 0.38
24-21-702	N/A	149.68	148.19	149.47	N/A	+ 0.21	− 1.28
24-21-803	170.19	169.85	166.31	165.18	+ 5.01	+ 4.67	+ 1.13
24-21-901	166.96	169.64	167.75	166.72	+ 0.24	[illegible]	[illegible]







PARMER COUNTY

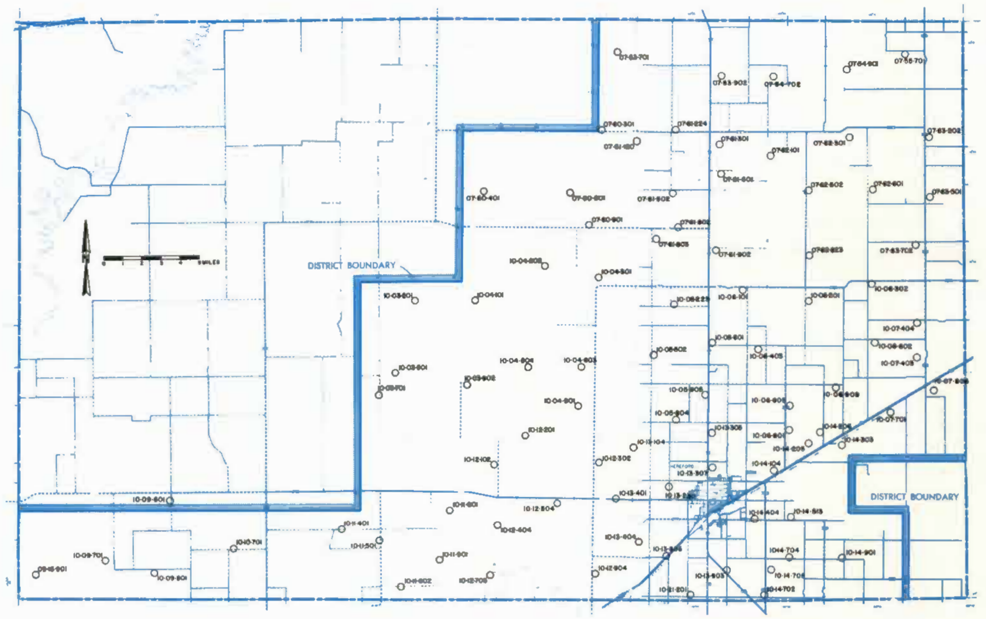
Well Number	Depth to Water Below Land Surface In Feet 1979	1984	1988	1989	Total Change In Water Levels In Feet 1979 to 1989	1984 to 1989	1988 to 1989
09-24-302	N/A	293.05	288.04	288.05	N/A	+ 5.00	- 0.01
09-24-601	343.14	337.03	334.35	333.85	+ 9.29	+ 3.18	+ 0.50
09-24-901	N/A	292.43	292.68	297.36	N/A	- 4.93	- 4.68
09-32-303	345.15	340.90	333.59	332.55	+ 12.60	+ 8.35	+ 1.04
09-32-501	N/A	358.28	356.97	357.01	N/A	+ 1.27	- 0.04
09-32-601	314.53	323.45	324.87	324.57	- 10.04	- 1.12	+ 0.30
09-40-301	321.65	334.55	320.36	321.43	+ 0.22	+ 13.12	- 1.07
09-40-801	N/A	263.95	271.70	272.95	N/A	- 9.00	- 1.25
09-40-901	283.09	304.10	310.42	312.66	- 29.57	- 8.56	- 2.24
09-40-903	258.38	273.28	279.15	281.50	- 23.12	- 8.22	- 2.35
09-48-301	238.64	248.64	254.32	256.60	- 17.96	- 7.96	- 2.28
10-17-301	197.52	192.48	194.78	194.99	+ 2.53	- 2.51	- 0.21
10-17-401	285.21	281.67	281.65	281.39	+ 3.82	+ 0.28	+ 0.26
10-17-501	266.86	262.33	260.11	259.45	+ 7.41	+ 2.88	+ 0.66
10-17-602	N/A	194.15	190.24	191.32	N/A	+ 2.83	- 1.08
10-17-804	N/A	219.50	214.97	215.68	N/A	+ 3.82	- 0.71
10-18-204	N/A	311.24	307.02	306.30	N/A	+ 4.94	+ 0.72
10-18-302	N/A	248.89	245.99	248.80	N/A	+ 0.09	- 2.81
10-18-503	N/A	N/A	262.04	N/A	N/A	N/A	N/A
10-18-602	310.53	308.19	304.12	303.55	+ 6.98	+ 4.64	+ 0.57
10-18-701	258.44	255.57	250.32	249.02	+ 9.42	+ 6.55	+ 1.30
10-18-901	N/A	271.79	266.48	265.46	N/A	+ 6.33	+ 1.02
10-19-101	291.84	293.20	292.62	292.12	- 0.28	+ 1.08	+ 0.50
10-19-202	N/A	312.21	314.43	315.62	N/A	- 3.41	- 1.19
10-19-301	280.72	279.30	278.05	278.58	+ 2.14	+ 0.72	- 0.53
10-19-404	N/A	238.86	242.48	244.10	N/A	- 5.24	- 1.62
10-19-602	264.54	274.23	278.44	279.04	- 14.50	- 4.81	- 0.60
10-19-802	N/A	231.24	234.14	234.49	N/A	- 3.25	- 0.35
10-20-201	N/A	191.01	192.62	193.10	N/A	- 2.09	- 0.48
10-20-402	260.55	258.72	253.47	254.60	+ 5.95	+ 4.12	- 1.13
10-20-901	N/A	202.19	203.92	202.98	N/A	- 0.79	+ 0.94
10-25-102	292.55	286.10	281.97	280.94	+ 11.61	+ 5.16	+ 1.03
10-25-301	303.35	303.93	303.27	302.95	+ 0.40	+ 0.98	+ 0.32
10-25-402	261.05	265.69	265.18	264.88	- 3.83	+ 0.81	+ 0.30
10-25-502	178.35	183.70	184.19	186.21	- 7.86	- 2.51	- 2.02

LAMB COUNTY

Well Number	Depth to Water Below Land Surface In Feet 1979	1984	1988	1989	Total Change In Water Levels In Feet 1979 to 1989	1984 to 1989	1988 to 1989
10-44-401	N/A	184.68	190.30	194.64	N/A	- 9.96	- 4.34
10-44-501	164.21	179.95	186.82	189.18	- 24.97	- 9.23	- 2.36
10-44-703	121.39	134.71	138.57	139.38	- 17.99	- 4.67	- 0.81
10-44-711	101.44	109.47	113.00	113.37	- 11.93	- 3.90	- 0.37
10-44-802	100.42	112.36	116.99	118.59	- 18.17	- 6.23	- 1.60
10-45-402	164.33	182.83	188.91	192.09	- 27.76	- 9.26	- 3.18
10-45-702	114.03	124.65	128.83	130.36	- 16.33	- 5.71	- 1.53
10-45-801	180.56	193.87	195.58	197.49	- 16.93	- 3.62	- 1.91
10-45-903	N/A	N/A	192.39	191.38	N/A	N/A	+ 1.01
10-46-601	203.05	218.56	221.28	223.14	- 20.09	- 4.58	- 1.86
10-46-703	192.89	204.28	210.11	211.52	- 18.63	- 7.24	- 1.41
10-47-401	176.02	N/A	200.19	202.12	- 26.10	N/A	- 1.93
10-47-501	175.56	N/A	194.15	195.29	- 19.73	N/A	- 1.14
10-47-802	N/A	218.71	222.66	222.72	N/A	- 4.01	- 0.06
10-48-403	193.87	207.59	211.06	211.56	- 17.69	- 3.97	- 0.50
10-52-209	87.20	105.49	105.46	106.26	- 19.06	- 0.77	- 0.80
10-52-308	N/A	102.52	104.67	105.40	N/A	- 2.88	- 0.73
10-52-406	N/A	N/A	113.79	113.66	N/A	N/A	+ 0.13
10-52-508	N/A	N/A	77.86	78.18	N/A	N/A	- 0.32
10-52-509	N/A	N/A	85.92	85.78	N/A	N/A	+ 0.14
10-52-601	41.05	46.97	52.52	54.07	- 13.02	- 7.10	- 1.55
10-52-715	N/A	N/A	135.74	131.96	N/A	N/A	+ 3.78
10-52-719	N/A	N/A	124.98	124.96	N/A	N/A	+ 0.02
10-52-804	N/A	N/A	118.59	118.04	N/A	N/A	+ 0.55
10-52-811	N/A	N/A	88.29	87.92	N/A	N/A	+ 0.37
10-52-813	N/A	N/A	85.11	85.41	N/A	N/A	- 0.30
10-52-902	57.03	61.38	65.15	66.19	- 9.16	- 4.81	- 1.04
10-52-905	N/A	96.08	97.56	97.41	N/A	- 1.33	+ 0.15
10-53-101	83.45	94.02	94.91	95.28	- 11.83	- 1.26	- 0.37
10-53-206	N/A	143.48	145.91	145.79	N/A	- 2.31	+ 0.12
10-53-307	124.20	136.89	139.63	139.37	- 15.17	- 2.48	+ 0.26
10-53-404	N/A	N/A	75.64	77.16	N/A	N/A	- 1.52
10-53-602	68.24	81.74	86.44	87.72	- 19.48	- 5.98	- 1.28
10-53-608	N/A	101.37	102.09	103.73	N/A	- 2.36	- 1.64

FLOYD COUNTY

Well Number	Depth to Water Below Land Surface In Feet 1979	1984	1988	1989	Total Change In Water Levels In Feet 1979 to 1989	1984 to 1989	1988 to 1989
11-44-903	N/A	180.03	188.10	189.71	N/A	- 9.68	- 1.61
11-45-408	N/A	210.07	211.70	211.16	N/A	- 1.09	+ 0.54
11-45-802	183.06	192.80	194.62	193.50	- 10.44	- 0.70	+ 1.12
11-45-806	171.88	174.87	175.70	177.77	- 5.89	- 2.90	- 2.07
11-45-902	185.23	188.08	188.50	188.85	- 3.62	- 0.77	- 0.35
11-46-605	N/A	213.98	214.00	N/A	N/A	N/A	N/A
11-46-701	216.36	222.76	223.66	224.94	- 8.58	- 2.18	- 1.28
11-46-802	N/A	261.14	262.14	263.88	N/A	- 2.74	- 1.74
11-47-703	232.97	237.32	238.23	239.11	- 6.14	- 1.79	- 0.88
11-52-305	181.29	189.50	192.55	192.87	- 11.58	- 3.37	- 0.32
11-52-609	N/A	210.78	215.35	215.77	N/A	- 4.99	- 0.42
11-52-901	202.39	220.38	226.45	227.07	- 24.68	- 6.69	- 0.62
11-52-908	204.53	225.73	231.29	231.92	- 27.39	- 6.19	- 0.63
11-53-102	196.59	199.64	197.70	198.59	- 2.00	+ 1.05	- 0.89
11-53-205	157.72	159.73	161.38	161.68	- 3.96	- 1.95	- 0.30
11-53-302	N/A	200.02	199.42	201.26	N/A	- 1.24	- 1.84
11-53-501	216.30	222.60	220.88	223.15	- 6.85	- 0.55	- 2.27
11-53-702	185.51	199.25	201.60	201.75	- 16.24	- 2.50	- 0.15
11-53-705	221.86	235.36	235.10	236.60	- 14.74	- 1.24	- 1.50
11-53-802	N/A	152.36	152.78	153.47	N/A	- 1.11	- 0.69
11-53-903	163.19	161.86	159.35	155.15	+ 8.04	+ 6.71	+ 4.20
11-54-101	213.86	217.95	218.97	219.15	- 5.29	- 1.20	- 0.18
11-54-302	259.81	266.95	265.92	266.62	- 6.81	+ 0.33	- 0.70
11-54-303	N/A	253.75	252.44	252.85	N/A	+ 0.90	- 0.41
11-54-401	182.61	183.77	N/A	N/A	N/A	N/A	N/A
11-54-601	N/A	246.85	245.13	244.44	N/A	+ 2.41	+ 0.69
11-54-802	N/A	175.74	173.64	172.35	N/A	+ 3.39	+ 1.29
11-54-901	223.22	222.93	222.25	221.10	+ 2.12	+ 1.83	+ 1.15
11-55-501	N/A	280.69	278.90	281.06	N/A	- 0.37	- 2.16
11-55-801	N/A	244.00	244.25	243.80	N/A	+ 0.20	+ 0.45
11-55-901	288.78	290.35	289.24	288.75	+ 0.03	+ 1.60	+ 0.49
11-60-302	210.58	230.98	233.19	233.70	- 23.12	- 2.72	- 0.51
11-60-502	214.45	231.97	224.25	226.85	- 12.40	+ 5.12	- 2.60
11-60-605	229.74	234.57	233.43	234.51	- 4.77	+ 0.06	- 1.08
11-60-801	N/A	154.88	151.90	152.60	N/A	+ 2.28	- 0.70



DEAF SMITH COUNTY

Well Number	Depth to Water Below Land Surface In Feet 1979	1984	1988	1989	Total Change In Water Levels In Feet 1979 to 1989	1984 to 1989	1988 to 1989
07-53-701	234.83	235.80	237.40	236.62	- 1.79	- 0.82	+ 0.78
07-53-902	231.03	236.02	236.59	238.95	- 7.92	- 2.93	- 2.36
07-54-702	N/A	N/A	171.00	173.40	N/A	N/A	- 2.40
07-54-901	180.02	187.67	190.45	193.34	- 13.32	- 5.67	- 2.89
07-55-701	231.84	235.28	236.07	240.12	- 8.28	- 4.84	- 4.05
07-60-301	287.14	N/A	298.58	301.69	- 14.55	N/A	- 3.11
07-60-401	302.37	309.90	307.29	307.40	- 5.03	+ 2.50	- 0.11
07-60-601	254.19	264.05	N/A	N/A	N/A	N/A	N/A
07-60-901	230.82	242.15	248.45	249.97	- 19.15	- 7.82	- 1.52
07-61-120	N/A	N/A	237.90	238.15	N/A	N/A	- 0.25
07-61-224	250.05	261.46	265.25	266.58	- 16.53	- 5.12	- 1.33
07-61-301	221.84	228.71	231.36	233.18	- 11.34	- 4.47	- 1.82
07-61-502	221.27	228.01	230.73	234.20	- 12.93	- 6.19	- 3.47
07-61-601	210.63	220.44	225.32	228.10	- 17.47	- 7.66	- 2.78
07-61-802	N/A	215.22	222.25	225.03	N/A	- 9.81	- 2.78
07-61-803	N/A	N/A	259.51	260.10	N/A	N/A	- 0.59
07-61-902	N/A	N/A	215.30	218.84	N/A	N/A	- 3.54
07-62-101	227.06	236.12	232.70	232.99	- 5.93	+ 3.13	- 0.29
07-62-301	187.45	N/A	194.00	197.18	- 9.73	N/A	- 3.18
07-62-502	N/A	205.13	208.75	211.69	N/A	- 6.56	- 2.94
07-62-601	199.77	204.80	203.95	207.85	- 8.08	- 3.05	- 3.90
07-62-823	175.92	185.80	189.54	N/A	N/A	N/A	N/A
07-63-202	193.44	194.98	194.46	198.30	- 4.86	- 3.32	- 3.84
07-63-501	140.32	149.01	154.45	157.88	- 17.56	- 8.87	- 3.43
07-63-702	167.62	N/A	177.85	179.80	- 12.18	N/A	- 1.95
09-16-901	123.70	127.32	131.00	131.20	- 7.50	- 3.88	- 0.20
10-03-201	291.84	300.31	300.19	301.25	- 9.41	- 0.94	- 1.06
10-03-501	258.25	258.09	257.67	259.40	- 1.15	- 1.31	- 1.73
10-03-701	223.87	225.22	225.85	226.70	- 2.83	- 1.48	- 0.85
10-03-902	272.07	273.53	267.68	266.30	+ 5.77	+ 7.23	+ 1.38
10-04-101	333.58	342.25	325.97	325.48	+ 8.10	+ 16.77	+ 0.49
10-04-202	298.04	309.50	307.10	308.46	- 10.42	+ 1.04	- 1.36
10-04-301	304.18	310.55	310.53	311.52	- 7.34	- 0.97	- 0.99
10-04-504	N/A	N/A	281.82	281.64	N/A	N/A	+ 0.18
10-04-603	257.69	267.36	268.20	268.42	- 10.73	- 1.06	- 0.22
10-04-901	210.00	216.70	212.35	N/A	N/A	N/A	N/A
10-05-225	220.02	234.45	242.48	242.90	- 22.88	- 8.45	- 0.42
10-05-502	210.62	N/A	216.72	N/A	N/A	N/A	N/A
10-05-601	163.49	175.49	181.25	183.87	- 20.38	- 8.38	- 2.62
10-05-804	N/A	174.62	186.36	187.95	N/A	- 13.33	- 1.59
10-05-905	N/A	200.48	205.02	209.24	N/A	- 8.76	- 4.22
10-06-101	N/A	177.90	185.02	187.17	N/A	- 9.27	- 2.15
10-06-201	169.00	179.26	180.13	182.50	- 13.50	- 3.24	- 2.37
10-06-302	171.29	185.20	186.90	191.33	- 20.04	- 6.13	- 4.43
10-06-403	184.78	195.90	196.79	197.31	- 12.53	- 1.41	- 0.52

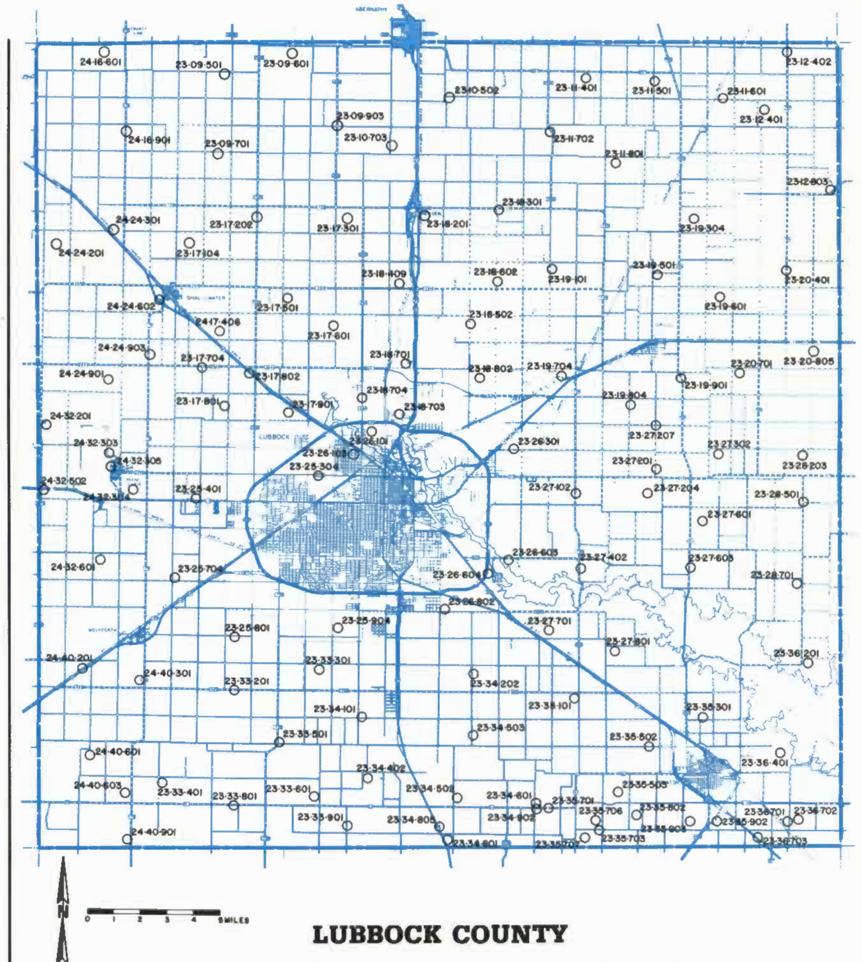
DEAF SMITH COUNTY

Well Number	Depth to Water Below Land Surface In Feet 1979	1984	1988	1989	Total Change In Water Levels In Feet 1979 to 1989	1984 to 1989	1988 to 1989
10-06-602	185.86	191.43	192.75	195.25	- 9.39	- 3.82	- 2.50
10-06-801	80.86	81.89	81.35	81.68	- 0.82	+ 0.21	- 0.33
10-06-805	N/A	N/A	N/A	150.45	N/A	N/A	N/A
10-06-909	153.65	159.27	160.01	161.98	- 8.33	- 2.71	- 1.97
10-07-403	157.21	165.80	168.10	169.90	- 12.69	- 4.10	- 1.80
10-07-404	167.90	179.78	184.00	187.60	- 19.70	- 7.82	- 3.60
10-07-701	124.69	112.04	109.13	108.69	+ 16.00	+ 3.35	+ 0.44
10-07-805	N/A	N/A	138.60	138.60	N/A	N/A	+ 0.00
10-09-601	N/A	N/A	55.35	54.17	N/A	N/A	+ 1.18
10-09-701	N/A	N/A	137.48	137.74	N/A	N/A	- 0.26
10-09-801	54.11	53.97	53.55	53.58	+ 0.53	+ 0.39	- 0.03
10-10-701	163.00	162.79	160.90	162.07	+ 0.93	+ 0.72	- 1.17
10-11-401	189.87	192.40	193.68	193.43	- 3.56	- 1.03	+ 0.25
10-11-501	197.40	201.88	200.75	201.11	- 3.71	+ 0.77	- 0.36
10-11-601	163.59	161.00	161.25	161.36	+ 2.23	- 0.36	- 0.11
10-11-802	230.33	235.52	235.85	236.45	- 6.12	- 0.93	- 0.60
10-11-901	192.52	199.47	N/A	202.30	- 9.78	- 2.83	N/A
10-12-102	164.68	171.31	173.35	173.45	- 8.77	- 2.14	- 0.10
10-12-201	70.48	72.89	71.30	70.95	- 0.47	+ 1.94	+ 0.35
10-12-302	190.50	202.58	206.50	208.55	- 18.05	- 5.97	- 2.05
10-12-404	N/A	N/A	219.18	223.19	N/A	N/A	- 4.01
10-12-504	223.72	232.38	226.20	228.99	- 5.27	+ 3.39	- 2.79
10-12-703	N/A	N/A	N/A	197.10	N/A	N/A	N/A
10-12-904	178.37	190.38	194.12	197.08	- 18.71	- 6.70	- 2.96
10-13-104	N/A	N/A	236.47	236.58	N/A	N/A	- 0.11
10-13-230	N/A	N/A	242.52	247.44	N/A	N/A	- 4.92
10-13-305	172.51	188.38	189.88	192.41	- 19.90	- 4.03	- 2.53
10-13-307	N/A	N/A	181.25	182.65	N/A	N/A	- 1.40
10-13-401	185.13	207.83	213.29	212.44	- 27.31	- 4.61	+ 0.85
10-13-404	N/A	181.57	N/A	189.57	N/A	- 8.00	N/A
10-13-806	N/A	N/A	189.01	191.06	N/A	N/A	- 2.05
10-13-903	192.05	203.44	209.10	211.10	- 19.05	- 7.66	- 2.00
10-14-104	81.73	78.72	77.34	77.49	+ 4.24	+ 1.23	- 0.15
10-14-205	121.78	110.75	103.17	101.82	+ 19.96	+ 8.93	+ 1.35
10-14-206	N/A	N/A	120.89	121.05	N/A	N/A	- 0.16
10-14-303	74.57	76.10	70.00	69.49	+ 5.08	+ 6.61	+ 0.51
10-14-404	154.68	166.45	158.90	160.45	- 5.77	+ 6.00	- 1.55
10-14-513	N/A	N/A	100.60	101.14	N/A	N/A	- 0.54
10-14-702	189.68	198.89	199.30	200.40	- 10.72	- 1.51	- 1.10
10-14-704	155.21	161.19	161.87	162.37	- 7.16	- 1.18	- 0.50
10-14-705	N/A	N/A	193.00	193.67	N/A	N/A	- 0.67
10-14-901	112.55	111.65	111.28	111.46	+ 1.09	+ 0.19	- 0.18
10-21-201	216.85	231.11	233.46	234.80	- 17.95	- 3.69	- 1.34

NOTE: N/A Denotes data not available

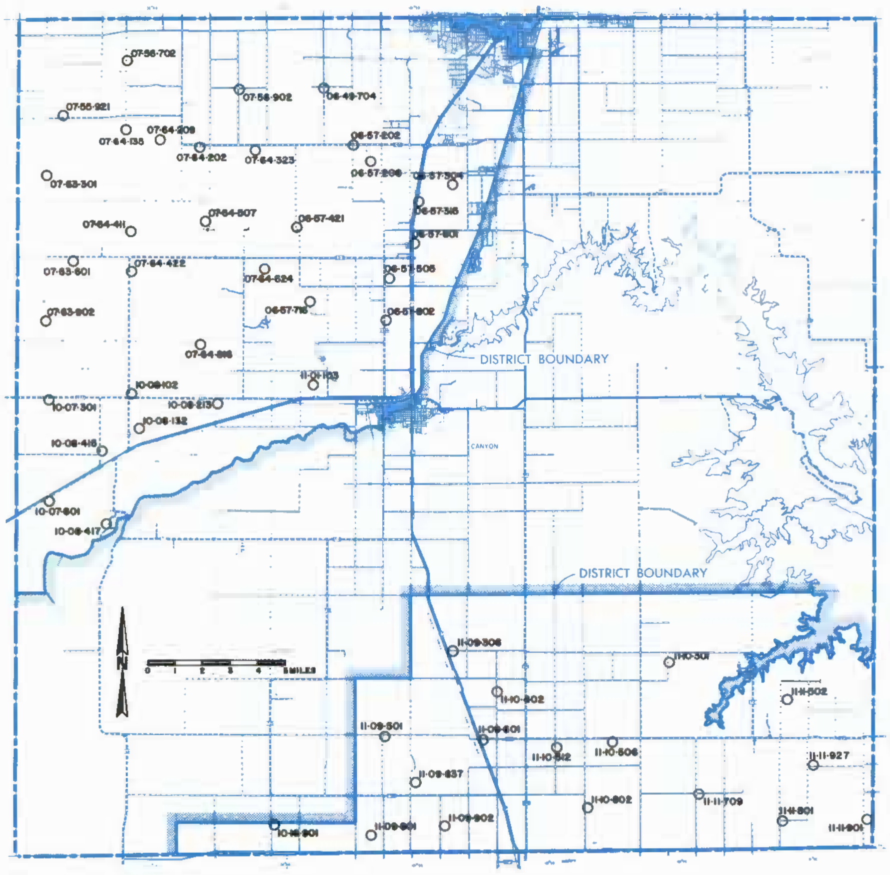
COCHRAN COUNTY

Well Number	Depth to Water Below Land Surface In Feet 1979	1984	1988	1989	Total Change In Water Levels In Feet 1979 to 1989	1984 to 1989	1988 to 1989
24-09-401	92.49	96.00	96.45	95.89	- 3.40	+ 0.11	+ 0.56
24-09-602	128.77	129.86	127.28	127.56	+ 1.21	+ 2.30	- 0.28
24-09-801	123.48	123.14	122.50	121.62	+ 1.86	+ 1.52	+ 0.88



LUBBOCK COUNTY

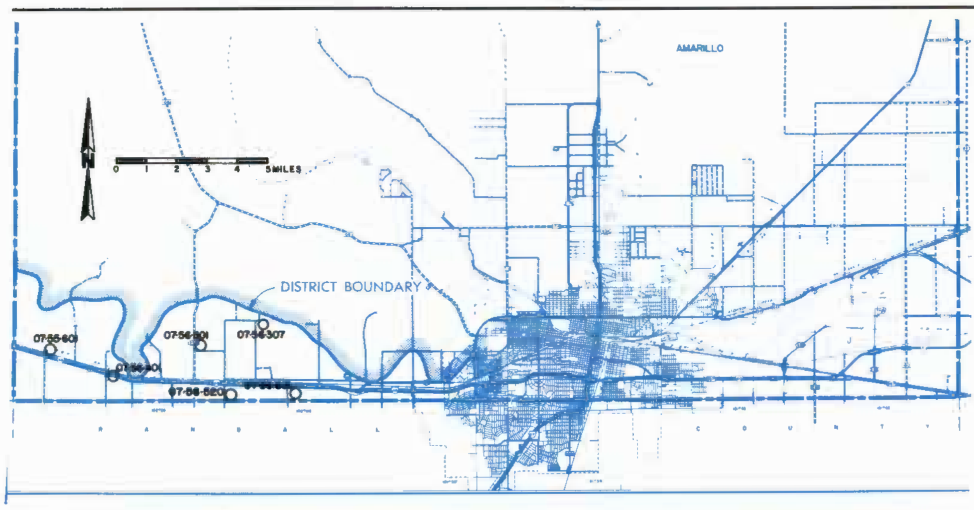
Well Number	Depth to Water Below Land Surface In Feet 1979	1984	1988	1989	Total Change In Water Levels In Feet 1979 to 1989	1984 to 1989	1988 to 1989
23-09-501	168.91	169.72	166.96	166.59	+ 2.32	+ 3.13	+ 0.37
23-09-601	145.17	145.87	145.33	145.61	- 0.44	+ 0.26	- 0.28
23-09-701	168.62	169.44	165.73	166.55	+ 2.07	+ 2.89	- 0.82
23-09-903	N/A	169.25	162.58	163.90	N/A	+ 5.35	- 1.32
23-10-502	199.99	207.27	207.48	203.59	- 3.60	+ 3.68	+ 3.89
23-10-703	N/A	171.07	164.95	165.91	N/A	+ 5.16	- 0.96
23-11-401	213.19	216.33	217.19	216.14	- 2.95	+ 0.19	+ 1.05
23-11-501	N/A	196.38	194.75	193.30	N/A	+ 3.08	+ 1.45
23-11-601	173.47	175.02	175.10	174.69	- 1.22	+ 0.33	+ 0.41
23-11-702	196.31	202.78	202.69	202.54	- 6.23	+ 0.24	+ 0.15
23-11-801	210.58	213.75	216.98	214.60	- 4.02	- 0.85	+ 2.38
23-12-401	180.69	185.59	187.02	187.85	- 7.16	- 2.26	- 0.83
23-12-402	202.89	212.01	213.93	213.84	- 10.95	- 1.83	+ 0.09
23-12-803	199.62	198.91	194.30	192.80	+ 6.82	+ 6.11	+ 1.50
23-17-104	N/A	137.40	136.74	136.74	N/A	+ 0.66	+ 0.00
23-17-202	163.72	162.59	160.58	162.26	+ 1.46	+ 0.33	- 1.68
23-17-301	N/A	166.77	163.32	165.84	N/A	+ 0.93	- 2.52
23-17-406	N/A	78.41	80.29	79.98	N/A	- 1.57	+ 0.31
23-17-501	131.59	131.67	132.72	133.74	- 2.15	- 2.07	- 1.02
23-17-601	N/A	119.49	118.88	119.88	N/A	- 0.39	- 1.00
23-17-704	77.68	77.26	77.49	78.26	- 0.58	- 1.00	- 0.77
23-17-801	90.04	86.51	85.99	85.94	+ 4.10	+ 0.57	+ 0.05
23-17-802	80.20	80.41	N/A	N/A	N/A	N/A	N/A
23-17-901	73.06	66.65	60.09	60.68	+ 12.38	+ 5.97	- 0.59
23-18-201	166.97	168.90	167.24	167.49	- 0.52	+ 1.41	- 0.25
23-18-301	201.17	201.66	203.79	N/A	N/A	N/A	N/A
23-18-409	N/A	152.16	146.97	149.96	N/A	+ 2.20	- 2.99
23-18-502	140.56	136.69	131.44	134.45	+ 6.11	+ 2.24	- 3.01
23-18-602	N/A	152.72	148.35	150.53	N/A	+ 2.19	- 2.18
23-18-701	88.48	89.23	87.69	88.54	- 0.06	+ 0.69	- 0.85
23-18-703	81.10	79.54	76.20	78.18	+ 2.92	+ 1.36	- 1.98
23-18-704	82.59	81.47	77.49	79.25	+ 3.34	+ 2.22	- 1.76
23-18-802	N/A	99.39	95.50	95.39	N/A	+ 4.00	+ 0.11
23-19-101	193.83	193.66	188.88	191.51	+ 2.32	+ 2.15	- 2.63
23-19-304	214.16	214.14	212.42	214.27	- 0.11	- 0.13	- 1.85
23-19-501	207.43	209.13	206.00	206.74	+ 0.69	+ 2.39	- 0.74
23-19-601	N/A	210.59	207.05	205.77	N/A	+ 4.82	+ 1.28
23-19-704	105.69	100.99	98.38	99.00	+ 6.69	+ 1.99	- 0.62
23-19-804	119.59	117.71	107.79	111.45	+ 8.14	+ 6.26	- 3.66
23-19-901	167.36	167.47	164.89	166.51	+ 0.85	+ 0.96	- 1.62
23-20-401	198.74	203.01	200.58	199.78	- 1.04	+ 3.23	+ 0.80
23-20-701	191.98	191.23	185.67	186.36	+ 5.62	+ 4.87	- 0.69
23-20-805	N/A	N/A	201.89	204.66	N/A	N/A	- 2.77
23-25-304	36.94	31.58	27.73	29.32	+ 7.62	+ 2.26	- 1.59



RANDALL COUNTY

Well Number	Depth to Water Below Land Surface In Feet				Total Change In Water Levels In Feet		
	1979	1984	1988	1989	1979 to 1989	1984 to 1989	1988 to 1989
06-49-704	N/A	212.98	214.98	215.39	N/A	– 2.41	– 0.41
06-57-202	200.65	201.53	202.12	204.03	– 3.38	– 2.50	– 1.91
06-57-208	N/A	200.44	196.68	197.98	N/A	+ 2.46	– 1.30
06-57-304	N/A	162.62	159.98	161.56	N/A	+ 1.06	– 1.58
06-57-315	N/A	152.24	153.74	153.99	N/A	– 1.75	– 0.25
06-57-421	185.49	191.81	189.58	189.29	– 3.80	+ 2.52	+ 0.29
06-57-505	N/A	187.57	182.98	182.74	N/A	+ 4.83	+ 0.24
06-57-601	187.50	188.06	185.56	185.26	+ 2.24	+ 2.80	+ 0.30
06-57-716	164.41	168.06	170.20	170.61	– 6.20	– 2.55	– 0.41
06-57-802	160.19	159.81	156.13	155.44	+ 4.75	+ 4.37	+ 0.69
07-55-921	220.40	227.34	229.21	231.62	– 11.22	– 4.28	– 2.41
07-56-702	248.17	251.59	249.91	254.95	– 6.78	– 3.36	– 5.04
07-56-902	215.84	215.31	215.61	215.98	– 0.14	– 0.67	– 0.37
07-63-301	235.15	234.38	232.32	232.18	+ 2.97	+ 2.20	+ 0.14
07-63-601	176.06	186.27	189.94	191.21	– 15.15	– 4.94	– 1.27
07-63-902	155.78	161.17	164.25	169.36	– 13.58	– 8.19	– 5.11
07-64-135	N/A	221.86	220.62	222.72	N/A	– 0.86	– 2.10
07-64-202	N/A	187.49	185.74	187.51	N/A	– 0.02	– 1.77
07-64-209	181.55	179.47	180.22	181.58	– 0.03	– 2.11	– 1.36
07-64-323	N/A	158.02	165.19	N/A	N/A	N/A	N/A
07-64-411	116.78	N/A	120.24	120.84	– 4.06	N/A	– 0.60
07-64-422	N/A	N/A	107.92	N/A	N/A	N/A	N/A
07-64-507	165.96	161.37	159.34	159.18	+ 6.78	+ 2.19	+ 0.16
07-64-624	N/A	170.59	173.73	173.39	N/A	– 2.80	+ 0.34
07-64-816	N/A	138.07	141.56	139.30	N/A	– 1.23	+ 2.26
10-07-301	135.75	138.34	139.03	139.72	– 3.97	– 1.38	– 0.69
10-07-601	103.40	104.00	103.88	103.84	– 0.44	+ 0.16	+ 0.04
10-08-102	145.63	147.73	149.98	149.05	– 3.42	– 1.32	+ 0.93
10-08-132	N/A	177.26	176.53	175.57	N/A	+ 1.69	+ 0.96
10-08-213	127.79	131.29	131.97	131.96	– 4.17	– 0.67	+ 0.01
10-08-415	111.10	114.06	N/A	N/A	N/A	N/A	N/A
10-08-417	N/A	N/A	97.63	97.78	N/A	N/A	– 0.15
10-16-901	182.89	184.36	184.98	184.51	– 1.62	– 0.15	+ 0.47
11-01-103	N/A	83.20	83.88	83.46	N/A	– 0.26	+ 0.42
11-09-306	161.19	162.95	162.45	163.55	– 2.36	– 0.60	– 1.10
11-09-501	186.15	186.91	185.56	185.40	+ 0.75	+ 1.51	+ 0.16
11-09-601	199.10	201.10	195.44	195.08	+ 4.02	+ 6.02	+ 0.36
11-09-801	197.28	196.25	192.98	192.08	+ 5.20	+ 4.17	+ 0.90
11-09-837	N/A	178.79	177.85	177.31	N/A	+ 1.48	+ 0.54
11-09-902	208.98	202.74	198.04	197.28	+ 11.70	+ 5.46	+ 0.76
11-10-301	128.97	129.49	127.67	127.63	+ 1.34	+ 1.86	+ 0.04
11-10-402	175.12	175.12	174.44	174.16	+ 0.96	+ 0.96	+ 0.28
11-10-506	N/A	141.35	142.83	142.90	N/A	– 1.55	– 0.07
11-10-512	179.09	179.35	178.02	177.35	+ 1.74	+ 2.00	+ 0.67
11-10-802	181.57	179.54	177.07	176.07	+ 5.50	+ 3.47	+ 1.00
11-11-502	167.05	166.40	167.29	167.41	– 0.36	– 1.01	– 0.12
11-11-709	N/A	N/A	183.24	182.30	N/A	N/A	+ 0.94
11-11-801	131.13	135.76	136.30	135.86	– 4.73	– 0.10	+ 0.44
11-11-901	130.33	134.61	135.02	134.91	– 4.58	– 0.30	+ 0.11
11-11-927	143.85	147.57	147.72	147.85	– 4.00	– 0.28	– 0.13

NOTE: N/A Denotes data not available



POTTER COUNTY

Well Number	Depth to Water Below Land Surface In Feet				Total Change In Water Levels In Feet		
	1979	1984	1988	1989	1979 to 1989	1984 to 1989	1988 to 1989
07-55-601	255.77	255.41	254.99	254.60	+ 1.17	+ 0.81	+ 0.39
07-56-307	223.88	224.45	224.53	224.88	– 1.00	– 0.43	– 0.35
07-56-401	233.22	242.94	243.32	246.70	– 13.48	– 3.76	– 3.38
07-56-501	226.69	230.25	231.38	N/A	N/A	N/A	N/A
07-56-520	N/A	N/A	N/A	N/A	N/A	N/A	N/A
07-56-601	218.88	225.68	221.25	222.02	– 3.14	+ 3.66	– 0.77

NOTE: N/A Denotes data not available

THE CROSS SECTION (USPS 564-920)
HIGH PLAINS UNDERGROUND WATER
CONSERVATION DISTRICT NO. 1
2930 AVENUE Q
LUBBOCK, TEXAS 79405

SECOND CLASS PERMIT

THE Cross SECTION

Published monthly by High Plains Underground Water Conservation District No. 1, 2930 Avenue Q, Lubbock, Texas 79405—Ph. 762-0181

Volume 35—No. 5 Publication Number USPS 564-920, Second Class Postage paid at Lubbock, Texas *May 1989*

Poor soil fertility conditions will limit 1989 cotton crop yields

ANOTHER BUMPER COTTON CROP is unlikely in 1989 unless farmers check soil fertility conditions for their individual fields and apply the recommended amounts of supplemental fertilizer to the soil.

Current soil fertility levels lack adequate amounts of nitrogen and phosphorus to support economically acceptable crop yields over most of the 15-county High Plains Underground Water Conservation District No. 1 service area, according to a recent Water District/USDA-Soil Conservation Service (USDA-SCS) soil fertility study.

During the 1989 study, 186 soil samples were collected from the plow layer of the soil at selected sites within the Water District service area. Test results revealed nitrogen and phosphorus levels in such short supply that yields will be limited to 300 to 350 pounds of cotton lint if supplemental fertilizer is not added to the soil.

Soil Samples Indicate Low Nitrate-Nitrogen Levels

The soil survey data indicated that 80 percent, or 149 samples, were either low or very low in nitrate-nitrogen readings. The average available nitrate-nitrogen content for these samples was 23 pounds per acre. This nitrogen level is far below the amount needed to support minimum acceptable yields for any major crop grown on the Texas High Plains, says Mike Risinger, USDA-SCS Soil Scientist.

See SOIL Page Three

Pending state legislation addresses various water concerns

The protection and management of the state's water resources continues to be of great importance to lawmakers during the 71st Texas legislative session in Austin.

More than 4,700 bills have been filed since the session convened in January 1989.

Descriptions of some of the proposed water-related legislation are presented below. Additional bill synopses were published in the March 1989 *Cross Section*.

TEXAS STATE LEGISLATURE HOUSE BILLS

HB 1185

This bill, sponsored by Representative Terral Smith of Austin, relates to administrative penalties for the violation of certain water rights and rules pertaining to surface water.

HB 1190

Representative Kent Marchant of Carrollton has introduced this bill which relates to Texas Water Commission approval of levee improvement district bonds.

HB 1267

This legislation sponsored by Representative Robert Junell of San Angelo, would expand the Texas Water Development Board grants program to include purchases of water quality testing equipment.

Senator Bill Sims of San Angelo sponsored the companion bill, SB 847.

HB 1441

This bill, introduced by Representative Mark Stiles of Beaumont, relates to the authority of the Jefferson County Navigation District to issue revenue bonds for water projects for the purpose of land drainage.

HB 1442

This legislation, also sponsored by Representative Stiles, relates to the authority of the Jefferson County Drainage District No. 6 to enter into various agreements and issue revenue bonds for projects for the purpose of navigation on Taylor's Bayou in Jefferson County.

HB 1951

This legislation, sponsored by Representative Phyllis Robinson of Gonzales, would allow the Texas Water Commission to order the release or pass-through of up to five percent of the annual firm yield of water in Lake Texana for the purpose of maintaining the ecological health of the bay and estuary system.

HB 1961

Representative Tom Craddick of Midland introduced this legislation which provides for the creation, administration, powers, duties, operation, and financing of the South Ector County Underground Water Conservation District. The District would have the powers and duties of a water conservation district as outlined under Chapter 52 of the Texas Water Code. The district would cover about 52,400 acres of Ector County.

HB 1991

This bill, sponsored by Representative Stan Schlueter of Killeen, would delete the portion of the creation order of the Lower Colorado River Authority that limits the powers of the directors to "matters of electricity generation, distribution and rates or related matters."

HB 2166

Representative Robert Saunders of LaGrange introduced this bill relating to spills or releases of hazardous substances into waters of the state.

HB 2248

Representative Junell sponsored this bill which would dissolve 16 Water Districts, which are either Municipal Utility Districts or water and sanitation districts.

HB 2299

This legislation, sponsored by Representative Terral Smith, would require underground water districts

See ADDITIONAL Page Two

House Natural Resources Committee

Chairman
Terral Smith
Austin

Vice-Chairman
John Willy
Angleton

Frank Collazo
Port Arthur

Steve Holzheauser
Houston

Jerry Yost
Longview

John Culberson
Houston

Robert Junell
San Angelo

Dick Swift
Palestine

Jeff Wentworth
San Antonio

Additional water-related legislation introduced during session

Continued From Page One

to develop a management plan for the most efficient use of the underground water for controlling and preventing waste and/or subsidence. Public involvement in the development of the plan would be encouraged. A water district would be allowed to review its plan annually and would be required to review its plan at least every three years. Where two or more districts exist within the boundaries of a management area designated by the Texas Water Commission, management plans would have to be developed jointly. The legislation also provides for a petition from a district which is not satisfied with the participation of any other districts within the same management area for the TWC to conduct an inquiry.

HB 2303

This bill, also sponsored by Representative Smith, would allow districts providing water or sewer facilities and services to charge a "standby fee" to owners of undeveloped property which are eligible for such services, but are currently not using them.

The companion bill is SB 1213.

HB 2305

Representative Terral Smith sponsored this legislation which would make the Texas Water Commission the lead agency for all groundwater quality matters in the state. Under this legislation, no unit of local government could enact rules or ordinances "relating, either directly or indirectly, to groundwater quality, including ... placing restrictions on activities or facilities which may impact groundwater quality," unless those rules or ordinances were in effect prior to January 1, 1989. The Texas Water Commission would be required to develop a classification system to identify and protect mapped major and minor aquifers, as well as other groundwaters of the state which might be put to beneficial use. The standards to be adopted would be based on "multiple beneficial use classification of the groundwater."

HB 2317

This bill by Representative Smith would remove some wording of Section 17.083 of the Texas Water Code which requires that specific allowable investments be made by the Texas Water Development Board with reserve money. The change reads "... investments authorized by law for state deposits."

HB 2318

Also sponsored by Representative Smith, this legislation would allow the Texas Water Development Board to use net proceeds from the sale of political subdivision bonds owned by the Texas Water Development Board and deposited in the water development fund for whatever purpose the TWDB approves.

Senate Natural Resources Committee

Chairman
H. Tati Santiesteban
El Paso

Vice-Chairman
Ted Lyon
Mesquite

Kenneth Armbrister
Victoria

J.E. Brown
Lake Jackson

John Montford
Lubbock

Bill Sims
San Angelo

Hector Uribe
Brownsville

Judith Zaffirini
Laredo

Teel Bivins
Amarillo

Steven Carriker
Roby

William Ratliff
Mt. Pleasant

The Water Subcommittee Members Include:

Chairman Uribe
Vice-Chairman Brown
Senator Montford
Senator Ratliff
Senator Zaffirini

HB 2353

This bill, introduced by Representative Jerry Yost of Longview, would amend Chapter 50 of the Texas Water Code to provide a procedure for the annexation of territory and for the consolidation of two or more districts into one district.

HB 2354

This legislation, also sponsored by Representative Yost, relates to requirements for the creation of municipal utility districts.

HB 2355

This bill by Representative Yost would amend Chapter 52 of the Texas Water Code to allow underground water conservation districts lying within a single county to hire a director as general manager, with the salary to be set by the other directors.

HB 2477

This legislation by Representative Terral Smith would revise Chapter 52 of the Texas Water Code to change language referring to the Texas Department of Water Resources to either the Texas Water Development Board or Texas Water Commission as appropriate and to bring various administrative procedures found elsewhere in the Water Code into Chapter 52.

The companion bill is SB 1212 by Senator H. Tati Santiesteban of El Paso.

HB 2514

This bill, introduced by Representative Smith, would amend the provisions of Chapter 51 of the Water Code which apply to excluding land from territory added to a water control and improvement district.

HB 2687

Sponsored by Representative Dudley Harrison of Sanderson, this legislation would provide that a watermaster must obtain a written permit annually to enter any landowner's property if the landowner gives notice of such a request.

HB 2771

Representative Terral Smith has sponsored this legislation known as the *Edwards Aquifer Administration Act*.

The policies which this bill is built upon include: 1) protection of water quality in the region of the Edwards Aquifer; 2) protection of the economic stability of the region by assurance of adequate water supply; 3) protection of environmental values of the region; 4) protection of springflow of Comal and San Marcos Springs; 5) prevention of sustained overdraft of the Edwards Aquifer; 6) recognition of historic uses and users; 7) provision for new uses and users through the issuance of permits by the Texas Water Commission; and 8) provision of markets for the purchase, lease or trade of groundwater rights.

The legislation would require a permit for continued use of water from the aquifer, based on past usage. It would also require meters and annual reports to the Texas Water Commission on the amounts of groundwater pumped. The TWC would be required to develop, implement, enforce and amend a drought management plan in order to "minimize ... the drawdown of the water table or the reduction of artesian pressure and spring flow, to prevent waste, and to protect the groundwater resources from serious harm."

HB 2799

Representative Smith also sponsored this bill which relates to the division of a Water Control and Improvement District into two or more separate districts.

HB 2836

This legislation by Representative Junell relates to the regulation of the primarily responsible driller by the Texas Water Well Drillers Board.

HB 2837

Also sponsored by Junell, this bill relates to the regulation of water wells and certain well drillers, imposing fees, establishing an advisory board, establishing a well drillers fund and provides administrative and civil penalties.

HB 2879

This legislation introduced by Representative Barry Connelly of Houston would prohibit persons who would receive direct financial benefit from or who have any financial interest in a regional district project from guaranteeing matching funds for such projects.

HB 2930

Representative Jeff Wentworth of San Antonio sponsored this legislation which would change the provi-

See TEXAS Next Page

THE Cross SECTION

THE CROSS SECTION (USPS 564-920)

A MONTHLY PUBLICATION OF THE HIGH PLAINS UNDERGROUND WATER CONSERVATION DISTRICT NO. 1

Second Class Postage Paid at Lubbock, Texas
District Office at Lubbock

POSTMASTER: Send address changes to:
The Cross Section, 2930 Avenue Q,
Lubbock, TX 79405 Telephone (806) 762-0181

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Texas lawmakers introduce additional water-related legislation

Continued From Page Two

sions of Chapter 26 of the Water Code to enable the Texas Water Commission to obtain delegation from the Federal government of the National Pollutant Discharge Elimination System regulatory authority in accordance with the Federal Water Pollution Control Act.

HB 2996

This bill by Representative William Keith Oakley of Terrell would provide for members of the Texas Water Commission to be elected, beginning at the next general election of state and county officers.

TEXAS STATE LEGISLATURE SENATE BILLS

SB 937

This bill, sponsored by Senator Carl Allen Parker of Port Arthur, would provide for the Texas Water Commission to appoint, with the advice and consent of the Senate, the directors of the Lower Neches Valley Authority.

SB 993

This legislation by Senator Theodore Lyon of Mesquite would pertain to the creation, administration, powers and duties, operations, and financing of Collin County Regional Water Authority and to the creation of subdistricts.

SB 1039

Sponsored by Senator James William Haley of Center, this bill would provide for the appointment of commissioners for the Sabine River Compact.

SB 1117

Senator John Montford of Lubbock sponsored this bill pertaining to the establishment and funding of the agricultural water conservation equipment loan program to be essentially the same as the pilot loan program which ends August 31, 1989.

SB 1196

Senator Robert Dickson of Sweetwater sponsored this legislation which relates to the award of certain costs to persons affected by activities regulated under Section 27 of the Water Code, which pertains to an injection well.

SB 1220

This legislation by Senator Santiesteban would amend Chapter 50 to clarify reasons for disqualification of board members, to specify contracts which must be let for bids and to amend the criteria for setting rates for out-of-district customers.

SB 1222

This bill by Senator Santiesteban relates to a discharge or spill of a hazardous substance into water in the state.

SB 1225

Also sponsored by Senator Santiesteban, this legislation would amend Chapter 11 of the Water Code to allow the Texas Water Commission to review and modify water rights to conserve or protect 1) state water; 2) quality of water in the state; 3) instream uses; 4) beneficial inflows into the state's bays and estuaries; 5) fish and wildlife habitats; or 6) other natural resources of the state.

SB 1273

This bill by Senator Carlos Truan of Corpus Christi would relate to the consolidation of water quality and radiation control functions of the Texas Water Commission.

SB 1280

Senator Don Henderson of Houston sponsored this bill which relates to the creation, confirmation election, director's qualifications and exclusions of property from a regional water district.

HB 2880 is the companion bill.

SJR 44

This Senate Joint Resolution sponsored by Senator Montford proposes a constitutional amendment to eliminate time limitations of the issuance of Texas agricultural water conservation bonds. (The original legislation establishing the program set a time limit of four years.)

Soil fertility study reveals low nitrogen and phosphorus levels

Continued From Page One

"Area soils require about 90 pounds of available nitrogen per acre to produce 80 bushels of corn, about 40 pounds of nitrogen per acre to produce 300 pounds of cotton lint, about 40 pounds of nitrogen per acre to produce 1,500 pounds of grain sorghum and about 50 pounds per acre to produce 20 bushels of wheat. Higher yield goals require even more nutrients," says Risinger.

Nitrogen is highly water soluble and moves with soil moisture. Large pre-plant nitrogen applications can be leached below the active root zone profile when heavy precipitation or a large irrigation follows the application.

"The most efficient nitrogen application is to begin with a pre-plant application based upon soil testing and then sidedress an additional five pounds of nitrogen per acre for each inch of water the plant receives through irrigation or rainfall. This will ensure the proper water-nutrient balance and will greatly improve the plant's water-use efficiency," says Risinger.

Low Soil Phosphorus Levels Also Noted

Approximately 62 percent, or 115 of the samples, indicated low or very low soil phosphorus levels. Soil fertility test results show the average P_2O_5 content in these samples to be 25 pounds per acre. This is considerably lower than the nutrient amounts required for minimum acceptable yields for the major crops grown in this region.

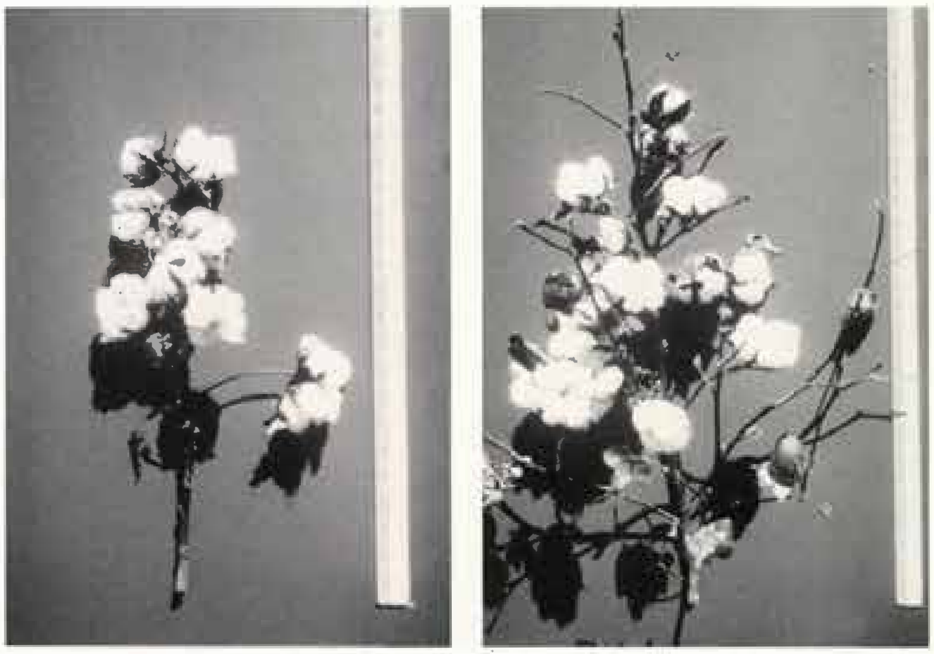
An 80 bushel corn crop yield requires about 60 pounds of available phosphorus, P_2O_5. About 30 pounds are required to produce 300 pounds of cotton lint, and 28 pounds are needed to produce 1,500 pounds of grain sorghum. A 30 bushel wheat crop yield would require about 28 pounds of P_2O_5.

Samples were analyzed for the presence of nitrate nitrogen, phosphorus, potassium, calcium, magnesium, zinc, iron, manganese, copper and sodium. Soil pH and salinity were also measured.

"Maintaining phosphorus levels is important since only about two percent of total soil phosphorus is available at a given time. Over a period of time, the insoluble phosphorus breaks down and becomes available to replenish any available phosphorus depleted by the growing crop. This is a slow process; and when the available phosphorus is depleted, the crop will suffer." says Risinger.

"The most efficient practice is to inject phosphate in bands about one and a half inches below and one and a half inches to the side of the seed. This will reduce phosphorus fixation and ensure a high concentration of soluble phosphorus for young plants," he says.

With more than half of the sampled fields showing inadequate nitrogen and phosphorus levels for adequate crop yields during the 1989 growing season, Risinger urges producers to collect soil samples from each of their fields, have the soil samples analyzed by a laboratory and follow the recommendation for the proper fertilizer amounts for the type of crop to be grown.



WHAT A DIFFERENCE!—Cotton plants from the James Mitchell farm near New Home illustrate the importance of soil fertility for increased plant yields. Due to a clogged nozzle on Mitchell's spray rig, the plant on the left did not receive a sidedress application of nitrogen. As a result, it is about 18 inches tall and has about 9 open bolls. The plant on the right received the sidedress application and it is about 28 inches tall with 14 open bolls.

Relationship Between Yield Decline and Fertilizer Use Examined

Cotton yields nosedived from the 10-year average of 460 pounds per harvested acre in 1960-1969 to an average 357 pounds in the 1970s. Cotton yields averaged 335 pounds per acre during the first half of the 1980s.

A study conducted by Texas Tech University Agricultural Economist Don E. Ethridge showed a significant decline in fertilizer sales from 1965 to 1985. He concluded that the cotton lint yield decline was very likely related to decreased fertilizer use in the region.

A regional soil fertility study conducted in 1987 by the High Plains Water District and the USDA-SCS supported Ethridge's theory. "The study showed that nitrogen and phosphorus levels in the soil were present only in amounts adequate to support the average yields being produced," says Risinger.

Since then, producers have worked to improve their soil fertility levels. In 1987, a near-record yield of 493 pounds per harvested acre was produced. The Water District and the USDA-SCS conducted the regional soil fertility study again in 1988, and it showed that most of the applied soil nutrients had been used by the 1987 bumper crop. Producers again worked to improve their soil fertility, and another near-record average yield of about 480 pounds per harvested acre was produced in 1988.

Lubbock County producers praise surge irrigation benefits

The use of surge irrigation continues to spread across the Texas High Plains. Today, thousands of surge valves are being used by irrigators to conserve groundwater and to improve furrow application efficiencies.

Second In A Two-Part Series

In May 1982, one of the first surge irrigation tests in the Texas High Plains was conducted on the Melvin Betzen farm near Hereford by researchers from the Bushland USDA-Southwestern Great Plains Research Center.

Betzen usually applied nine inches of water per acre to get the water to the furrow end. According to the USDA-Soil Conservation Service (USDA-SCS), three and a half inches of water would fill his soil to field capacity. The remaining five and a half inches of water were being lost to deep percolation and tailwater.

Using a surge valve, Betzen applied 4.9 inches of water to 20 rows. Researchers concluded that the surge valve doubled the area covered in a specified time, using about the same amount of water as had previously been needed with regular furrow irrigation.

In 1983, the High Plains Underground Water Conservation District No. 1 purchased 17 surge valves for testing and evaluation. Initial surge irrigation tests were conducted at the James Wedel farm near Muleshoe, the Phil Johnson farm near Hub, and the James Mitchell farm at New Home.

Surge Enables Longer Row Runs

Before he learned about surge irrigation in the early 1980s, Ronald C. Schilling of Slaton says it was almost impossible to water his long contour rows with the limited groundwater supply on his 480-acre farm.

"Tailwater was never a major problem with us because we never could get the water out to the end of these long rows in this sandy soil. Surge irrigation now allows us to get the water out all the way," he says.

Schilling once considered installing an underground pipeline across the middle of the field during the early 1980s. However, he felt the pipeline would be impractical because of his farm's limited groundwater resources.

In 1983, the High Plains Underground Water Conservation District No. 1 made surge valves available to irrigators through their local USDA-SCS office. It was one of these "loaner" valves that sold Schilling on the surge irrigation idea.

"I borrowed one of the surge valves in the Water District's cooperative program and tried it out. After I saw what it could do, I knew I had to have one of them," he says.

Schilling later purchased one of the first commercial surge valves manufactured by Jim Bartos of Aluminum Metal Products, Inc. in Lubbock. "The Bartos valve has been pretty much trouble-free since I bought it six years ago. I have only replaced one timer unit since then," he says.

Surge irrigation has been a cost-effective addition to Schilling's farm management program. Improved furrow application efficiencies help Schilling conserve his limited groundwater supplies. Since less water is pumped with surge irrigation, energy costs associated with pumping are also reduced.

"Surge irrigation has allowed me to have a 15 percent increase in my water use efficiency, and this alone has paid for the surge valve. It allows a more even crop yield. With a surge valve, you can produce more product per gallon of water pumped than you can with regular furrow irrigation," he says.

Uniform water application across the field is another reason why Schilling is pleased with surge. The irrigation technique helps eliminate the over-irrigation or under-irrigation commonly associated with conventional furrow irrigation.

"Surge has eliminated a lot of the 'hot spots' caused by uneven watering. On the upper and lower ends of the field, there would be too much water applied to the crop, while in the middle, the cotton would be burning up because it wasn't receiving enough water.

Schilling is also pleased with the labor savings offered by surge systems. "I like the surge valve's convenience because it allows you to change the water whenever you want to — instead of when you have to! That convenience is worth a lot," he says.

The Slaton producer is working to get the most benefit from his limited groundwater supply. "I don't have enough groundwater on my farm to operate a center pivot sprinkler. Surge irrigation is the next best thing," he says.

SURGE IRRIGATION IMPROVES WATER USE EFFICIENCIES—Ronald Schilling credits his surge valve (shown above) with a 15 percent increase in water use efficiency on his farm near Slaton.

"A Unique Way to Manage Irrigation Water"

Steve Jones of Lubbock was one of the first irrigators to discover the benefits of surge valves after their introduction to the area.

He began using Hastings surge valves in 1983, but dissatisfaction with the Hastings control box later caused him to switch to the Pro Jr. surge valve manufactured by P & R Surge Systems of Lubbock. He currently uses five P & R surge valves and two Hastings valves on the 2,400 acres that he irrigates.

"Surge irrigation is a unique way to manage irrigation water, and I am very satisified with it," he says.

Jones grows 2,100 acres of cotton, 200 acres of onions, 200 acres of watermelon, 100 acres of pumpkins, and five acres of tomatoes north of Lubbock. Unfortunately, surge irrigation doesn't work well with all his crops.

"Surge irrigation simply doesn't work on vine crops. When watermelon or pumpkin vines get in the middle of the furrow, they hold the water back; and that defeats the entire purpose of a surge valve," he says.

Jones says he started using surge irrigation because of its economic benefits. "I found surge irrigation to be more economical than conventional row watering. I can use it to irrigate a lot more rows in less time. With 200 acres of onions, it's important to get the water out as quickly as possible to get the crop up and going," he says.

Since onions have a shallow root zone, they do not require deep water infiltration. Surge irrigation gives Jones the option to apply as little as two to three inches of water in a uniform pattern across the onions.

"Surge irrigation also helps eliminate row washing that happens when you run long rows in highly erodible land. The surge action helps seal the furrows, and they don't wash out near as bad.

Jones says he is pleased with the benefits surge irrigation has provided him during the past six years. "Surge irrigation is a good water management tool. I only wish that I had more surge valves," he says.

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2930 AVENUE Q
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1954 35TH ANNIVERSARY ISSUE 1989

THE Cross SECTION

Published monthly by High Plains Underground Water Conservation District No. 1, 2930 Avenue Q, Lubbock, Texas 79405—Ph. 762-0181

Volume 35—No. 6 Publication Number USPS 564-920, Second Class Postage paid at Lubbock, Texas June 1989

BRINE DISPOSAL — A typical salt-water disposal pit found in the 1950s in the southern portion of the High Plains Underground Water Conservation District No. 1 is shown in this file photo.

District Uses Available Moisture Meter To Determine When and How Much To Irrigate

June 1958 — The High Plains irrigation farmer who irrigates according to the way he feels is soon to become as up-to-date as a bathing suit with arms and legs.

This month we will explain ... a meter that measures electrically the amount of moisture which is available to a plant at various soil depths.

Small electrodes used with the device are buried beneath the crop row at a sufficient variety of depths to give an adequate picture of the available moisture in the upper three or four feet of the root zone. The electrodes are imbedded in small gypsum blocks and attached to wires which lead to the surface.

The meter itself contains batteries and is portable. It may be attached at any time to the electrode wires at the land surface to obtain a reading. The amount of moisture present at the block depth which is being tested registers on the meter.

The more moisture present the better electrical conductance, and consequently a higher meter reading. The meter dial is calibrated in percentages of available moisture, with 100 per cent representing "field capacity."

When the moisture-holding characteristics of the soil are known by the irrigator (your County Agricultural Agent can assist you in making this determination), he will then know from the meter readings whether or not he needs to irrigate and if so, the quantity of water that needs to be applied.

A Milestone . . .

It has been 35 years since the first issue of *The Cross Section* rolled off the press in June 1954.

On Page One of that premier issue was a statement of purpose from the editor and manager. ". . . we shall endeavor to present to you a cross section of the present day activities in the field of Underground Water as an instrument for keeping in touch with the plans and functions of your District."

Since then, *The Cross Section* has covered numerous water-related activities ranging from tailwater waste and secondary recovery to lakeweed control and the Lubbock Lake Landmark.

In observance of *The Cross Section's* 35th anniversary, selected articles and photographs are reprinted in this issue to mark milestones in the history of the High Plains Underground Water Conservation District No. 1.

I hope our readers will look back with pride and nostalgia at the accomplishments of their underground water conservation district as reported on the pages of *The Cross Section* — **Carmon McCain.**

Salt-Water Pollution Is Becoming A Major Concern in Oil-Producing Areas

August 1957 — Salt-water pollution of the fresh water in certain areas of the High Plains Underground Water Conservation District has reached alarming proportions.

In the opinion of our own hydrologist, W.L. Broadhurst, and others qualified to express an opinion on the subject, the pollution can be coming from surface pits into which oil field brine is disposed.

According to our information, there is no effective regulation over surface salt-water disposal pits, either by the Railroad Commission, which controls oil production in the State, or by the State Board of Water Engineers. The matter is left entirely up to the discretion of the oil producer and the land owner to come to a common understanding as to the location and operation of the disposal pits.

The theory that the water will evaporate from the pits and leave the salt deposited at the surface is not altogether true. The thing that happens in most cases is that an oil slick forms on the surface of the salt water, thereby preventing evaporation and the water together with the salt in solution percolates through the underlying sediments until it reaches the water-table. The salt does not filter out of the water as it moves through the underground formations, and once polluted, the underground water is not fit for domestic or agricultural uses.

Most of the oil producers are attempting to alleviate this salt-water pollution problem by changing their method of disposal. Many have begun injecting the salt water under pressure back into the same formation from which it came through wells which are cased with solid pipe through the fresh water-bearing section. But, there are others who are not making any effort to change their method of operation. These companies, by continuing such wasteful practice, show that they have no real interest in our area other than the immediate dollar that can be taken from it.

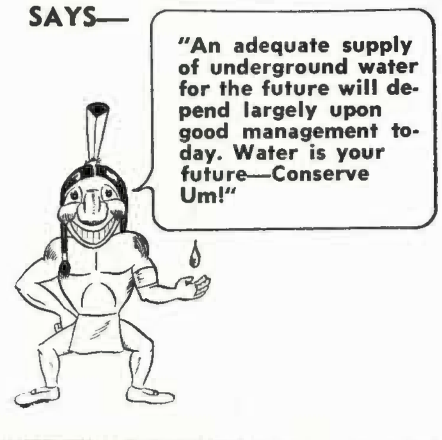
McFarland Seeks Tax Deduction On Underground Pipe

June 1954 — In keeping with the policy of the Board of Directors of the High Plains Underground Water Conservation District in encouraging the use of underground pipe as a water conservation measure and through the cooperation of the concrete pipeline companies, a hearing before the Senate Finance Committee was arranged regarding the deduction for installation of underground irrigation pipelines from annual income tax returns.

It is the feeling of the District that all the encouragement possible should be given to the irrigation farmer to aid him in the installation of such lines.

It has been pointed out to the Board that pipeline would be more readily installed if it were possible to deduct the cost immediately upon completion instead of showing depreciation over a period of years.

"CHIEF RUNNING WATER," SAYS—



CHIEF RUNNING WATER made his debut in a full-color comic book in April 1959. The Chief explained the need for water conservation to 5th, 6th and 7th graders within the Water District service area.

Ground Water Depletion Case Won

January 1963 — What many consider to be the greatest single economic development to occur in the Southern High Plains of Texas since the general acceptance of irrigation has come to pass.

The High Plains Underground Water Conservation District has received notification that the Honorable Joseph B. Dooley, Judge of the U.S. District Court for the Northern District of Texas has ruled that ground water in the Southern High Plains of Texas is a depletable natural deposit and as such is eligible for a federal income-tax deduction under the cost-depletion portion of the tax laws.

Mildred and Marvin Shurbet

His decision culminated long and continuous efforts by the Water District to obtain an income-tax deduction for water users throughout the area.

Back in 1954, the Board of Directors of the High Plains Water District authorized the District's staff to commence work on such a program. That decision was the beginning of a long but fruitful struggle.

The Water District first attempted to obtain an administrative ruling directly from the U.S. Internal Revenue Service. Such a ruling would have paved the way to a cost-depletion program for ground water users in the Southern High Plains of Texas.

A brief containing basic facts pertaining to ground water in the area, and other pertinent information, was prepared by Lloyd Croslin, a Lubbock attorney now deceased, and Ray Lawrence, a Lubbock Certified Public Accountant. After about a year's work on the brief, it was presented to the Internal Revenue Service by Croslin, Lawrence, and Joe Greenhill, an Austin attorney who now is an Associate Justice on the Texas Supreme Court. Congressman George Mahon was most helpful, particularly in arranging hearings before the federal agency.

Marvin Shurbet volunteered and was selected as the individual around whom the case would be prepared. Shurbet, a Floyd County farmer, had formerly been a member of the District's Board of Directors. He served at the time the depletion program efforts were instigated. He had a personal interest in the outcome of the case and was typical of the many irrigators in the Southern High Plains.

Finally, after preparing the case as diligently and as methodically as was humanly possible, the suit was filed. In January 1962, the case, styled Marvin Shurbet, et ux. v. United States of America, was tried in Judge Dooley's Court at Lubbock. Specifically, it asked for a tax refund of about $300.

One year after the trial, almost to the day, Judge Dooley's decision was announced in a letter to George W. McCleskey, Lubbock attorney for Shurbet and the Water District, and Louis F. Oberdorfer, Assistant Attorney General in Washington, D.C.

Judge Dooley's decision, if upheld on appeal, will mean that all persons in the Southern High Plains of Texas who can show a cost in the water beneath their land and who are using the water to produce income may take a deduction on their federal income tax returns for the cost of the water as it is depleted.

Open Hole Accident, No Pit Order Highlight 1960s Articles

Child Falls In Well

January 1960 — The thing that has been dreaded for so long has happened. A child has fallen into an abandoned irrigation well.

A 3-year-old boy, Randy Gene McKinley, and his family were visiting his grandfather near Dell City, Texas. Randy and a group of playmates were playing near an abandoned well, which was covered with a barrel. Some of the children had pushed the barrel away from the hole. Randy stepped into the well and fell feet first approximately 68 feet to the water that stood in the well. The 300-foot deep well was cased with 16-inch pipe from top to bottom. Randy apparently clung to the casing to hold his head out of the water.

J. Manuel Corral, a Mexican who works on the place, realizing that the boy's life would surely be lost in a very short time, suggested that he be lowered head-first into the 16-inch well.

A rope was secured to the feet of the 125-pound Corral, and he started the 68-foot head-first descent into the small dark well shaft. He became lodged several times and had to claw himself free. He became dizzy from the inverted position of his body. The foul-smell of the long unused well, the pain inflicted to his ankles by the rope and the thought that he might become stuck in the well undoubtedly caused Corral to approach a point of panic many times during the long 15-minute period it required to reach the boy. Only the thought of little Randy in the water below kept him squirming and inching his way steadily closer to the end of his mission. Finally, Corral reached the cold and crying lad after Randy had been in the well about an hour. Both were pulled back to the surface.

The greatest Christmas gift that could have been presented Mr. and Mrs. McKinley was given to them the day before Christmas — their son, well and no worse for the ordeal.

W.L. Broadhurst Resigns Position

February 1964 — Recognizing the opportunities Mr. W.L. Broadhurst has in getting back into a field of research in which he has spent most of his life, the Board of Directors of the Water District accepted his resignation effective as of February 15, 1964.

Mr. Broadhurst's contributions to the people of the Southern High Plains during the almost eleven years he spent with the Water District will have a marked bearing on many of the future plans of water development and conservation.

He did much of the research in the water depletion case tried in the Federal District Court two years ago and spent considerable time on the stand testifying in the case as a witness called by attorneys for Mr. Marvin Shurbet, the taxpayer.

It was through Mr. Broadhurst's efforts that many of the studies of the Ogallala Formation were begun and finally brought to published forms.

No Pit Order Issued

May 1966 — The Railroad Commission has issued orders banning the use of salt water disposal pits in all oil and gas fields in the thirteen West Texas Counties in the Ogallala Ground Water Region. The orders require that all pits (not just unlined) be drained and filled by the deadlines established.

Deadlines are May 1, 1967, for pits in Martin, Andrews, Bailey, Cochran, Dawson, Gaines, Hale, Hockley, Lynn, Terry and Yoakum Counties. Deadline for compliance in Hemphill and Swisher Counties is September 1, 1966.

Similar orders had been issued by the Water Pollution Control Board in parts of the Ogallala region before the Courts held, and the Legislature decreed, that the Railroad Commission has exclusive jurisdiction over oilfield wastes.

The Commission's orders cover the entire county in each case.

Water, Inc. A Reality

May 1967 — Independent people with independent ways built West Texas.

In fact, people have criticized West Texans of being so independent that they seldom agree on anything.

On May 24, the people of West Texas and Eastern New Mexico agreed. Water Incorporated was formed and has become a reality.

The Organization is a non-profit association founded to work for the vast importation of water to the High Plains and adjacent areas.

Cross Section Editors Noted

1954 - 1989

(1) Florence B. Jeu Devine (1954)
(2) Allan White (1955-1963)
(3) Claudette McGinnis (1963-1964)
(4) Bill J. Waddle (1964-1968)
(5) Tom Moorhead (1968)
(6) Jimmy Ross (1968-1970)
(7) Frank Rayner (1970-1971)
(8) John L. Seymour (1971)
(9) Frank Rayner (1971-1972)
(10) Rebecca Clinton (1972-1976)
(11) Frank Rayner (1976-1977)
(12) Pat Nickell (1977)
(13) D.D. Smith (1977-1978)
(14) Dean Thompson (1978-1979)
(15) Patricia Bruno (1979-1984)
(16) Kathy Redeker (1984-1987)
(17) Carmon McCain (1987-Present)

THE Cross SECTION

POSTMASTER: Send Address Changes To:
The Cross Section, 2930 Avenue Q
Lubbock, Tx 79405 Telephone (806) 762-0181

Tornado — The Storm of May 11, 1970

May 1970 — A massive storm with clouds towering over 55,000 feet, moved over Lubbock Monday evening, May 11, 1970. At about 9:30 p.m., this storm spewed a mammoth tornado, or tornados, that in a few short minutes swept away well over 1,000 buildings, and extensively damaged an estimated 8,000 others. Within hours, 20 dead were accounted for — eleven days later a total of 26 persons had died from injuries received in this storm. Three million dollars worth of automobiles and trucks (estimated to involve about 10,000 vehicles) were damaged or destroyed, as were over 100 airplanes. Property loss has been estimated to exceed 135 million dollars. All this damage was wrought by winds measured at over 200 miles per hour and estimated to have approached 300 miles per hour.

The tornado, or tornados, reportedly touched down at the intersection of 15th Street and Avenue Q, 140 feet west of the District's office, causing heavy damage and demolishing one building. However, the District's office sustained only very minor damage. No windows were broken, and there was no damage to the building's interior, furnishings or records.

By Wednesday noon, the streets had been cleared enough to permit free access to the office, and the debris scattered around the building and its parking lot had been removed by District personnel. For the next five days, the District's Field Representatives, Messers Goolsby, Seale and Seales then assisted with the city-wide recovery operations.

TORNADO DAMAGE — The offices of the High Plains Underground Water Conservation District No. 1 are shown at 1628 15th Street, Lubbock, Texas. Note the building at left that was destroyed by the May 11th storm. The building faces Avenue Q at the 15th Street intersection.

Irrigation Application Efficiencies Improve During the 1970s

Court Rules For Landowner

November 1971 — On October 27, 1971, the Texas Supreme Court handed down its decision in Sun Oil Co. v. Whitaker granting the landowner, Earnest Whitaker, damages because Sun Oil Company had used fresh water belonging to Whitaker for waterflooding purposes. The Court enjoined Sun from using any additional water belonging to Whitaker. The Court, however, did not require Sun to pay exemplary damages to Whitaker. Sun has filed a motion for rehearing with the Clerk of the Supreme Court.

Sun had filed suit against Whitaker in 1966 seeking to enjoin Whitaker from interfering with Sun's use of Ogallala water for waterflooding purposes. Sun claimed the right to use Ogallala water free of charge because of its rights under its oil and gas lease. Thereafter, Sun began to use fresh water for waterflooding purposes and Whitaker filed a cross-action seeking to stop Sun from using water and for damages from Sun for water used by Sun. Judge M.C. Ledbetter (the 121st District Court of Cochran County) entered a judgement for Whitaker after a jury found in favor of Whitaker.

Researchers Test Practice

February 1974 — A concept for prolonging an existing water supply, drip irrigation, is being considered by many researchers as a practice adaptable to the Texas High Plains.

Already employed at sites in other parts of the United States, drip irrigation is a means of applying a small and continuous amount of irrigation water to plants in specific concentrated areas of application.

Drip irrigation, considered to be a unique and effective method of saving water while maintaining a high level of productivity, is primarily used in greenhouses, gardens and orchards. However, its application is being researched for extensive use on other crops, such as cotton.

Board Accepts New Office

March 1975 — The Board of Directors of the High Plains Underground Water Conservation District No. 1, at its March 19 meeting, officially accepted the keys to the District's new office headquarters at 2930 Avenue Q in Lubbock.

Several years of planning the design of the facility and saving the funds for purchase of the property, construction and other professional fees were culminated by a groundbreaking ceremony July 11, 1974.

The 8,000-square-foot building will house all well records and related data, a reference library, a 30-foot by 40-foot board room (featuring sound-projection equipment), a photography reproduction laboratory and a water quality analysis laboratory.

OILFIELDS SURVEYED — Don McReynolds, Frank Rayner and Dan Seale (left to right) plan an aerial survey of some of the oil fields within the District to locate open, unlined salt water disposal pits.

Pivots Save Fuel and Water

June 1976 — Sprinkler irrigation, said by many researchers and irrigators to be a way to stretch the water supply and avoid wasteful runoff, has become more and more popular on the High Plains of Texas.

According to the 1975 High Plains Irrigation Survey, prepared by the Texas Agricultural Extension Service, Lubbock, sprinkler systems in the 40-county High Plains area irrigated 1,577,000 acres, or 25 percent of the area's total irrigated acreage.

Approximately 27 percent of the 1,230 sprinkler systems used in 1975 are the center pivot type, and use of the center pivot increased 11 percent in 1975.

Death Trap Attracts Explorer

April 1978 — The small hole in the ground (about 16 to 20 inches in diameter) seemed innocuous. The old well site was a long way from Lubbock when it was drilled many years ago, but the city had finally grown around the farmer's field.

A housing area with hundreds of kids was less than three blocks away to the west and Lowery Field was within a hundred yards to the northwest of the abandoned site. It was an inviting target for kids to explore.

The old, solid concrete, well pumpbase was about five feet long on its four sides and about one foot thick, weighing about three thousand pounds.

The old sixteen-inch casing of the well had sunk into the earth, was now about five feet beneath the bottom of the concrete base and was still uncapped. But that wasn't the horrifying part.

Scrape-marks on the walls were clearly visible where someone, probably small children, had been down in the small cavern mining it out to make it a larger and more comfortable hiding and playing area. Also found were old soft drink cans and a wooden window shutter that had apparently been used to cover the open hole of the casing.

How much more would it have taken before the pumpbase thundered down on its unsuspecting visitors? How much longer before the shutter disappeared down the over one-hundred-foot deep hole along with an unwary child? The "double death trap" was set and baited for an adventurous child.

Thankfully nothing else will be put down its "death tube." The owner of the land has had it permanently sealed. You can't even see where it was anymore, thanks to the leveling of two mounds of earth.

Field Lab "Practical Tool"

July 1979 — "The whole purpose of the Field Water Conservation Laboratory," according to Water District Agriculturalist Ken Carver, "is to show the farmer some simple, inexpensive, and commercially available equipment that he can use in practical water management on his farm." With that brief introduction, the District's Board of Directors took a hands-on tour of the recently assembled and equipped trailer which has since been delivered to the Lubbock area Soil Conservation Service office for use in field training workshops.

The trailer is equipped with meters, gauges, fittings, probes, instruments and hand tools enough to do the job of evaluating the efficiency of nearly any irrigation system on the High Plains. Total cost of the equipment and trailer was six thousand, six hundred dollars, an expense the Directors feel is well justified in the potential savings it offers to area irrigators.

CARL BUTLER raises the sock to check the water flow from his sprinkler.

New Sprinkler Design Gets High Efficiency

August 1980 — Would you believe a 99.6 percent efficiency rating on an irrigation distribution system? Carl Butler got it with his modified sprinkler system, low pressures, drop lines and canvas socks under a center pivot.

Butler's unique system is circling a 640 acre tract in Hockley County a mile east and four and a half miles south of Anton. It is an original idea, and it is drawing a good deal of attention from farmers and irrigation manufacturers alike.

Butler has modified his irrigation system with a series of pipes, joints, and flanges. He rigged the pipes to connect from the original water outlet on top of the transmission line. He has positioned drop lines to fall directly over the furrow row to be watered and to bring the water within two feet above the land surface. A 20 inch, swiveling, adjustable tube positions the water in the center of the furrow. The tube is plugged with a plastic cap which has a precision cut hole in it. The hole at each drop is a different size: smaller where water pressure is highest close to the tower at the water intake point and larger at the end of the line where pressure is lower. This allows the same amount of water to be released in each row. The plastic cap is covered with a flexible plastic pipe and a canvas sock which drags in the furrow and lays the water right down the row on a diffused distribution pattern which prevents soil erosion and virtually eliminates loss to evaporation in the water application.

Butler has also incorporated another unique feature in his operation. He has plowed his rows in a circle to conform to the center pivot's modified watering system. He is farming two rows in and one out and delivering his water between the two rows. The pivot covers the entire section except the corners which he furrow irrigates conventionally.

Surge Irrigation, Aquifer Water Level Rises Featured In 1980s

November 1982 — For the furrow irrigator whose soil takes in massive quantities of water at the top end of the field and loses it to deep percolation while the stream moves toward the bottom of the row, there is a new row watering technique.

The equipment investment is minimal. It uses much less water to furrow irrigate the same number and length of rows. It can do the job in much less time or can water twice as many rows in about the same time. It eliminates or cuts tailwater runoff to a minimum. It dramatically reduces deep percolation losses, and to top it all off, the system is automated and is already commercially available. Sound too good to be true?

The technique is a new concept in row watering called surge irrigation. It involves turning the irrigation flow on and off for set lengths of time rather than allowing it to continuously flood from one end of the field to the other.

Secondary Recovery Studied

December 1985 — Progress on the investigation of the release of water from the wet sands of the Ogallala Formation has to date been very gratifying. A tremendous amount of knowledge has been gained since the investigation of the concept began in mid-1981.

Three sites have been field tested, and the changes in the water levels which have occurred at each site have been illustrated in maps in issues of the *Cross Section.*

The first item of significance observed from these tests is the fact that water levels rose following each test, which indicates that water is released when air is injected under pressure into the wet sand formation. Secondly, water level rises continue to occur for at least a three-year period after an air-injection test has been conducted.

Thirdly, it has been noted that the length of time that air needs to be injected into the formation is relatively short; and there is a direct relationship between the volume of air injected and the injection pressures to the area of material which can be stimulated to release water.

All three of the field sites tested thus far are located in areas that have a high density of wells that have been seasonally pumped. This has made it somewhat difficult to monitor the total effects of secondary recovery operations. Pumpage of some local wells masks the long-term drainage to some extent.

Several cities have indicated an interest in using secondary recovery techniques to increase their water supplies. However, none have immediate plans for doing so, because, at the present time, they do not need additional water to meet their foreseeable future demands.

First-Ever Water Rise Noted

April 1987 — The High Plains Water District has recorded another first in its 36-year history by documenting an average net rise in the water levels in observation wells penetrating the Ogallala Formation throughout the District's 5.2 million acre service area. The net rise of more than one-half foot indicates a reverse in the trend of water-level changes from a decline in water levels to stabilization of the aquifer.

"The most important thing about a zero net change, such as that recorded last year, or a net rise, such as what we have this year, in the measured water levels is that the amount of water in the aquifer is not changing significantly. The aquifer is stablizing," states Don McReynolds, Director of the Geohydrologic Division at the Water District. "If we're not using the water now, it means more water will be available for future use."

Nuclear Waste Site Halted

February 1988 — The Department of Energy (DOE) has been ordered by Congress to stop characterization studies within 90 days at the proposed high level nuclear waste disposal sites in Deaf Smith County, Texas and Hanford, Washington.

The DOE was authorized to conduct a characterization study at the Yucca Mountain, Nevada, site. If the study reveals the site to be unfavorable for high level nuclear waste storage, the DOE must then return to Congress for further project instructions.

During the past several years, the High Plains Underground Water Conservation District No. 1 has closely monitored DOE work plans and studies for the Deaf Smith County site. High Plains Water District staff advised the DOE and Congress of various technical problems associated with the possible use of the site which could endanger the Ogallala Aquifer.

Congress resolved the issue in its year-end action. Thank God.

— A. Wayne Wyatt

THE CROSS SECTION (USPS 564-920)
HIGH PLAINS UNDERGROUND WATER
CONSERVATION DISTRICT NO. 1
2930 AVENUE Q
LUBBOCK, TEXAS 79405

SECOND CLASS PERMIT

THE Cross SECTION

Published monthly by High Plains Underground Water Conservation District No. 1, 2930 Avenue Q, Lubbock, Texas 79405—Ph. 762-0181

Volume 35—No. 7 Publication Number USPS 564-920, Second Class Postage paid at Lubbock, Texas *July 1989*

Water legislation considered during 71st Legislative Session

MANAGER'S NOTE: The regular session of the 71st Texas Legislature adjourned at midnight May 29. More than 5,000 bills had been introduced. Most received consideration in committee hearings. Some passed both houses of the legislature. Some have been signed by Governor Clements and have become law. Many of those that failed to pass this session will likely be revised and reintroduced in the next regular session. Legislation addressing water issues is always a hot topic and draws interested parties from all parts of the state.

Our principal goals for this session were to assist Senator John T. Montford in passage of legislation to extend the Agricultural Water Conservation Equipment Loan program, to assist Representative Terral Smith in revising Chapter 52 of the Texas Water Code to simplify and streamline some of the administrative procedures required of underground water conservation districts and to assist Representative Smith to obtain passage of this legislation in the House of Representatives and Senator H. Tati Santiesteban to obtain passage in the Senate. We also worked to prevent passage of legislation that threatened private ownership of underground water. The March and May issues of *The Cross Section* carried summaries of many of the water-related bills. Those interested in legislative action may enjoy a summary of the activities associated with some of these bills and learning about their final outcome. — **A. Wayne Wyatt.**

SB 1117/SJR 44

A pilot agricultural water conservation loan program was approved by the legislature in 1985. This being the first time such a program had been attempted, the legislature set a time limit of two years to

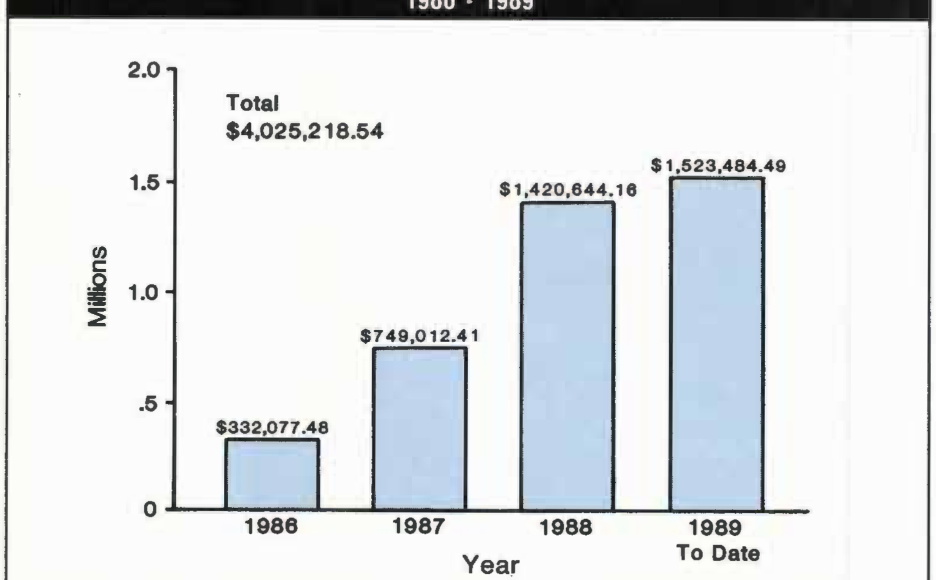
Senator John T. Montford

evaluate the results. In 1987, the legislature extended the evaluation period two years to August 1989. The pilot program was financed from state funds and has been a success.

In November 1985, Texas voters approved a Constitutional Amendment authorizing the sale of up to $200 million in bonds to finance a continuing program, with a termination date of August 1989.

Senator John T. Montford introduced the bills needed to extend the time on the Agricultural Water Conservation Equipment Loan Program in SB 1117 and SJR 44. SB 1117 is the enabling legislation for the program. SJR 44 provides for the Constitutional Amendment which will need voter approval in November for the

PILOT AGRICULTURAL WATER CONSERVATION EQUIPMENT LOANS MADE BY THE HIGH PLAINS UNDERGROUND WATER CONSERVATION DISTRICT 1986 - 1989



Senator H. Tati Santiesteban

program to continue.

In their passage through the two houses of the Legislature, the two bills were treated as a set, being heard and voted on together. At the hearing in the Senate Natural Resources Committee March 22, a substitute was introduced for SB 1117. The changes were in the administrative handling of loans. The bills received a favorable report from the Committee. They were placed on the Senate Intent Calendar for April 3. They passed the Senate April 3 and were sent to the House, where they were introduced and referred to the Natural Resources Committee.

They were heard before the Natural Resources Committee April 19, where another substitute was introduced. These changes had to do with the handling of the bonds which would fund the program. With a favorable report from the Natural Resources Committee, the bills were referred to the Calendars Committee. The Calendars Committee placed the bills on the agenda for House consideration. They passed first reading without question. At second reading before the House of Representatives, a floor amendment was added to SB 1117; and the bills were passed to third reading. After passing third reading in the House with the floor amendment, they were sent back to the Senate. The Senate concurred with the House amendments, and SB 1117 was sent to the governor.

SB 1117 was signed by the governor June 17, while SJR 44 was filed without signature May 23. Texas voters will decide in November 1989 whether to extend the length of time for the program.

Representative Terral Smith

If the voters approve, the program will become permanent in the spring of 1990.

SB 1212/HB 2477

The Texas Water Code as it has existed sets out guidelines for administrative requirements for General Law Districts in Chapter 50, provisions for Water Control and Improvement Districts in Chapter 51, and specifics for Underground Water Conservation Districts in Chapter 52. Where no specifics for Underground Water Conservation Districts were given in Chapter 52, Chapter 50 and Chapter 51 had to be searched to find legal guidance. Representative Smith and Senator Santiesteban felt that the operation of underground water conservation districts could be more efficient by bringing the applicable provisions from Chapter 51 into Chapter 52, with appropriate adaptations.

Representative Smith filed HB 2477 on March 9, and Senator Tati Santiesteban filed SB 1212 on March 10. Differences between the two versions were mostly grammatical.

HB 2477 was set for hearing before the House Natural Resources Committee April 12. At the hearing, testimony was given explaining the need for a more explicit definition of tailwater, as well as requesting a few other provisions in the bill that had not been included. The bill was referred to subcommittee, where the changes we had asked for were made. It then went back to committee, where it was reported favorably as substituted, and sent to the

See STATE Page Two

State lawmakers debate Edwards Aquifer management issue

Continued From Page One

Calendars Committee to be scheduled for consideration by the full House of Representatives.

A flood of bills from other committees to the Calendars Committee delayed the bill being set for floor debate. Meanwhile back in the Senate, SB 1212 came up for hearing. A substitute was offered by Senator Santiesteban, which included the changes previously made by the House committee. The Senate Natural Resources Committee reported the bill favorably to the Senate, and it was set on the local calendar and passed by the Senate May 20.

SB 1212 was sent to the House of Representatives and referred to the Natural Resources Committee on May 23. With only a few days remaining in the session, the committee squeezed a hearing of the bill into their busy schedule and reported it out favorably, with an amendment which would allow the Texas Water Commission to place some restrictions on the powers of a district being formed under Chapter 52.

On May 26, during the second reading of the bill, the House of Representatives added two floor amendments. One of the amendments changed the definition of tailwater. The other amendment incorporated what had started out as HB 2299. HB 2299 provided a path for arbitration by a committee made up of managers and/or directors of other water conservation districts where two or more water conservation districts exist within a management area designated by the Texas Water Commission and a conflict arises between these districts over whether one of them is fulfilling the purposes for which it was created. On May 27, the House of Representatives passed SB 1212 with the two floor amendments and one committee amendment.

With only one day left in the session, the Senate refused to concur with the amendments and appointed members to a conference committee on May 28.

May 29 was the last day of the session. During that day, action was chaotic and hard to follow. Somehow during that wild day, a conference committee was appointed by the House, and the committee members met with their counterparts from the Senate to work out an agreement between the Senate version and the House version of SB 1212. The final version again changed the definition of tailwater and shortened the processes originally laid out in HB 2299.

The Senate adopted the conference report; and with only 15 minutes remaining in the session, the House also concurred.

Governor Clements signed SB 1212 into law June 18, and it will become effective September 1, 1989. After that time, some changes in our rules will have to be made to conform with the changes in the law.

SB 1441/HB 2771/SCR 157

Called the *Edwards Aquifer Water Administration Act*, versions which were virtually identical were filed in both the House of Representatives and the Senate. SB 1441 was filed by Senators Krier and Tejeda, while HB 2771 was filed by Representative Terral Smith in early March.

The control and management of the Edwards Aquifer has become a highly-charged emotional issue. Proponents are convinced that only through state control of the aquifer can the public good be served. They believe that any lowering of the levels of water contained within the aquifer should not be tolerated and that continuous spring-flow from the aquifer must be guaranteed. Opponents have varied objections to the concepts laid out in this proposed legislation, but are in agreement that state control is to be avoided at all costs.

HB 2771 came up for hearing first. The hearing was held on the floor of the House. Many of those speaking in favor of the bill are practiced public speakers, such as San Antonio Mayor Henry Cisneros. They presented facts and figures showing a steady lowering of the level of water within the aquifer and spoke of the risk of a future without enough water for the residents of the city of San Antonio and the tragedy of the loss of spring flows even for short periods of time.

More than 200 people registered to testify against the bill. These people were mostly residents within the recharge area of the Edwards Aquifer. For hour after hour, they spoke passionately about the right of capture of groundwater and the ownership of groundwater. The gist of their arguments was that the proposal would, for all intents and purposes, be a confiscation of private property by the state without just recompense.

After hearing almost nine hours of testimony, the House Natural Resources Committee referred the bill to subcommittee for further study.

A week later, on April 12, the Senate Natural Resources Committee heard testimony regarding SB 1441. The small size of the hearing room limited the number of people able to get in, and there was standing room only. Anyone leaving the room, even for a minute, was replaced by someone waiting in the hall and could not return to the room. Chairman Santiesteban limited testimony on each side to about an hour and a half. Though the speakers were fewer, both sides selected their best to represent them. SB 1441 was referred to subcommittee.

A House subcommittee hearing was held May 4, and a substitute bill was introduced. The House committee set a hearing for May 10, but HB 2441 was never called up.

Meanwhile, several bills which would have created one or more underground water conservation districts in Uvalde and Medina Counties were filed. Residents of Medina County and Uvalde County had voted to be removed from the Edwards Underground Water District earlier in the year. All bills were referred to the Natural Resources Committees. Hearings were conducted on two or more of the bills, but final action was never taken by the committee in either the House or Senate.

SCR 157 was filed by Senator Kreir late in the session. The intent was to create a special committee to study the problems of the Edwards Aquifer area and make recommendations for solution. SCR 157 was referred to the House Administration Committee. However, no action was taken.

In spite of the flurry of activity and the great emotion surrounding the Edwards Aquifer problem, the 71st Regular Legislative Session ended without any legislation being passed in regard to the issue.

HB 422

Filed by Representative Smith January 16, this bill would have provided for assumption of jurisdiction by the Texas Water Commission of territory in which an election to create an underground water conservation district or to join an existing district was defeated.

Hearing was set for April 26 by the House Natural Resources Committee. President George Bush visited Austin on this date and addressed the Legislature. The committee hearing was delayed until late in the evening. The committee adjourned after midnight before this bill was reached on the agenda.

Although the session ended without action on this issue, it is almost certain that the issue will continue to come up each session until it is passed.

SB 847/HB 1267

Representative Robert Junell filed HB 1267 February 20. The bill expanded the items in the matching funds-grant program of the Texas Water Development Board to include water quality testing equipment. It was referred to the Natural Resources Committee where a hearing was set for March 22. An amendment affecting administrative procedure was added, and the bill was reported favorably to the House. It was set on the local calendar for April 13.

See NEW Page Four

Mark Menke appointed new Potter County committeeman

At their regular June meeting, the High Plains Underground Water Conservation District No. 1 Board of Directors appointed Mike Menke of Bushland to serve the unexpired term of Potter County Committeeman Linden C. Moore Jr. of Bushland, who died May 16th.

Menke, 34, farms 650 acres in Potter County and an additional 450 acres in Randall County. With wheat, milo, oats and sunflowers as principal crops, Menke has incorporated water-saving equipment and techniques, such as surge valves and furrow diking, into his farm management program. His brother, Mark, served on the District's Potter County Committee from 1979 to 1988.

Potter County residents may contact Menke regarding Water District matters at Route 1, Box 476, Amarillo, Texas 79106 or by calling (806) 352-7534.

Moore, 71, had served on the Potter County Committee since 1985 and was also a member of the Bushland Water Board. He was born in Electra, Texas, and lived in Amarillo for 18 years before moving to Bushland where he lived for 32 years. He was employed by International Harvester and farmed in the Bushland area after his retirement. Moore was a U.S. Army Air Corps veteran of World War II. Survivors include his wife, a daughter, a son, three sisters, a brother and three grandchildren.

THE Cross SECTION

THE CROSS SECTION (USPS 564-920)

A MONTHLY PUBLICATION OF THE HIGH PLAINS UNDERGROUND WATER CONSERVATION DISTRICT NO. 1

Second Class Postage Paid at Lubbock, Texas District Office at Lubbock

POSTMASTER: Send address changes to: **The Cross Section,** 2930 Avenue Q, Lubbock, TX 79405 Telephone (806) 762-0181

CARMON McCAIN, Editor
DIRECTOR, INFORMATION/EDUCATION

Irrigation methods for feedlot effluent management noted

Disposal of livestock waste and rainfall runoff from feedlots provides both a problem and an opportunity for many Texas High Plains livestock operations. State and federal laws and regulations require safe containment of feedlot wastewater to prevent surface water and groundwater contamination. About 70 to 75 percent of the cattle feeding operations on the High Plains use holding ponds to collect rainfall runoff from feedlot surfaces. About 20 to 25 percent of the feedlots use playa lakes to contain the runoff. A 200-acre feedlot produces 27 to 33 million gallons of wastewater per year.

Although most feedlots use furrows to apply this wastewater to the soil, big gun sprinklers, border irrigation and center pivots can also offer several advantages for managing effluent, says Dr. John M. Sweeten, an Agricultural Engineer who specializes in agricultural waste management for the Texas Agricultural Extension Service at College Station. Land application of wastewater utilizes the soil's filtration and absorption capacities to treat effluent by stabilizing organic solids, reducing pathogens and utilizing nutrients, such as nitrogen and phosphorus.

RAINFALL RUNOFF FROM FEEDLOTS COLLECTED—Holding ponds help contain rainfall runoff from feedlot surfaces. Managing effluent in this manner allows feedlot operators to avoid any potential surface and groundwater contamination. *Photo Courtesy of Dr. John Sweeten.*

Sweeten adds that careful irrigation system design and management is necessary to avoid problems that can be associated with effluent irrigation. These include tailwater runoff, nutrient overloading and salt accumulations.

Nutrients

"Effluent application rates are limited by the nutrient content, particularly nitrogen and phosphorus. The amount of nitrogen applied through wastewater irrigation should not greatly exceed the crop's annual nitrogen uptake as determined by soil testing and crop fertility guides," says Sweeten.

No more than six to eight inches of straight feedlot effluent should be applied during an irrigation season, he adds.

Wastewater nitrogen concentrations vary from 20 to 60 pounds per acre-inch for cattle feedlot runoff stored in holding ponds. Effluent stored in a playa lake that collects runoff from several hundred acres, in addition to a feedlot, will be more diluted and thus nitrogen and salinity levels will be much lower.

Sweeten emphasizes that soil testing and effluent testing are necessities. Wastewater needs to be tested for all forms of nitrogen and not just for nitrates. Nearly 80 percent of wastewater nitrogen is present as ammonium, he says.

The phosphorus content in feedlot wastewater varies widely and averages about 10 to 12 pounds of elemental phosphorus per acre-inch.

Salinity

Feedlot runoff can be high in terms of total salinity hazard. Feedlot wastewater contains from 3,000 to 10,000 parts per million total dissolved solids (TDS). The upper limit for irrigation water is 1,500 to 2,000 parts per million TDS without restricted crop selection or application.

Irrigating with high saline water can result in salt accumulation in the soil and cause crop damage. Most of the salts are potassium, chloride, bicarbonate, calcium and sodium, according to laboratory test results, Sweeten says.

"Some dilution is usually in order. If you don't get dilution by playa basin storage, you need to dilute with fresh irrigation water," he says. High salinity levels in medium and fine textured soils require a 10 to 25 percent leaching fraction, or a fresh water runoff dilution ratio of 2:1 or more, to leach the sodium salts out of the upper soil profile.

Runoff

Tailwater runoff from effluent irrigation must be avoided because of the concentration of biochemical oxygen demand (an important measure of wastewater strength), total dissolved solids, nutrients and pathogens.

Surface irrigation in level borders is an excellent way to control runoff of applied effluent and is preferred to furrow irrigation. Control of potential runoff from big gun and center pivot sprinkler systems requires attention to sprinkler design, nozzle selection and sprinkler operation. In addition, tailwater control terraces, collection pits and vegetated buffer strips may also be needed to collect runoff or reduce the organic matter content.

Sweeten notes that soil management techniques such as deep ripping the soil or conservation tillage help reduce irrigation runoff. He advises irrigators to pay careful attention to effluent application rates and to avoid steep slopes. "Don't irrigate within 100 feet of a drainage canal or ditch," he says.

Particle Size

Big gun sprinklers and flood irrigation in level borders do not require filtration. However, center pivots usually require a primary settling treatment and any accompanying secondary biodegradation treatment that may occur in holding ponds to remove coarse particles.

Surface Storage

Cattle feedlots produce runoff at a rate of one-quarter to one third of the area's annual rainfall. Thus an 18-

See PROPER Page Four

Feedlot effluent could produce algae for fish food

Aquaculture experts believe effluent from High Plains cattle feedlots could play a major role in the future production of algae for fish food.

Utilizing algae-based fish food instead of fish food made from soybeans will improve the health benefits of eating farm-raised fish, according to Dr. Nick C. Parker, leader of the Texas Cooperative Fish and Wildlife Research Unit at Texas Tech University in Lubbock.

"Fish take fatty acids from their food and incorporate them into their flesh. Soybeans are a major fish food ingredient, and they contain the fatty acid, Omega-6. The touted health benefits of fish and fish oils are caused in part by Omega-3 fatty acids. By incorporating Omega-3 acids from other fish food sources, we can block the conversion of Omega-6 fatty acids into eicosanoids — the hormone-like materials believed to contribute to arthritis and other diseases," he says.

Research has shown that ocean fish feeding on phytoplankton and other lower food chain organisms have higher amounts of Omega-3 fatty acids than is found in farm-raised fish.

"If we can incorporate the Omega-3 fatty acids into the fish feed, then we could have another commodity for the Texas High Plains," he says.

Water and feedlot effluent unsuitable for crop production may be just right for growing algae on the Texas High Plains.

"The nutrient-rich organic mixture would be digested anaerobically before being added to water in a 50-foot-long, algae-seeded, fiberglass tank. The algae would feed upon the nutrients contained in the effluent mixture. Air jets would be used to keep the water circulating and to bring water from the bottom of the tank to the surface where sunlight could strike it. This should allow algae to grow within the entire water column," he says.

When ready for harvesting, the algae would be removed from the tank and allowed to dry naturally. Parker adds that the warm temperatures and low humidities characteristic of the Texas High Plains are ideal for algae drying. After this process, the algae is ready to be incorporated into the fish meal.

Parker says additional research will be required to determine if the algae-based fish food could be produced without acquiring any off flavorings. "Some algae continually produce natural off flavor compounds, while others produce them when they become stressed."

Fish are the second largest product imported by the United States. The nation's number one import, petroleum, was valued at 16.5 billion dollars in 1987. Fish and fish products followed with a value of 8.8 billion dollars.

Demand for fish products continues to be high, but despite increased U.S. production, the supply can't meet the demand. Catfish production in the United States has increased 300 percent during the past 25 years. In 1960, the surface area for commercial catfish ponds was a mere 400 acres. By 1985, the surface area had increased to 121,030 acres. In Mississippi alone, more than 83,980 acres of surface area were used for catfish production.

Catfish accounts for 51 percent of the fish produced in the United States. Although considered a Southern gamefish, catfish has recently gained popularity with diners in restaurants as far north as New York City.

In 1988, 295 million pounds of farm-raised catfish were processed to yield about 160 million pounds of edible product, or 55 percent of returned product. However, Parker notes that this amount is less than one pound of edible fish per person in the United States.

"The 1987 per capita consumption of fish increased by one pound of fish per person. Americans now consume an average of 15½ pounds of fish per year. We will have to continue importing fish to accommodate that extra one pound of fish per person," he says.

Proper irrigation system design avoids effluent runoff problems

Continued From Page Three

inch average annual rainfall on a 200-acre feedlot will produce about five to six inches, or 1,000 to 1,200 acre-inches, of runoff a year which must be contained.

The Texas Water Commission (TWC) requires feedlots to have runoff retention ponds capable of holding runoff from a 25-year 24-hour runoff event. In the Texas High Plains, this would be a five-inch rain received in a 24-hour period. "The runoff fraction is usually 75 to 80 percent of this design storm," Sweeten notes.

A 200-acre feedlot that feeds about 41,000 cattle would be required to have a one-time holding capacity of about 780 acre-inches, or about 21 million gallons.

When soil or crop conditions are not suitable for irrigation, the wastewater must be stored in clay-lined holding ponds to prevent seepage. The TWC sets minimum standards for soil liner characteristics and thickness.

Should the retention pond or lagoon become half full or more, the TWC requires the feedlot to restore the pond's required minimum holding capacity within 21 days. This is usually accomplished by irrigation pumping and evaporation. The pond's storage capacity should be greater than the required minimum if the feedlot operator wishes to save the runoff for optimum irrigation application times, Sweeten says.

Year-round irrigation opportunities provide a good way to maintain wastewater storage capacities at the required level. Sweeten says, "It's important to have double cropping to the extent possible with both summer and winter crops. I always tell people when they irrigate with wastewater to have something green growing all the time to maximize uptake of nutrients and moisture."

Aerosol Drift

Fine droplets produced by high pressure center pivots are more susceptible to aerosol drift, possible pathogen dispersal and odor problems than the larger droplets produced by low pressure center pivots or big gun sprinklers which discharge the droplets closer to the ground, Sweeten says.

Odor

"Odor emission is largely a surface area phenomenon. If you can restrict the wetted surface to a smaller area, then you get less odor emission. When wastewater goes into the soil, you have essentially no odor from the soil itself," he says.

Feedlot managers using effluent for irrigation may have several options to reduce the "FIDO" factors — odor frequency, intensity, duration and offensiveness.

These include frequent removal of wastewater from storage systems; operating sprinkler systems only during daylight hours to promote odor dispersal and allow surface drying; scheduling irrigation according to wind direction; diluting wastewater with fresh water; and possibly installing low pressure spray nozzles on center pivot drop lines.

New underground water conservation districts authorized

Continued From Page Two

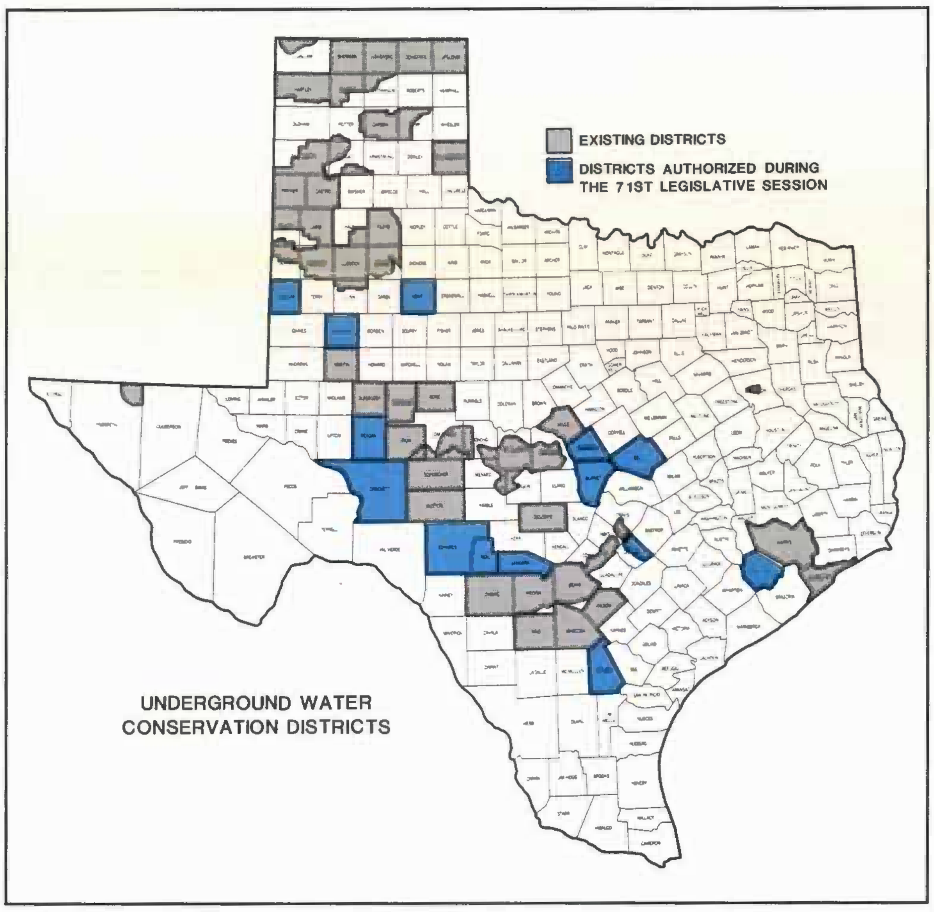
Senator Bill Sims filed a companion bill, SB 847, on March 3. A hearing before the Senate Natural Resources Committee was held March 29. Senator Sims offered a substitute bill, which included the amendment adopted by the House Natural Resources Committee. The Committee voted SB 847 favorably to the Senate as substituted. It was set on the Senate local calendar and passed by the Senate on April 5. The House Natural Resources Committee included SB 847 on its agenda of April 11 and reported it favorably from committee. SB 847 was then set on the House local calendar for April 13.

On April 13, the House version was laid on the table subject to call, and the Senate version passed in the House. The Governor signed SB 847 into law April 26.

This new law will provide cost share grants to water conservation districts to purchase equipment to do water quality testing within their service areas. This will help us stretch our local taxpayers' dollars to perform our job a little better.

SB 61/SJR 5

Senator Montford filed SJR 5, proposing a Constitutional amendment, and enabling legislation SB 61 on December 9. The purpose of this legislation is to allow the Texas Water Development Board to issue bonds to provide up to $500,000,000 for low interest loans to municipalities for water supply, water quality and flood control purposes. There was no opposition to this legislation, and it passed the Senate without incident. In the House, a floor amendment was added which affected the administrative procedures dealing with the bonds. After passage in the House, the Senate concurred with the House amendment. SJR 5 was filed without signature May 31.



New Underground Water Conservation Districts

Legislation providing for creation of 18 new underground water conservation districts was considered by the legislature. Most will encompass only a single county. Those that passed are as follows: Bandera County, Bell County, Burnet County, Crockett County, Dawson County, Fort Bend County, Kent County, Lampasas County, Live Oak County, parts of Caldwell, Hays and Travis Counties, Reagan County and Yoakum County.

THE CROSS SECTION (USPS 564-920)
HIGH PLAINS UNDERGROUND WATER
CONSERVATION DISTRICT NO. 1
2930 AVENUE Q
LUBBOCK, TEXAS 79405

SECOND CLASS PERMIT

THE Cross SECTION

Published monthly by High Plains Underground Water Conservation District No. 1, 2930 Avenue Q, Lubbock, Texas 79405—Ph. 762-0181

Volume 35—No. 8 Publication Number USPS 564-920, Second Class Postage paid at Lubbock, Texas *August 1989*

After legislators deadlock over issue

Guadalupe-Blanco River Authority files lawsuit seeking State regulation of Edwards Aquifer groundwater pumpage

The management of groundwater in the Edwards Aquifer continues to be a controversial issue. A lawsuit, "In Re: *The Adjudication of Rights to Water in the Edwards Aquifer,*" was recently filed in Hays County District Court by the Guadalupe-Blanco River Authority (GBRA) headquartered in Seguin.

In their petition, the GBRA cites unregulated pumpage from the Edwards Aquifer as a threat to the Comal and San Marcos Springs, the Guadalupe River Basin, the San Antonio Bay and Estuary and the entire Edwards Aquifer. The GBRA's lawsuit seeks to give the Texas Water Commission the power to regulate the pumping of water from the aquifer in order to protect and maintain water flow through the Comal and San Marcos Springs.

The GBRA contends that the Edwards Aquifer is an underground stream with a definite water supply source, a definite destination, known boundaries, a current of water and a known presence of aquatic life and is therefore an underground stream.

Texas State law defines underground water as "water percolating below the surface of the earth that is suitable for agricultural, gardening, domestic or stock-raising purposes, but does not include defined subterranean streams or the underflow of rivers." Groundwater in Texas belongs to the owner of the land.

The petition claims that the spring flow from the Edwards Aquifer "has constituted a significant portion of the flow of the Guadalupe River during normal weather conditions and most of the flow ... during dry conditions." It further contends that spring flow from the aquifer "is being intercepted by massive, unregulated diversions from wells, before the water reaches the Comal and San Marcos Springs."

According to an article published in the June issue of the *Texas Water Report,* pumpage from the aquifer has been increasing steadily since the turn of the century.

"Circa 1900, total diversion from wells was around 30,000 acre-feet, with the amount rising to 100,000 acre-feet by 1934, with a rapid increase in the last 25 years, to reach some 530,000 acre-feet in 1984. Most of the use, and increase, recently has been in Bexar County, with 310,000 acre-feet withdrawn in 1984."

The article cites a current count of more than 800 major wells used for public supply, irrigation and industrial purposes within the area and points out that the number is increasing without any regulation by the State.

GBRA's petition notes that increased pumpage "has had a significant and progressively greater adverse effect on the Comal and San Marcos Springs." The springs dried up during a severe drought in the 1950s, and studies indicate that "future droughts, with more wells pumping, would result in both springs drying up for long periods or permanently." The GBRA claims that "severe environmental and economic damage" would occur in the Guadalupe Basin as a result.

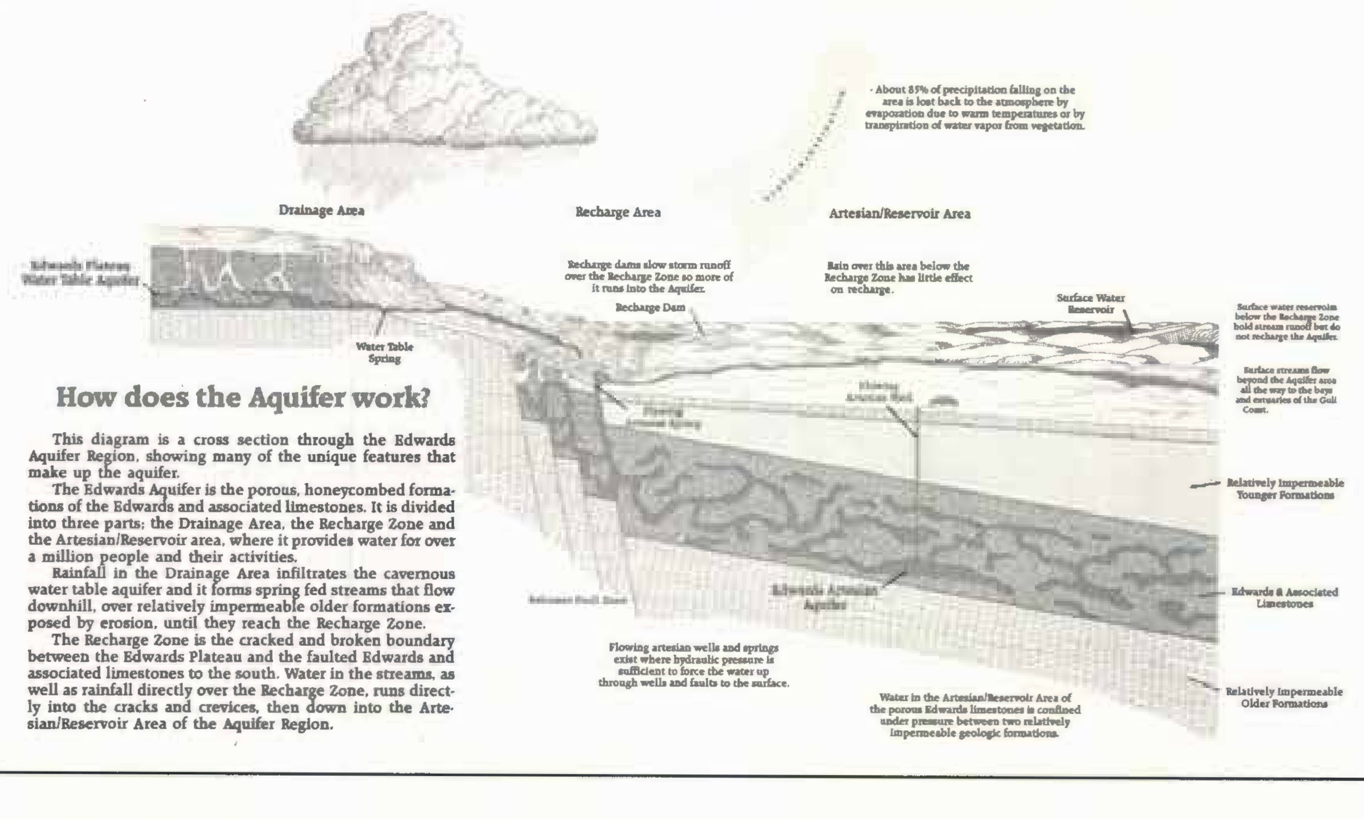
Battle lines concerning the lawsuit are being drawn. The City Councils of New Braunfels and San Marcos may support the GBRA lawsuit. Opponents are expected to include the city of San Antonio and groups in Medina and Uvalde Counties.

The River Authority has also notified Secretary of the Interior Manuel Lujan Jr. of alleged violations of the Endangered Species Act. According to the *Texas Water Report,* individuals who have pumped water from the Edwards Aquifer and/or federal agencies "authorizing funding or carrying out pumping" from the aquifer could be named as violators.

If the Department of the Interior rules that the species cited are endangered, Federal agencies, well owners and pumpers could be forced to develop a conservation program for endangered and threatened species in the Comal and San Marcos Rivers or work to protect their habitats.

The endangered or threatened species listed by the GBRA are found in Hays County and include the San Marcos Gambusia, the Fountain Darter, Texas Wild Rice and the San Marcos Salamander.

The Edwards Aquifer System



How does the Aquifer work?

This diagram is a cross section through the Edwards Aquifer Region, showing many of the unique features that make up the aquifer.

The Edwards Aquifer is the porous, honeycombed formations of the Edwards and associated limestones. It is divided into three parts; the Drainage Area, the Recharge Zone and the Artesian/Reservoir area, where it provides water for over a million people and their activities.

Rainfall in the Drainage Area infiltrates the cavernous water table aquifer and it forms spring fed streams that flow downhill, over relatively impermeable older formations exposed by erosion, until they reach the Recharge Zone.

The Recharge Zone is the cracked and broken boundary between the Edwards Plateau and the faulted Edwards and associated limestones to the south. Water in the streams, as well as rainfall directly over the Recharge Zone, runs directly into the cracks and crevices, then down into the Artesian/Reservoir Area of the Aquifer Region.

Conservation tillage boosts cotton and sorghum net profits

Cropping systems research begun in 1985 by the Texas Agricultural Experiment Station at Lubbock has shown that conservation tillage crop rotation can boost cotton and sorghum net profits.

According to Dr. J. Wayne Keeling, TAES Assistant Professor, experiments are being conducted at test sites located at Lubbock, Halfway (Hale County), and Wellman (Terry County) to evaluate conservation tillage/crop rotation systems for crop profitability, production, and yields.

This research is multi-disciplinary and involves scientists at the Lubbock Center as well as at Temple and College Station. Data on inputs, production costs, yields and net returns are being used in crop simulation models, such as EPIC and economic models.

Each tillage/crop rotation system is compared to conventionally tilled cotton and grain sorghum crops under dryland and irrigated conditions.

Lubbock County

At the Lubbock County test site, Keeling noted a dramatic increase in dryland cotton yields in 1988 with the use of a wheat-cotton and conservation tillage rotation. Dryland cotton yields increased 140 percent under the wheat-cotton conservation tillage system, while net returns increased from $15 per acre to $173 per acre.

In an irrigated continuous cotton cropping system, researchers at the Lubbock site noted that conventional tillage produced 964 pounds of cotton per acre with a net return of $332 per acre. Minimum tillage yielded 1,020 pounds per acre with a net return of $369 per acre. No-till yielded 1,045 pounds per acre with a net return of $367 per acre.

For continuous cotton under dryland conditions, conventional tillage produced 230 pounds of cotton per acre and had a net return of $15 per acre. No-till produced 280 pounds per acre and returned $42 per acre. Minimum tillage produced the highest yield/return under dryland conditions with 342 pounds of cotton per acre and $73 net return.

During a three-year period, net returns at the Lubbock site were increased 21 percent for irrigated cotton and 93 percent for dryland cotton using a wheat-cotton conservation tillage rotation.

No major differences in irrigated sorghum yields were found between cropping systems. However, reduced production costs caused the net returns to increase with continuous sorghum and cotton-sorghum conservation till rotation.

As compared to conventional tillage, conservation tillage increased dryland grain sorghum yields from 1,687 pounds per acre to 2,626 pounds per acre. Net returns increased dramatically from $7 per acre to $72 per acre.

Dryland sorghum yields were 92 percent higher and net returns increased from $7 per acre to $98 per acre with a wheat-sorghum conservation tillage rotation.

Terry County

At the Terry County site near Wellman, TAES research data revealed that the highest yields and largest net returns were achieved with a wheat-cotton or a terminated wheat-cotton crop rotation.

In dryland continuous cotton cropping, yields and net returns were higher with reduced and no-till systems.

No-till in continuous cotton yielded 821 pounds per acre and had a net return of $314 per acre. Reduced tillage produced 743 pounds of cotton per acre with a net return of $282 per acre. Conventional tillage practices yielded 747 pounds of cotton per acre with a net return of $271 per acre.

In continuous grain sorghum, no-till produced 3,302 pounds per acre with a $101 return. Conventionally-tilled sorghum yielded 3,230 pounds per acre and a net return of $77 per acre.

A terminated wheat-sorghum rotation produced the largest yield and highest net return at the Wellman site. This tillage/rotation system produced 4,236 pounds of sorghum per acre and had a net return of $132 per acre.

Hale County

At the Halfway site in Hale County, TAES researchers found that conservation tillage produced the highest yield and greatest net return in both irrigated and dryland cotton cropping.

Under irrigation, a wheat-cotton rotation yielded 1,054 pounds of cotton per acre with a net return of $405 per acre. A similar crop rotation under dryland conditions yielded 725 pounds per acre with a $286 net return.

An irrigated, conventionally-tilled cotton-sorghum rotation produced 5,931 pounds of sorghum per acre at the Halfway site. This rotation had a net return of $161 per acre. However, continuous sorghum cropping produced a slightly higher crop yield and net return under dryland conditions. This cropping method produced 5,221 pounds of sorghum and had a net return of $167 per acre.

Under dryland conditions, a similar cotton-sorghum crop rotation produced 5,127 pounds of sorghum per acre with a net return of $187 per acre.

Across all locations, economic benefits from conservation tillage were greatest for dryland cotton and sorghum. The wheat-cotton conservation tillage rotation was most consistent in terms of highest cotton yields and net returns.

Irrigation subsidy reform act introduced

EDITOR'S NOTE: Producers growing surplus crops with irrigation water obtained from the Bureau of Reclamation (BuRec) projects have had the "best of both worlds" for many years, according to a Pennsylvania Senator and a Connecticut Congressman. They are referring to producers in the western states, particularly California, who have participated in U.S. Department of Agriculture commodity price support programs on crops grown using low cost irrigation water from BuRec projects.

Legislation filed at the national level proposes to restrict participation to one program or the other. If it becomes law, this legislation could help equalize the competition between producers who receive the low cost water and those producers who pay a premium for land which has groundwater in storage and drill irrigation wells and install distribution systems at great expense. These producers must also pay energy costs of up to $35 to $50 per acre-foot to pump the groundwater for irrigation purposes.

This proposed legislation is highlighted in this article from the June 1989 issue of *Waterline* — **CEM.**

On May 17th, Senators John Heinz (R-Pennsylvania) and Tom Harkin (D-Iowa) introduced Senate bill 1032 to establish eligibility requirements for agricultural commodity price support programs with respect to Bureau of Reclamation (BuRec) irrigation water.

The bill, if enacted, would give farmers growing surplus crops using BuRec project water two choices. Either pay full-cost for project water and be allowed to participate in the Department of Agriculture's (USDA) commodity price support programs or receive below cost project water and be prohibited from participating in the USDA programs.

In his introductory remarks, Senator Heinz said, "This legislation is designed to reconcile two costly, contradictory Federal policies. On the one hand, a few different Federal agencies — principally the Bureau of Reclamation — spent a great deal of the taxpayer's money to give below-cost water to a few farmers so they can grow more crops. Yet on the other hand, USDA spends even more of the taxpayer's money paying these same farmers not to grow crops. It's time for one of those hands to get out of the taxpayer's pocket."

A companion bill, HR 2386 was introduced the same day in the House of Representatives by Congressman Sam Gejdenson (D-Connecticut-2).

In the 100th Congress, Congressman Gejdenson introduced a similar bill HR 1443. The bill was referred to the House Interior and Insular Affairs Committee and never got out of subcommittee. NWRA's Executive Vice-President, Thomas Donnelly, testified in opposition to HR 1443. (*Waterline,* May 1987).

This Congress, Congressman Gejdenson is taking a different approach. He first solicited a Senate colleague (Senator Heinz) to introduce a companion bill and then wrote the bill in such a way that it would be referred to the Agricultural Committees in both houses of Congress. However, because the bill involves the Bureau of Reclamation, it is likely both the Senate Energy and Natural Resources Committee and the House Interior and Insular Affairs Committee will seek sequential referral. Hearings have not been scheduled in either the House or the Senate.

July headline Error noted

In the July 1989 *Cross Section,* the Page Two headline "Mark Menke appointed new Potter County committeeman," should have read "Mike Menke appointed new Potter County committeeman."

On June 13, 1989, the High Plains Underground Water Conservation District No. 1 Board of Directors appointed Mike Menke to serve the unexpired term of L.C. Moore, Jr.

Mark Menke served on the Potter County Committee from 1979 to 1988.

We sincerely regret this error.

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Second Class Postage Paid at Lubbock, Texas District Office at Lubbock

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CARMON McCAIN, Editor
DIRECTOR, INFORMATION/EDUCATION

Precipitation enhancement increases cotton yield averages

Is it feasible to increase natural precipitation through aerial applications of silver iodide to growing cumulus clouds? If so, can this type of weather modification increase the surface water runoff to the watersheds of Lake J.B. Thomas near Colorado City and E.V. Spence Reservoir at Robert Lee? As the Colorado River Municipal Water District weather modification program completed its 18th year of operation, researchers have accumulated data that they believe answer these questions with a firm "Yes."

"Our water reservoir supplies are dependent on precipitation in West Texas. Since rainfall is vital to our existence, increased rainfall through weather modification provides an opportunity for progress in the area of water resource management," says Ray Jones, project meteorologist.

Counties or portions of counties in the Colorado River Municipal Water District's precipitation enhancement operations area include Lynn, Garza, Kent, Dawson, Borden, Scurry, Fisher, Martin, Howard, Mitchell, Nolan, Glasscock, Sterling and Coke Counties. The cloud-seeding effort is focused in a target area including all or portions of Dawson, Borden, Scurry, Howard, Mitchell, Nolan, Glasscock, Sterling and Coke Counties.

These counties are also included in a larger research effort known as the SouthWest Cooperative Program, which includes portions of Texas and Oklahoma. The goal of the program is to develop a "scientifically sound and socially acceptable technology for convective rainfall enhancement over the Texas-Oklahoma region."

In 1988, budget constraints forced the SouthWest Cooperative Program to cancel randomized cloud-seeding experiments in the Texas-Oklahoma region. However, the 5-centimeter C-Band Skywater Radar, located northeast of Big Spring, was utilized by the SWCP to gather data and to coordinate the District's cloud-seeding operations.

1988 Cloud-Seeding Operations Noted

The Colorado River Municipal Water District contracted with North American Weather Consultants to provide an airplane and pilot for the 1988 cloud-seeding operations. An Aztec aircraft was utilized by the Water District to fly 24 cloud-seeding missions and three demonstration flights from May to September 1988.

According to the District's aircraft operations summary, the plane's wing-mounted silver iodide generator burners were ignited near growing cumulus clouds within the Borden, Scurry, Howard and Mitchell County target area.

Upon command from a meteorologist at the Skywater Radar site, the pilot would dispense a maximum of 2.26 grams of silver iodide per minute through the plane's wing-mounted generator burners. The amount of silver iodide dispensed varied according to the cloud growth rate, rainfall intensity, cloud location and movement, cloud base temperatures and altitudes.

Updrafts carried the silver iodide into the clouds where it provided condensation nuclei in the same way that dust, smoke, sand or soil particles in clouds provide the center around which raindrops form.

There are two basic precipitation processes: coalescence, which occurs in "warm" clouds with temperatures above 32 degrees Fahrenheit and "ice phase" occurring in clouds with temperatures below 32 degrees. The introduction of silver iodide particles is particularly effective when cloud temperatures are below 32 degrees Fahrenheit. Introducing these particles into a super-cooled cloud causes the liquid droplets to freeze. The freezing action creates a great amount of heat, which causes the cloud to become more buoyant. As a result, the cloud rises higher, grows larger and produces more rain than non-seeded clouds.

Cotton Yield Increases Determine Program Benefits

Since cotton is the major agricultural crop grown within the 14-county precipitation enhancement area, a comparison of crop yields from 1971-1988 has been used to determine benefits from the weather modification program. Coke and Sterling Counties were eliminated from the comparative study because of their limited dryland cotton production.

Most cloud-seeding missions from 1971 to 1988 were flown to enhance precipitation in the "target area" consisting of Borden, Scurry, Howard and Mitchell Counties. Within these four counties, the 17-year average cotton crop yield increased an average of 48 percent. The highest average yield increase was noted in Howard County (56 percent above normal), while the lowest average yield increase was found in Borden County (38 percent above normal). An average 45 percent cotton yield increase was recorded for Garza, Kent, Fisher and Nolan Counties which are located downwind from the target area.

Only an average six percent cotton yield increase was noted in Lynn, Dawson, Martin and Glasscock Counties which are located upwind from the target area.

This difference in amounts of increase can be explained by cloud movement and the fact that clouds seeded upwind of the target area generally reach maximum precipitation efficiency over the target area or slightly downwind from it.

Data also indicates that in nine out of the last 17 cloud-seeding years, cotton yields in pounds per acre for the seeded counties surpassed cotton yields for the upwind and downwind counties.

District Uses Rain Gauge Network and Cooperative Weather Reporting Stations To Determine Precipitation Totals

In order to obtain accurate rainfall totals, the Colorado River Municipal Water District utilizes a network of 81 fencepost rain gauges located at three-mile intervals along major roads in the target area. These gauges are monitored from April to October each season.

A comparative study was performed on rainfall from rainfall recording stations.

During cloud-seeding years, the average May-September rainfall was 14.46 inches in seeded areas, while the average rainfall for the same five-month period is 12.86 inches in unseeded areas.

During the five months of the 1988 cloud-seeding program, rainfall totals were above average for most of the area. Colorado River Municipal Water District data indicated that more than 22 inches of rain fell at the Skywater radar site northeast of Big Spring.

Heavy rainfall was noted in the extreme western portion of the target area in Borden, Dawson, Martin and Howard Counties. More than 20 inches of rainfall was recorded from north of Big Spring to south of Lamesa.

The smallest amount of precipitation recorded in the target area during the 1988 cloud-seeding season was found near Lake J.B. Thomas. This area received more than 12 inches of rainfall from May to September.

September 1988 was the wettest month during the five-month precipitation enhancement program. July 1988 was the second wettest, while August 1988 was the driest.

During May-September 1988, Lake J.B. Thomas received 13,722 acre-feet of runoff while E.V. Spence Reservoir received 27,228 acre-feet of runoff.

High pressure system slows area rainfall

A stubborn high pressure system centered over the Rocky Mountains, combined with a low pressure system over the Great Lakes area, has reduced the number of precipitation events across the Texas South Plains.

"We have had the moisture available for precipitation," says Ron McQueen, a National Weather Service Forecaster at Lubbock. "However, a high pressure system developed earlier and stronger than normal this year over the Rockies. It has been very persistent, although we saw some breaks in it during May and early June. Parts of West Texas got a soaking, but the precipitation was not wide-spread," he says.

When a high pressure system is aloft, it causes relatively warm air at higher elevations. At 18,000 feet, temperatures of −6 degrees Celsius or 24 to 25 degrees Fahrenheit are common. McQueen says that these temperatures are warm for this time of year.

"In this situation, the rising warm air encounters another mass of warm air. As a result, a "cap" forms between 9,000 and 18,000 feet above the ground. This causes the warm air updrafts to weaken, and the development of thunderstorms is halted. The moisture and heating for thunderstorms have been there. We just have been lacking the necessary upper level disturbances," says McQueen.

The average annual precipitation total for Lubbock from 1911 to 1988 is 18.66 inches, with about 11 inches falling through mid-July. The Lubbock National Weather Service office has recorded only 7.91 inches of precipitation through July 1989.

IF IT WOULD ONLY RAIN — During July, High Plains producers have seen thunderstorms dissipate just as rapidly as they develop. When the cloud tops rise above 10,000 feet, they encounter warm air masses that slow further upward development. The updrafts within the cloud are weakened, and the thunderstorm does not develop sufficiently to produce precipitation.

Gypsum blocks help producers meet crop water demands

Gypsum blocks and hand-held resistance meters allow High Plains producers to understand how much moisture is being extracted from the plant root zone by their crops. With a working knowledge of these moisture extraction patterns, irrigators can better manage their use of groundwater supplies.

Gypsum blocks are simply wires or wire mesh embedded in an inch-long gypsum cylinder. When the leads from the gypsum block are attached to a hand-held resistance meter, the irrigator can quickly determine the amount of available moisture in the soil profile at the depth the gypsum block has been installed.

Producers install these soil moisture monitoring devices after the crop has emerged. Gypsum blocks are usually installed at one-foot intervals down to four feet in the soil profile by using a rod or auger. If an auger is used to make the hole, the producer may install as many as four gypsum blocks in the same hole.

The lead wires from the gypsum blocks are then connected to a wooden stake at ground level and coded to indicate the depth at which the gypsum block is buried.

This coding may be as simple as tying a knot in the wire to correspond with the level at which the gypsum block is buried. For example, four knots tied in the lead wire could indicate that the gypsum block is buried at the four foot level. Two knots could indicate that the gypsum block is buried two feet below land surface. Some irrigators color code the lead wires by attaching different colors of tape to mark the various depths of the gypsum blocks.

A WINDOW INTO THE SOIL — The gypsum has been scraped away to reveal the stainless steel electrodes that make up the core of a gypsum block. Electrical resistance between the electrodes registers on a resistance meter to measure soil moisture.

Hand-held resistance meters measure the electrical resistance within the gypsum block and display this information as a percent of field capacity. The electrical resistance within the gypsum block is related to the amount of moisture stored in the soil profile. A meter reading of "0" would indicate dry soil conditions, while a reading of "10" would reveal soil conditions at field capacity.

Irrigators are encouraged to take frequent gypsum block readings to determine the amount of water in storage within the soil profile at different crop developmental stages. By using these blocks as a guide, irrigators can apply the amount of water needed by the crops and avoid over-irrigating or under-irrigating.

Gypsum blocks work best with low water use crops such as cotton, grain sorghum and some small grains, although some corn producers have reported success in using these soil moisture monitoring devices.

"Irrigating By The Block: Soil Moisture Blocks and Resistance Meters" is a four-page Water Management Note available free of charge to irrigators within the 15-county High Plains Underground Water Conservation District No. 1 service area. The booklet contains descriptive text and photographs designed to aid the irrigator in the use and installation of gypsum blocks. Copies can be obtained by contacting the High Plains Water District, 2930 Avenue Q, Lubbock, Texas 79405 or by calling (806) 762-0181.

Irrigators may purchase soil moisture monitoring devices

The High Plains Underground Water Conservation District No. 1 in cooperation with local Soil and Water Conservation District offices offers tensiometers, gypsum blocks and resistance meters for sale to irrigators within the 15-county Water District service area.

"Since private enterprise was not providing this equipment to irrigators, the Water District began a cooperative distribution program with the SWCD offices," says Ken Carver, High Plains Water District Assistant Manager.

"The District established this program to acquaint irrigators with the water conservation benefits obtained from soil moisture monitoring. This equipment helps producers improve their irrigation scheduling and reduce the amount of water being applied to their crops," he says.

Gypsum blocks cost $3.50 each and should be replaced after each growing season because of deterioration. The hand-held resistance meter costs $170 and should last from five to 10 years. Tensiometers are also available in various lengths at a cost of about $35.

"Most cotton producers prefer using the gypsum blocks since they work better in the lower moisture ranges. However, most corn producers prefer tensiometers because the instrument is more sensitive and provides more accurate information in the higher moisture ranges," says Carver.

Irrigators interested in purchasing tensiometers, gypsum blocks and resistance meters should contact their local High Plains Water District office, the local Soil and Water Conservation District Board or the High Plains Water District headquarters at 2930 Avenue Q, Lubbock, Texas 79405 or call (806) 762-0181.

THE CROSS SECTION (USPS 564-920)
HIGH PLAINS UNDERGROUND WATER
CONSERVATION DISTRICT NO. 1
2930 AVENUE Q
LUBBOCK, TEXAS 79405

SECOND CLASS PERMIT

THE Cross SECTION

Published monthly by High Plains Underground Water Conservation District No. 1, 2930 Avenue Q, Lubbock, Texas 79405—Ph. 762-0181

Volume 35—No. 9 Publication Number USPS 564-920, Second Class Postage paid at Lubbock, Texas *September 1989*

Annual domestic water well disinfection recommended

By A. Wayne Wyatt

All domestic water supply wells should be disinfected at least once each year to ensure a safe water supply for your family.

When wells are drilled, bacteria may be introduced into the well from the soil, from water used in the drilling process and from the drilling equipment. Additionally, if gravel is used for a gravel pack, it likely will contain bacteria. Bacteria and algae may also be introduced into a well when pumps are installed. Tools used to install or pull pumps for repairs, if not chlorinated, may spread bacteria and algae from well to well. Bacteria and algae can also enter the well through air vents if the well is not sealed properly. Any new well or a well that has been repaired should be disinfected before the water from the well is used for domestic purposes.

Most strains of bacteria are beneficial. However, some types of bacteria and algae thrive in the environment found in wells to the point that they may clog the pump, the casing perforations, and the gravel pack. Any one or a combination of these conditions can result in a reduced well yield or a failed well.

Even more important, some types or strains of bacteria can cause diseases when they are ingested in water from a well. Laboratory confirmation of contamination involves analysis for fecal coliform bacteria. Although the coliform bacteria are not harmful, they are easily found in lab analyses and are therefore used to indicate the probable presence of contamination.

Fecal coliform bacteria usually occur in wells when waste from warm-blooded animals, including man, enters the well. Consumption of water from a contaminated well can result in the consumer being infected with about any disease known to man, including polio, typhoid and diphtheria. It is rare that such dread diseases are reported, thanks to the generally good sanitary practices in the United States. Generally, the health problems reported are intestinal viruses, low grade fever, and recurring headaches.

Common sources of contamination of wells by bacteria are cesspools; improperly constructed septic systems; seepage from livestock waste; waste from burrowing warm-blooded animals, such as mice and rats; precipitation runoff containing animal or fowl waste; and leaks from the pump or pipes which dissolve waste on the pump base that drains back into the well. Probably the most difficult source of contamination to locate is animal burrows.

A CONTAMINATED WELL — Contaminants have entered this domestic water well through the cracks in the pump base and openings around the casing. See the October 1987 *Cross Section* for a review of proper water well completion specifications.

Changes in the taste of the water coming from a well, a foul odor, and/or discoloration of the water are indications that bacterial contamination may have occurred. However, the water may be contaminated without any apparent change. If you have any reason to believe that your domestic supply well has been contaminated, do not consume the water or use it in food preparation or for tooth brushing unless it has been boiled for at least five minutes. Have the water tested immediately; and if it is contaminated, get the well treated and retested before consuming any water from it.

Simple laboratory tests can be conducted which will indicate the presence of fecal coliform bacteria. If you are a resident of the High Plains Underground Water Conservation District, the Water District will collect a water sample and conduct the test

See PROPER Page Three

Bacteriological testing program reassures rural residents

CATCHING A SAMPLE — Engineer Technician Dan Seale collects one of two domestic water samples used to detect fecal coliform bacteria. The testing is performed free of charge to residents within the 15-county High Plains Water District service area.

The High Plains Underground Water Conservation District initiated a bacteriological water quality testing program in 1978. The program is designed to assist rural residents of the District in determining if their domestic water supply is safe for human consumption.

Rural residents who suspect that their domestic well might have become contaminated can call the Water District for assistance. The majority of those who request a test just want to be assured that their water supply is safe. "It is better to be safe than sorry," says Dan Seale, Water District Engineer Technician. Seale handles the testing program for the Water District.

Eight hundred and forty-four domestic water wells have been sampled and tested for fecal coliform bacteria since the program began. Of the 844 wells sampled, only 63 wells (7 percent) have shown positive test results. Seale says 61 of the 63 contaminated wells were disinfected and put back into use after the source of contamination was located and eliminated. The remaining two wells were so badly contaminated by cesspools that the owners had to abandon them and drill new domestic wells.

Sampling The Domestic Water Well

Upon request, Seale conducts a free bacteriological water analysis for residents within the 15-county High Plains Water District service area. Prior to taking the water sample, Seale visits with the well owner to learn about the well installation and any possible contamination source such as an old abandoned cesspool.

An examination of the actual well site follows. Seale looks for any openings that could allow contaminants inside the well. Some of these entryways include improperly sealed casings, cracks in the concrete pump base, rodent holes, and openings where pump wires enter the casing. If such openings are discovered, Seale offers well owners recommendations for closing them.

Collecting the Water Sample and Checking for Bacteria

Obtaining the actual water sample is a simple process, Seale says. How-

See DOMESTIC Page Four

TAES Center at Halfway slates 80th annual Field Day

The Texas Agricultural Experiment Station at Halfway will host its 80th annual Field Day on Tuesday, September 12, 1989 from 1 p.m. to 4 p.m.

The TAES Center at Halfway is located between Plainview and Olton on U.S. Highway 70. Travelers from Lubbock should exit Interstate 27 at Hale Center and take FM 1424 for about 10 miles until it intersects with Highway 70. The Halfway Center is located five miles west of this intersection. Those traveling on I-27 from Amarillo should take the Highway 70 exit at Plainview and travel west to Halfway.

Dr. John R. Abernathy, Professor and TAES Resident Director of Research, and Charles Woodfin, 1989 TAES Field Day Committee Chairman, invite interested farmers and the public to attend this event.

Various displays and exhibits at the Field Day will show mobile irrigator planting systems, agronomic cropping systems, cotton genetics, food grade corn production, and research on weeds and the Russian wheat aphid. Specialists will be stationed throughout the displays and will be available to discuss any specific problems producers might have.

Agencies located at the Lubbock-Halfway Center that are cooperating in the event include the Texas Agricultural Extension Service, the High Plains Research Foundation, the Texas Forest Service and the USDA-Agricultural Research Service (USDA-ARS).

Tillage seminar scheduled

Interested producers are invited to attend a conservation tillage seminar Thursday, September 14th in the auditorium of the Texas Agricultural Experiment Station at Lubbock. The meeting will begin at 8 a.m. and is open to the public.

Two Terry County producers will share their first-hand experiences with conservation tillage during the morning session. Dr. Bill Lyle, TAES Associate Professor, will also discuss center pivot irrigation with conservation tillage.

A representative from U.S. Congressman Larry Combest's office will be on hand to discuss the role of conservation tillage in compliance with the 1990 Food Security Act as well as other future ag-related legislation.

After the luncheon, a tour of conservation tillage field plots will be conducted by Dr. J. Wayne Keeling, TAES Associate Professor.

The Texas Agricultural Experiment Station is located north of the City of Lubbock. Persons attending the seminar should travel north on Interstate Highway 27 and exit at FM 1294. The Texas Agricultural Experiment Station is approximately ½ mile east of this intersection.

The seminar is hosted by the Lubbock County Soil and Water Conservation District, the Texas Agricultural Experiment Station, the USDA-Soil Conservation Service and the Monsanto Chemical Company.

Groundwater protection meeting set

The fourth annual Groundwater Protection Seminar will be held October 10-11 in Room 118 of the Stephen F. Austin Building in Austin. This seminar is being held by the Texas Water Commission, in cooperation with those agencies participating in the state's Groundwater Protection Committee. There is no charge to attend.

A major goal of the seminar is to educate and inform attendees about protecting their groundwater supply from contaminants that could adversely affect public health. Topics at the seminar will include delineation of wellhead protection areas, nonpoint source contamination, local emergency spill response, and groundwater protection strategies.

The free seminar is open to anyone concerned with the protection of groundwater, including representatives of local municipalities, industry, water districts, and interested members of the public and the environmental community.

The Stephen F. Austin Building is located in downtown Austin, north of the State Capitol on the northwest corner of 17th Street and North Congress Avenue.

To receive the seminar brochure for this event, call the Texas Water Commission's Groundwater Conservation Section at (512) 463-8273.

Hockley County office moves

The Hockley County office of the High Plains Underground Water Conservation District No. 1 has moved from 609 Austin Street to 1012 Austin Street in Levelland.

According to County Secretary Jim Montgomery, the office's mailing address will continue to be P.O. Box 968, Levelland, TX 79336. The office telephone number, (806) 894-6127, will also remain the same.

The new location will continue to issue permits for water wells, provide public information regarding Water District programs and maintain Hockley County water well log records. Water District publications will also be available to the public at the new office.

THE CROSS SECTION (USPS 564-920)

A MONTHLY PUBLICATION OF THE HIGH PLAINS UNDERGROUND WATER CONSERVATION DISTRICT NO. 1

Second Class Postage Paid at Lubbock, Texas
District Office at Lubbock

POSTMASTER: Send address changes to:
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NOTICE: Information regarding times and places of the monthly County Committee meetings can be secured from the respective County Secretaries.

Applications for well permits can be secured at the address shown below the respective County Secretary's name.

Proper chlorination disinfects contaminated domestic water wells

Continued From Page One

at no charge. If the well is contaminated, the staff will guide you in locating the source of contamination and offer advice on the elimination of the source of contamination. If the source of contamination is not eliminated, the water in the well will likely be contaminated again in the near future. The staff will also provide counsel on treating the well with chlorine to kill the bacteria present in the well.

The Texas Department of Health recommends a concentration of chlorine of 100 parts per million for disinfecting the well bore, pumps, pipe, etc. This ratio equals about two gallons of liquid laundry bleach per 1,000 gallons of water. Calcium Hypochlorite can also be used. It is usually sold under the trade name of HTH and contains 65 percent chlorine. About 1.3 pounds of Calcium Hypochlorite per 1,000 gallons of water gives about the right ratio. An exact concentration of 100 parts per million of chlorine is extremely hard to obtain. Adding chlorine in an amount equal to twice the recommended dosage would be more desirable than using only half the recommended amount. See Table One for the amount of chlorine needed to treat various quantities of water to bring the chlorine level to 100 parts per million.

Before using any chemical, always read the label for proper handling and safety precautions. Do *not* inhale the chlorine gas that will escape as the dry chemical is mixed with water or when the chemical is being added to the well. Do *not* add the chemical to a well inside a closed well house with little or no ventilation. If your well is located inside a closed well house, extend a hose from the well to the outside of the well house to add the chemical. If the well is located outside or in a well-ventilated enclosure, position yourself upwind while adding the chemical to the well.

The size of the well casing and the feet of standing water in the well need to be determined to calculate the volume of water to be treated. Measure across the top of the casing to determine its diameter. To determine the feet of standing water in a well, you need to measure the depth-to-water below land surface in the well and determine how deep the well was drilled. The depth of the well is obtained from the water well driller's log. Subtract the depth-to-water from the depth of the well to determine the number of feet of water standing in your well. An alternative to using this method to determine the feet of standing water in the well would be to use the saturated thickness of the formation at the well site as shown on hydrologic atlases available from the Water District. You may write or telephone for assistance in determining the approximate feet of standing water in your well. You will have to provide the legal description of the location of the property for this data to be provided by letter or telephone.

As an example, if you measure the depth-to-water below land surface at 200 feet and the driller's log shows the well was drilled to a depth of 445 feet, the difference in these values would indicate 245 feet of standing water in the well. You measured the diameter of the casing as being 10 inches. Table Two indicates that a 10-inch diameter casing will hold 4.08 gallons of water per foot. Two hundred and forty-five feet of water times 4.08 gallons per foot equals 1,000 gallons. Table One indicates that two gallons of five percent household bleach, or 1.30 pounds of HTH with a 65 percent chlorine concentration, will bring the chlorine concentration to 100 parts per million in 1,000 gallons of water.

If laundry bleach is used, it should be added directly to the well, followed by a quantity of water at least equal to the amount of bleach used to treat the well to wash the residue from the pump and casing.

Any contamination of the well will also be present throughout the water distribution system. The distribution system must be disinfected along with the well. To disinfect the distribution lines while the chlorine solution works in the well, open the hydrants in the house and the yard and any other outlets on the system, such as stock watering troughs and sprinkler systems, and allow water to flow until a distinct odor of chlorine is detected. Then close the hydrants and leave the chlorine in the pipelines and in the well for 24 hours. If it is possible for the well to be surged or backwashed, this should be done at four to six-hour intervals during the 24-hour period.

If you use HTH, it should be dissolved in water before adding it to the well. Use a ratio of one pound of chemical per two gallons of water to dissolve it. The carrier (about 35 percent of the dry chemical mix) will not dissolve readily in water. The solids which do not dissolve must *not* be added to the well. Filter out the solids and dispose of them in a sanitary waste disposal site. Following the chemical injection, add water to wash the residue from the pump and casing. Use the same procedures described above for disinfecting the distribution lines.

When the 24-hour treatment time has passed, the chlorine needs to be pumped out of the well. Open the hydrants *outside* the house and let the water flow until there is no odor of chlorine in the water. Only then should you open all the hydrants inside the house. Let them flow until the chlorine odor is completely gone. There are two reasons for this recommendation. First, if you open only the hydrants in the house, all the chlorine-treated water in the well, pressure tank and lines will flow through these lines, filling the house with the chlorine odor. Second, there may be enough chlorine in this volume of water to kill all or part of the beneficial bacteria in your septic tank, which would reduce its efficiency for several weeks and possibly even cause it to fail.

If you had reason to believe that the well was contaminated with bacteria before it was disinfected, you should have the water tested before using it for drinking or food preparation. Also, you should have the well tested again in about six months to make sure the contamination has not recurred.

Table One

Approximate quantities of chlorine compound required to produce a chlorine concentration of 100 parts per million.

Gallons of Water in Well	Liquid Bleach (5 percent)	Calcium Hypochlorite (65 percent)
250	½ gallon	0.32 pound
500	1 gallon	0.65 pound
750	1½ gallons	0.97 pound
1,000	2 gallons	1.30 pounds
1,500	3 gallons	1.95 pounds
2,000	4 gallons	2.60 pounds
2,500	5 gallons	3.35 pounds
3,000	6 gallons	3.90 pounds
3,500	7 gallons	4.55 pounds
4,000	8 gallons	5.20 pounds
4,500	9 gallons	5.85 pounds
5,000	10 gallons	6.50 pounds
7,500	15 gallons	9.75 pounds
10,000	20 gallons	13.00 pounds

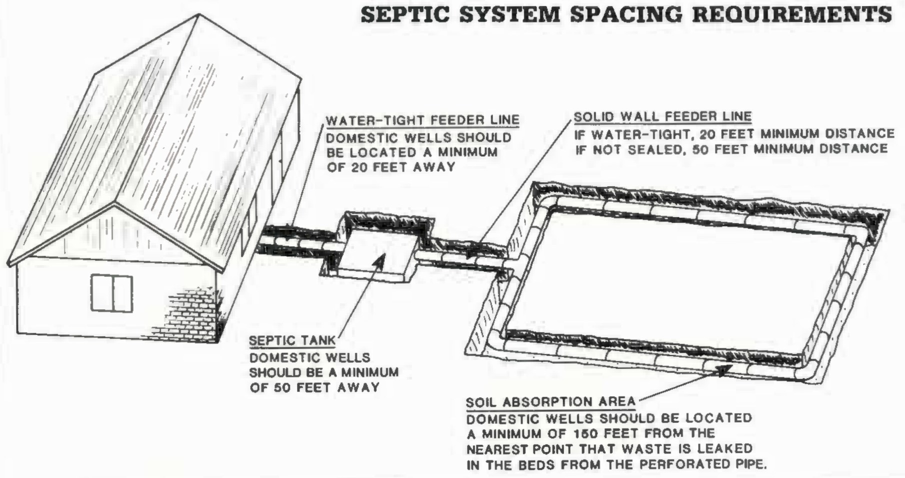
Table Two

VOLUMES OF WATER IN GALLONS AT VARIOUS SATURATED THICKNESSES IN FEET

Inside Diameter of Casing In Inches	Volume In Gallons Per Linear Foot	Feet of Standing Water In Casing									
		10	20	30	40	50	60	70	80	90	100
3	.037	3.7	7.4	11.1	14.8	18.5	22.2	25.9	29.6	33.3	37.0
3½	0.50	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0
4	0.65	6.5	13.0	19.5	26.0	32.5	39.0	45.5	52.0	58.5	65.0
4½	0.74	7.4	14.8	22.2	29.6	37.0	44.4	51.8	59.2	66.6	74.0
5	1.02	10.2	20.4	30.6	40.8	51.0	61.2	71.4	81.6	91.8	102.0
5½	1.23	12.3	24.6	36.9	49.2	61.5	73.8	86.1	98.4	110.7	123.0
6	1.47	14.7	29.4	44.1	58.8	73.5	88.2	102.9	117.6	132.3	147.0
7	2.00	20.0	40.0	60.0	80.0	100.0	120.0	140.0	160.0	180.0	200.0
8	2.61	26.1	52.2	78.3	104.4	130.5	156.6	182.7	208.8	234.9	261.0
10	4.08	40.8	81.6	122.4	163.2	204.0	244.8	285.6	326.4	367.2	408.0
12	5.88	58.8	117.6	176.4	235.2	294.0	352.8	411.6	470.4	529.2	588.0
14	8.00	80.0	160.0	240.0	320.0	400.0	480.0	560.0	640.0	720.0	800.0
16	10.00	100.0	200.0	300.0	400.0	500.0	600.0	700.0	800.0	900.0	1000.0
18	13.22	132.2	264.4	396.6	528.8	661.0	793.2	925.4	1057.6	1189.8	1322.0
20	16.32	163.2	326.4	489.6	652.8	816.0	979.2	1142.4	1305.6	1468.8	1632.0

Septic system spacing reduces well contamination risk

SEPTIC SYSTEM SPACING REQUIREMENTS



For discussion purposes, let's talk about a septic system as if it consists of four distinct parts.

The first part would be the *feeder line* which is used to transport the sewage from the residence to the septic tank. It should be a water-tight line; however, a leak might develop sometime in the future. A domestic well should not be located within 20 feet of this line.

The second part would be the *septic tank.* A domestic well should be located a minimum of 50 feet from the septic tank.

The third part would be the *solid wall feeder line* connecting the septic tank to the perforated line used in the soil absorption field. The feeder line should also be a water-tight line. The domestic well should be located a minimum of 20 feet from any point on this line. If the feeder line is not sealed to be water-tight, the well should be a minimum of 50 feet from the line.

The fourth part would be the *soil absorption beds.* The domestic well should be located a minimum of 150 feet from the nearest point that waste is leaked in the beds from the perforated pipe.

Domestic wells should be regularly inspected for openings

Continued From Page One

ever, he emphasizes that if it is not done correctly and collected in a sterile container, the results almost always indicate contamination.

An interior or exterior faucet is opened to flush out any sediments that might be in the water line. The faucet is sterilized by open flame, and two water samples are collected in small sample bags. The samples are placed in an ice chest and must be returned to the Water District office for incubation within six hours.

Seale begins the bacteriological analysis by preparing several small petri dishes with a liquid media which provides any fecal coliform bacteria present with nourishment for growth.

A sterile filter is then placed on a mesh screen covering the bottom portion of a vacuum canister. The funnel-shaped upper portion is attached, and Seale pours the domestic water well sample into it. Since the filter between the upper and lower portions of the canister is nearly impenetrable, Seale must use a hand-held vacuum pump to literally "pull" the water through the filter.

After the filter is saturated, it is removed from the canister and placed into a petri dish. The dish is taped shut and allowed to incubate 24 hours at 104°F.

Any filter showing blue spots or a bluish tinge after the incubation period indicates the presence of fecal coliform bacteria in the well water, Seale says. The well owner is notified by telephone if the test is positive, and a second sample is collected to verify contamination before any further recommendations are made. If no bacteria is found, the well owner is notified by letter.

Keep Well Houses Clean To Avoid Contamination

"The most important thing that I can suggest to domestic water well owners is not to store anything near their well that they wouldn't want in their drinking water," says Seale.

He has seen everything from agricultural chemicals and insecticides to cat litter boxes and rat poison stored near domestic water well sites. "A rodent hole, a crack in the pump base or a gap where the electrical wires enter the casing can provide a direct conduit for contaminants to enter the well. Keeping the area around the well clean greatly reduces the chances of contamination," he says.

Seale also recommends keeping weeds and grass trimmed outside the well house. "This will allow domestic water well owners to see if animals burrow into their well house so that they can take necessary action to prevent possible contamination problems," he says.

If a rodent hole is found, Seale urges well owners not to flush the rodent out of the hole with a garden hose. "Placing the hose in the hole and turning on the water may wash contaminants into the drinking water supply. Also, well owners must never put poison into rodent holes near their well sites," he says.

Seale recommends a regular inspection of the well site to locate any openings or gaps that could allow contaminants into the well, and the well owner can note any repairs that need to be made. For example, if the water line from the pump is leaking inside the well house, it should be repaired as soon as possible before the water carries any contaminants into the well via cracks or holes in the pumpbase.

Chlorination Disinfects Contaminated Wells

If a domestic well is contaminated, it can usually be cleared up with chlorination. The Water District will make a recommendation of the amount of laundry bleach or chlorine crystals which are needed to disinfect a well if contamination is found; however, the individual well owner is responsible for the actual chlorination.

Bacteriological Sampling May Be Scheduled Through Water District Office

If rural residents have repeated flu-like symptoms, or if guests in the house complain of cramping and diarrhea, this can signal a contaminated water supply. Such contamination can occur without the water having a tell-tale odor, taste or discoloration.

"If you suspect that your well is contaminated, don't be afraid to call the Water District to schedule a bacteriological analysis," says Seale. "In the meantime, use an alternative source for water to drink, cook with and brush teeth with."

Bacteriological water testing within the Water District service area may be scheduled by contacting Dan Seale at the High Plains Underground Water Conservation District No. 1, 2930 Avenue Q, Lubbock, Texas 79405 or by calling (806) 762-0181.

THE CROSS SECTION (USPS 564-920)
HIGH PLAINS UNDERGROUND WATER
CONSERVATION DISTRICT NO. 1
2930 AVENUE Q
LUBBOCK, TEXAS 79405

SECOND CLASS PERMIT

THE Cross SECTION

Published monthly by High Plains Underground Water Conservation District No. 1, 2930 Avenue Q, Lubbock, Texas 79405—Ph. 762-0181

Volume 35—No. 10 Publication Number USPS 564-920, Second Class Postage paid at Lubbock, Texas October 1989

John Birdwell named to Texas Water Commission

John E. Birdwell Jr.

Lubbock cattleman John E. Birdwell Jr. has been appointed by Governor Bill Clements to serve as a member of the Texas Water Commission. He replaces Paul Hopkins of La Marque, whose term has expired.

Birdwell, 60, was born in Ralls and is a Texas Tech University graduate. He serves as chairman of Birdwell Cattle Feeders, a ranching and cattle feeding operation.

He is a board member of the National Cattlemen's Association and a member of both the Texas Cattle Feeders Association and the Texas Hereford Association. He is a past president of the Texas and Southwestern Cattle Raisers Association.

Birdwell formerly served on the Texas Tech Board of Regents and was a former board member for the Brazos River Authority.

He joins Chairman Buck J. Wynne of Dallas and John Houchins of Houston on the three-member Water Commission.

"John Birdwell's appointment will result in one of the most balanced regulatory panels in state government," said TWC Chairman Wynne. "I know John through various legislative activities, and I am delighted that the Governor has appointed him to work with us at the Commission. We already have a solid working relationship. John will bring considerable knowledge and insight with regard to water and its importance to our state and its economy," said Wynne.

Floydada couple recognized for farm conservation practices

Eddie and Jennisu Smith of Floydada are among 50 farm and ranch families recently recognized for their outstanding conservation practices by the National Endowment for Soil and Water Conservation. The Smiths will represent Texas in the seventh annual National Soil and Water Conservation Awards Program.

The awards program, created by the National Endowment for Soil and Water Conservation and funded by the Du Pont Company, honors those agricultural producers who effectively manage soil and water resources, who prevent agricultural air and water pollution, and who help inform other producers and the public about the protection of agricultural resources.

Previous state winners nominated by the High Plains Underground Water Conservation District No. 1 are Mr. and Mrs. Lyndon Wagner of Bushland (1988) and Mr. and Mrs. Ronald Schilling of Slaton (1987).

"These remarkable people demonstrate every day that resource conservation is an essential, yet cost-effective investment in healthy and sustainable agriculture. They lead the way in voluntary action to enhance the environment," says Emmett Barker, Endowment chairman.

Award selection is based on comprehensive conservation techniques, conservation education and individual initiative.

The Smiths produce cotton, grain sorghum and soybeans on the 2,360 acres they farm near Floydada. They incorporate minimum tillage, furrow dikes, surge irrigation and windstrips as part of their farm management program. They also include underground pipe, tailwater pits, modified playas, soil moisture monitoring devices and crop rotation in their total soil and water conservation program.

Smith utilizes a chemical controller to meter the exact amount of chemical applied to his fields to reduce the potential for human error. Smith also uses a custom blend liquid fertilizer that he applies according to laboratory soil test results. For the last two years, Smith has been cooperating with the Texas Agricultural Extension Service on a soil fertility demonstration project. The project is designed to determine the proper fertilizer placement in the soil for maximum cotton production.

Smith attends farm shows across the United States to learn about new conservation ideas that could be implemented on his Floyd County farm.

"Conservation pays financially and preserves our natural resources for the future. We try to farm in harmony with nature to protect our soil and water resources. Careful management of these resources means utilizing every drop of rainfall and managing the soil to prevent water and wind erosion. We have to learn to farm based on our growing season weather conditions if we are to continue to be profitable," says Smith.

CONSERVATION IS IMPORTANT — Jennisu and Eddie Smith work to conserve the soil and water resources on their farm south of Floydada. As a result, they will represent Texas in the National Endowment for Soil and Water Conservation annual awards program.

Smith is a director of the Floydada Co-op Gin and the Plains Cotton Co-op. He was the 1986 president of the Floydada Chamber of Commerce, and he serves as a member of the Floyd County Agricultural Stabilization and Conservation Service Committee.

State winners are selected from several hundred nominees by public and agricultural conservation leaders in each state. The winners receive award certificates and are honored at a variety of local and statewide events during the year.

From the state winners, 10 national Endowment award finalists are chosen. The 10 finalists will receive an expense-paid trip to the national awards ceremony in Milwaukee, October 22, 1989.

A total of three winners will be selected from the 10 national finalists to receive an expense-paid trip to Washington, D.C. for a White House ceremony. In addition, the three winners will receive a $1,000 cash award and certificate.

State water rights governed by public and private ownership

EDITOR'S NOTE: The right to use water in Texas is often taken for granted. While some consider water rights to be automatic, they have actually been determined by law since the 1800s. It is these laws that determine if water is publicly or privately owned, who may use water and how it may be used.

This article, reprinted from the August 1989 Texas A & M University *Real Estate Journal,* provides a historical overview of the laws influencing Texas water rights. The article begins in the October *Cross Section* and will conclude in the November *Cross Section.* **— CEM.**

By Judon Fambrough

Homeowners Mike and Elizabeth Moore live on the Guadalupe River. When mortgage interest rates fell recently, they sought refinancing for their home. The loan process halted when the lender discovered the Moores took water directly from the river for home use. The lender refused to refinance until the Moores could prove that their water use was legal.

First in a Two-Part Series

Although the names are fictitious, the incident is real. What many take for granted as a proper use of water, in fact, may be illegal. With drought and an increased demand, the right to use water in Texas becomes a significant issue.

The first step in determining the right to use water is deciding whether the water is publicly or privately owned. The right to use publicly owned water (or state water) is governed by both statutory and case law. The right to use privately owned water is basically unrestricted as long as the owner does not waste it or withdraw it negligently.

In general, water in a stream or lake belongs to the state. This proposition is codified in Section 11.021 of the Texas Water Code.

"The water of the ordinary flow, underflow, and tides of every flowing river, natural stream, and lake, and of every bay or arm of the Gulf of Mexico, and the storm water, floodwater, and rainwater of every river, natural stream, canyon, and ravine, depression, and watershed in the state is the property of the state."

The right of individuals to use state water from a stream or lake depends on three factors: the year the land surrounding the stream or lake was patented, i.e. conveyed from the sovereign (or state) to private ownership; whether a certificate of adjudication has been issued; and the type of use contemplated.

The Spanish and Mexican rules of law governed all patents (or grants) until 1840. These laws, taken from the civil law of Europe, provided that all water rights not expressly granted to individuals were retained by the state. However, all citizens had a common right to use water for domestic purposes, livestock and navigation. A specific grant was required for other uses including irrigation and milling.

In 1840, Texas adopted the common law of England. The common law contained a collection of rights known as *riparian water rights.* Riparian water rights provide that landowners whose property is contiguous (or adjacent) to a stream or natural lake may use the water for domestic purposes, livestock, irrigation and power.

Riparian owners may use only the normal flow of the stream, i.e., the overflow, or flood waters, cannot be used. The riparian owners are limited to an amount of water reasonably necessary for the riparian purposes. The riparian right cannot be lost by non-use.

In 1895, Texas passed the Irrigation Act, which marked the end of granting any further riparian water rights in streams or lakes. This legislation represented the first step in adopting the appropriation doctrine followed by the state today. The statute declared the unappropriated flow of every river or stream in arid regions to be state property. The act established procedures whereby per-

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"The underground water districts may have the power to conserve, preserve, protect, recharge, control subsidence and prevent waste of underground water from an underground water reservoir."

THE Cross SECTION

THE CROSS SECTION (USPS 564-920)

A MONTHLY PUBLICATION OF THE HIGH PLAINS UNDERGROUND WATER CONSERVATION DISTRICT NO. 1

Second Class Postage Paid at Lubbock, Texas District Office at Lubbock

POSTMASTER: Send address changes to:
The Cross Section, 2930 Avenue Q,
Lubbock, TX 79405 Telephone (806) 762-0181

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NOTICE: Information regarding times and places of the monthly County Committee meetings can be secured from the respective County Secretaries.

Applications for well permits can be secured at the address shown below the respective County Secretary's name.

Texas Water Commission determines state water appropriation based upon adjudication of existing riparian rights claims

Continued From Page Two

sons could lawfully appropriate (or acquire) the right to divert state water from a watercourse and apply it to beneficial use.

Certificate of Adjudication

In 1967, the Texas legislators passed a comprehensive, state-wide water plan known as the *Water Adjudication Act,* presently codified in Sections 11.301 et seq. of the Texas Water Code.

The purpose of the act is "to require recordation with the commission of claims of water rights which are presently unrecorded and to limit the exercise of these claims to actual use." The act targets four categories of water rights: (1) riparian, (2) impoundment of more than 200 acre-foot reservoirs, (3) irrigation rights under the Irrigation Act of 1889 and 1895 that were not filed with the State Board of Water Engineers in accordance with the Irrigation Act of 1913, as amended, and (4) other claims of water rights except claims under permits or certified filings.

The act required filing a sworn claim of all existing riparian rights with the Texas Water Commission, formerly the Texas Department of Water Resources, no later than September 1, 1969. The claims are recognized only if valid under existing laws and then only to the extent of maximum actual application of water to beneficial use without waste during any calendar year from 1963 to 1967. Primarily, the act sought documentation of irrigation rights.

Each claim is investigated by the Texas Water Commission. If a claimant is successful, he or she is issued a certificate of adjudication describing the limits of the water rights established during the investigation. Unlike riparian water rights, a certificate of adjudication is subject to cancellation for nonuse.

Approximately 7,500 water rights claims have been filed and most have been adjudicated. The commission, as a group, adjudicates the claims by river basins or portions of a river basin. In 1985, the major river basin segments unadjudicated included the lower portions of the Colorado, Brazos, Trinity, Red, Pecos and Devils Rivers.

The Water Adjudication Act attempts to merge riparian water rights into the statutory scheme of appropriation followed throughout the rest of the state. Once all claims are adjudicated, the Water Commission can determine the amount of water that can be taken (appropriated) in any basin across the state. Anyone or any entity wishing to use any remaining water must petition the Water Commission for a permit.

The Water Adjudication Act does not require the filing of sworn claims to water rights for domestic use and livestock. Thus, domestic use and livestock appear to be the only surviving rights from the riparian doctrine in Texas. Likewise, the right to use water for domestic and livestock purposes in the old Spanish and Mexican land grants also appears to have survived.

"In 1840, Texas adopted English common law, which contained the riparian water rights. Riparian water rights provide that landowners whose property is contiguous to a stream or natural lake may use the water for domestic purposes, livestock, irrigation or power."

Where does this leave Mike and Elizabeth Moore? If their land on the Guadalupe River was patented before 1895, their domestic water use is legal, even though no certificate of adjudication was or has been issued.

Sections 11.142 and 11.143 of the Texas Water Code describe yet another surviving right. These sections allow the creation of reservoirs holding less than 200 acre-feet without obtaining a permit. (An acre-foot is that quantity of water required to cover one acre of land to a depth of one foot or approximately 325,851 gallons.) The water collected in the reservoirs may be used only for domestic and livestock purposes. Water used solely for recreation is not mentioned in the statutes, but they mention salt water for mariculture.

In general, water located in underground streams and the underflow of streams is state water. Both the case law addressing the issue and Section 11.021 of the Water Code reinforce this rule.

The problem with underground streams parallels a problem with surface streams, i.e., proving the existence of a watercourse.

The definition of a watercourse is not found in the statutes, but in case law. The controlling definition is taken from a 1925 case. It required a watercourse to have a definite bed and banks, even though the bed and banks might be slight, imperceptible or even absent in places. A watercourse must have a current and a permanent source of supply. By permanent, the court did not mean that water must always be present, but rather that under certain, similar conditions, a flow of water would be produced; these conditions must recur with some degree of regularity, so that they establish and maintain a running stream for considerable periods. *Hoefs v. Short,* 273 S. W. 785 (Tex. 1925).

Obviously, the case was long on description and short on definition. Consequently, it may be difficult to determine where or when a watercourse begins. The problem is further compounded in defining unobservable underground streams.

The characteristics of a watercourse were developed for waters flowing in a stream. However, the same concepts can be applied to a lake or other body of still waters. Thus, a natural or artificial lake must have a bed, banks or shores and a water supply that may or may not have the same permanent source. *Diversion Lake Club v. Heath,* 86 S. W. 2d 441 (Tex. 1935) and *Taylor Fishing Club v. Hammett,* 88 S. W. 2d 127 (Tex. App. 1935).

The underflow of a stream has been defined neither by statute nor case law. Rather, the Texas Department of Water Resources issued the following definition.

"Underflow of stream is water in sand, soil and gravel below the bed of the watercourse, together with the water in the lateral extensions of the water-bearing material on each side of the surface channel, such that the surface flows, the latter flows being confined with a space reasonably defined and having a direction corresponding to that of the surface flow."

The definition appears to have been taken from cases in California. The standards, however, appear at least as vague as those defining a watercourse.

Suppose that the Moores were misusing state water. What are the consequences?

Section 11.081 of the code provides that a person who willfully takes, diverts or appropriates any state water without complying with the law is guilty of a misdemeanor punishable by a fine of not more than $100 or by confinement in the county jail for not more than six months or by both. A separate offense is committed for each day of unauthorized use.

Section 11.082 of the code provides that a person who willfully takes, diverts, or appropriates state water without complying with the law also is liable for civil penalties of not more than $1,000 for each day the violation takes place.

Similar fines and confinement in jail are described in Section 11.083, 11.084 and 11.085. The offenses cover persons who:

- willfully open, close, change or interfere with any headgate or water box without authority to do so,
- willfully use water or conduct water through a ditch or upon their land without authority to do so,
- sell or offer to sell a permanent water right without first perfecting the right and
- take or divert any water from a watercourse or watershed into another stream, watercourse, or watershed without authority to do so.

Privately owned Texas water is determined primarily by the location. There are three categories of privately owned water: diffused surface water, percolating groundwater and water from springs and artesian wells.

Diffused surface water generally consists of rainwater or melting ice and snow that drains (or runs) over the face of land before reaching a watercourse. Conversely, diffused surface water is all water not found in a watercourse. Obviously this definition magnifies the problems associated with determining a watercourse.

The overflow of state water that does not return to a stream may be defined as diffused surface water. *Bass v. Taylor,* 90 S. W. 2d 811 (Tex. 1936).

There is little law regarding a landowner's right to use privately owned diffused surface water. In the absence of rules, a good working hypothesis is that the landowner may make a reasonable, beneficial use of the water.

Percolating groundwater consists of groundwater other than underground streams and the underflow of surface streams. This includes water

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Water conservation districts monitor underground water use

Continued From Page Three

percolating, oozing or filtering through the earth. All underground water is generally presumed to be percolating groundwater. *Texas Co. v. Burkett*, 296 S. W. 273 (Tex. 1927).

The rule of Texas water law is that the surface owner has the right to capture underground percolating water and use it or sell it like any other species of property. The owner of the surface estate owns the groundwater beneath it.

Two cases have restricted this otherwise unlimited-use rule. The two courts have ruled that the owner may not maliciously take groundwater for the sole purpose of injuring a neighbor. Furthermore, the owner may not willfully waste groundwater and may be liable for the negligent withdrawal of groundwater that causes subsidence of a neighbor's land. *Friendswood Development Co. v. Smith-Southwest Industries, Inc.*, 576 S. W. 2d 21 (Tex. 1978) and *City of Sherman v. Public Utility Commission of Texas*, 643 S. W. 2d 681 (Tex. 1983).

Groundwater Regulations

Presently, there is no state-wide regulation of percolating groundwater. However, underground water conservation districts may be created pursuant to Chapter 52 of the Texas Water Code. The districts may have the power to conserve, preserve, protect, recharge, control subsidence and prevent waste of underground water from an underground water reservoir. The districts may provide for the spacing of water wells and may regulate the production from wells.

Prior to passage of Chapter 52 of the Texas Water Code, the Edwards Underground Water District was created in 1959. In 1979, the district's enabling act was amended, empowering the district to conserve, preserve, protect and increase the recharge of and prevent the waste and pollution of underground water. The district includes all or portions of Bexar, Comal, Hays, Medina and Uvalde Counties.

In 1975, the Texas Legislature created the Harris-Galveston Coastal Subsidence District. The district is to regulate the withdrawal of groundwater within the district to end subsidence that contributes to flooding, inundation or overflow and rising waters resulting from storms and hurricanes.

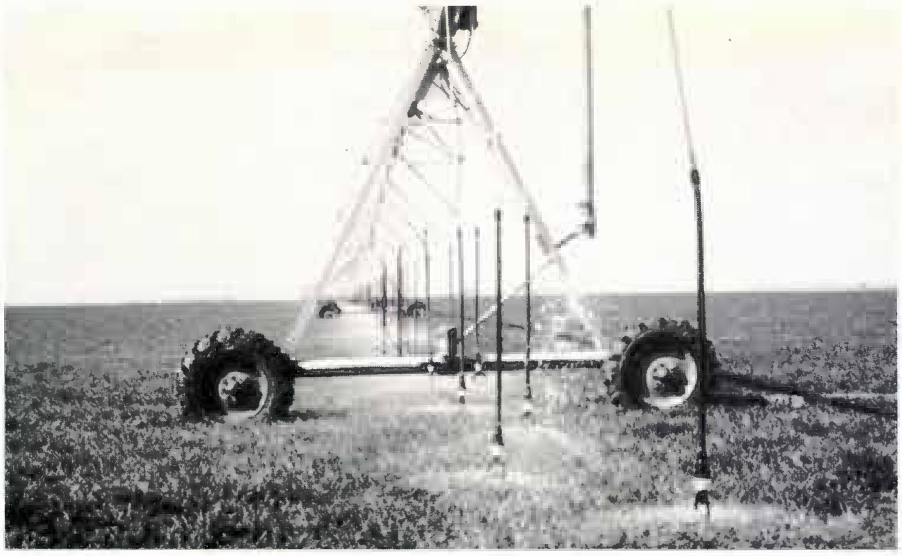
The act provides for the issuance of permits and collection of permit fees based on the length of the permit and the maximum amount of authorized groundwater withdrawal.

To Be Continued

Irrigation systems upgraded through Pilot Ag Loan Program have cumulatively saved 25,000 acre-feet of groundwater

Approximately 150 producers within the 15-county High Plains Underground Water Conservation District No. 1 have upgraded their irrigation application and distribution efficiencies since 1985 with funds from the Pilot Agricultural Water Conservation Equipment Loan Program. The improved efficiencies have resulted in savings in excess of 25,000 acre-feet of water.

The program can best be illustrated by describing how one irrigator eliminated annual water losses of 159 acre-feet by upgrading his irrigation system from furrow irrigation to a seven-tower LEPA center pivot system. He previously had open ditch losses from deep percolation and evaporation losses of about 25 acre-feet per year before the water reached the field. Deep percolation and evaporation from the furrow stream equaled about 125 acre-feet of the water that was delivered to the field. Tailwater runoff from this farm had been about nine acre-feet per year.



PILOT AG LOAN PROGRAM SUCCESSFUL — LEPA center pivot systems are among irrigation equipment eligible for purchase with low-interest loans under the Pilot Agricultural Water Conservation Equipment Loan Program. Voters can extend the time limit on the Ag Loan program by approving Constitutional Amendment 18 on November 7th.

By changing his irrigation methods from furrow irrigation to a LEPA center pivot system and eliminating open ditch and tailwater losses, this irrigator was able to realize an annual groundwater savings of 144 acre-feet — even though the LEPA system had a water loss of 15 acre-feet. Water savings of more than 1,500 acre-feet should be realized during the LEPA sprinkler system's 10 or more year life expectancy. Fuel and labor costs are also reduced as a result of the improved water application efficiency.

"Considering that one acre-foot of water is equal to covering an acre of land with water one foot deep, the groundwater saved through the Pilot Agricultural Water Conservation Loan Program is quite significant," says Ken Carver, High Plains Water District Assistant Manager.

Deep percolation, evaporation and tailwater runoff have historically resulted in high water losses for irrigators on the Texas High Plains. By taking advantage of the low-interest loans available through the Pilot Loan Program, producers have purchased water conservation equipment such as underground pipelines, surge valves and center pivot irrigation systems to reduce these water losses to the very minimum.

In 1985, the Texas Legislature approved the Pilot Agricultural Water Conservation Equipment Loan Program. A two-year time limit was given to evaluate the pilot program; and in 1987, the legislature extended the evaluation period to August 1989.

The 1989 legislative session passed legislation introduced by Senator John T. Montford of Lubbock to permanently establish the Ag Loan Program. On November 7th, voters will have an opportunity to vote for Constitutional Amendment 18 which will "eliminate certain time limitations relating to the issuance of Texas agricultural water conservation bonds."

THE CROSS SECTION (USPS 564-920)
HIGH PLAINS UNDERGROUND WATER
CONSERVATION DISTRICT NO. 1
2930 AVENUE Q
LUBBOCK, TEXAS 79405

SECOND CLASS PERMIT

THE Cross SECTION

Published monthly by High Plains Underground Water Conservation District No. 1, 2930 Avenue Q, Lubbock, Texas 79405—Ph. 762-0181

Volume 35—No. 11 Publication Number USPS 564-920, Second Class Postage paid at Lubbock, Texas *November 1989*

District salutes water savings by area irrigators

You've come a long way, baby!

High Plains Water District irrigators have realized for many years that they were pumping water from an aquifer which received very little recharge and which could be mined rapidly if great care and attention were not given to conservation.

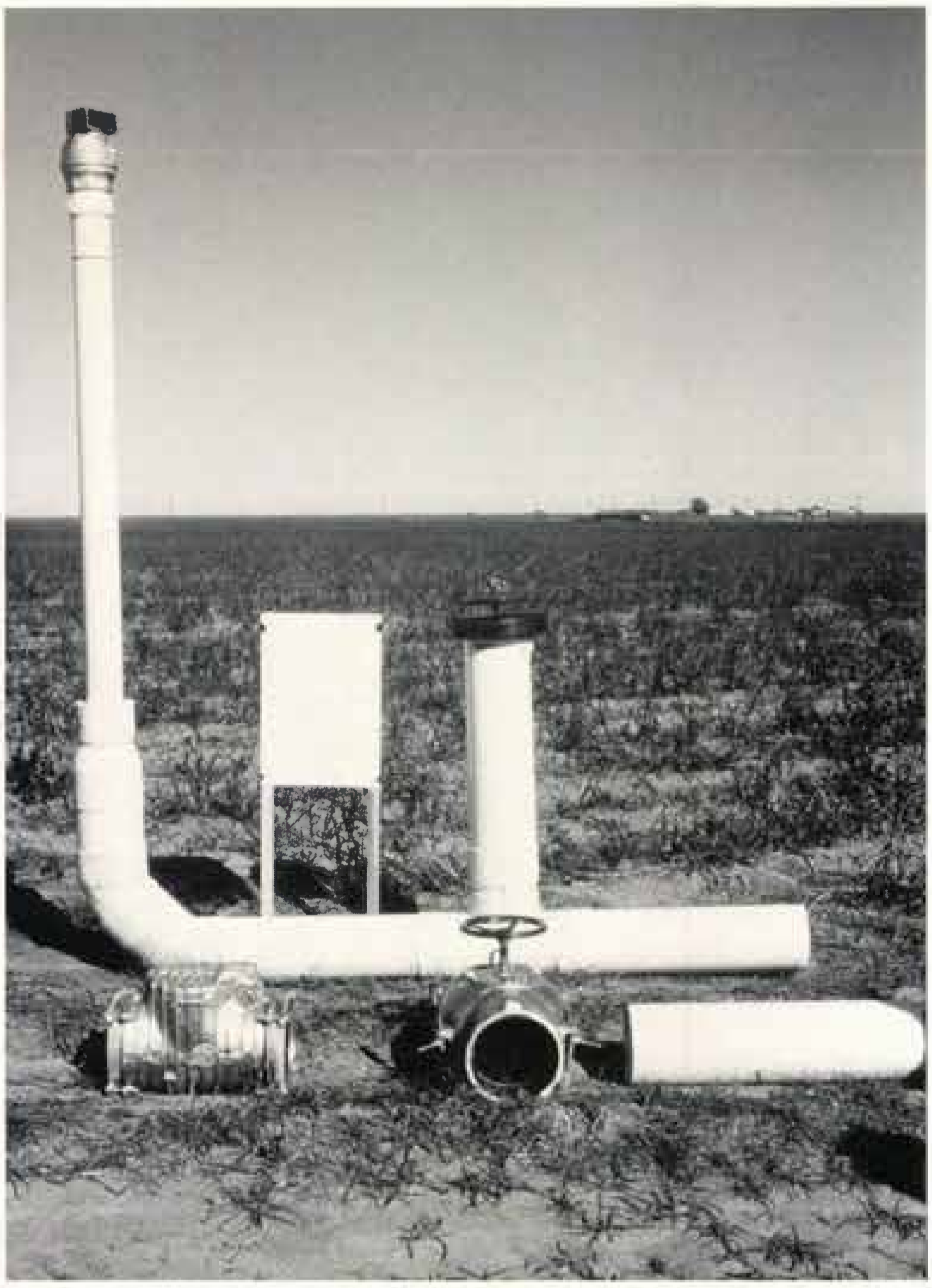
They have worked very hard to improve their equipment and skills since irrigation began in the High Plains. The photographs accompanying this article illustrate water losses during irrigation in the past and how these losses are being reduced with technology available today. Water savings of almost 50 percent have been achieved by many irrigators.

Thousands of irrigators within the High Plains Water District service area have worked to improve their efficiencies. The results of their efforts are best illustrated by the reduced declines in the water table during the past few years.

In the 1960s, water-level declines of three and four feet per year were commonplace. In 1985, the water level stabilized for the first time since the Water District's creation in 1951, and rose one-half foot in 1986 and nine-tenths of a foot in 1987. During the drought year of 1988, a decline of only one-half foot occurred. Comparison of today's annual changes in water levels to the three to four foot declines commonplace in the 1960s justifies the headline of this article, "You've Come A Long Way, Baby!"

See PRODUCERS Page Two

OPEN DITCH WATER LOSSES — Deep percolation and evaporation from open, unlined ditches result in water losses of 10 to 30 percent per 1,000 feet of ditch. The total water loss per foot of ditch in a 2,000 hour irrigation season averages about 5,000 gallons of water.



UNDERGROUND PIPE ELIMINATES DITCH EVAPORATION AND DEEP PERCOLATION LOSSES — More than 10,000 miles of underground pipeline have been installed within the water district service area.

Producers save water by reducing furrow irrigation losses

Continued From Page One

HOW HAVE THE IMPROVEMENTS IN EFFICIENCY AFFECTED CROP YIELDS?

Cotton, the major crop in the southern High Plains, had near record yields during 1986 and 1987.

Corn is the second major acreage crop grown in the area. Yields per acre have remained roughly stable. Evidently, the improved efficiencies have not only helped stabilize the aquifer, but also crop production.

Irrigators who have converted their irrigation systems from conventional furrow to LEPA report reduced irrigation application labor costs of up to 75 percent, decreases from 35 to 50 percent in fuel used for irrigation and water savings of at least 25 percent.

Timely applications of irrigation water applied uniformly across the field make water previously lost to evaporation available to the crops during critical growth periods. This has resulted in increased yields of 25 percent or more.

Several producers have reported that the savings on fuel costs alone more than equal their annual payments on a center pivot system.

The conserved water left in the ground for future use has a recognized value. In 1988, actual farm sales in seven counties served by the High Plains Water District were tabulated. When the sales prices were reduced by the value of the improvements, land classified as "dryland" sold for an average of about $250 per acre less than irrigated land.

Using 150 feet of saturated thickness as an average for each acre of the irrigated land, each surface acre would have had 22.5 acre-feet of water in storage. Based upon this assumption, the price paid in 1988 for water stored in the Ogallala

See SURGE Page Three

LARGE WATER SURFACE AREAS INCREASE EVAPORATION — Irrigators have learned that a solid set irrigation pattern results in almost two-thirds of the field having a full water surface area exposed to evaporation. Also, a solid set pattern leaves the total soil surface area wet, allowing additional evaporation losses to occur.

IRRIGATING EVERY OTHER ROW REDUCES SURFACE AREA — Many irrigators have changed from a solid set irrigation pattern to an every-other-row pattern, decreasing the water surface area and cutting evaporation losses almost in half.

TAILWATER WASTE — Irrigators have learned that allowing tailwater to escape from their fields depletes the groundwater supply, makes them liable for any accidents or damages due to the tailwater, and provides no benefit to crop yields, while wasting the fuel used to pump the water.

TAILWATER PITS COLLECT RUNOFF FOR LATER USE — By capturing runoff from the field and making it available for re-use, tailwater pits reduce the amount of water irrigators must pump from the Ogallala Aquifer. More than 3,000 tailwater return pits are currently in use within the High Plains Water District service area.

THE Cross SECTION

THE CROSS SECTION (USPS 564-920)

A MONTHLY PUBLICATION OF THE HIGH PLAINS UNDERGROUND WATER CONSERVATION DISTRICT NO. 1

Second Class Postage Paid at Lubbock, Texas
District Office at Lubbock

POSTMASTER: Send address changes to:
The Cross Section, 2930 Avenue Q,
Lubbock, TX 79405 Telephone (806) 762-0181

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Surge valves, center pivots improve irrigation efficiencies

Continued From Page Two

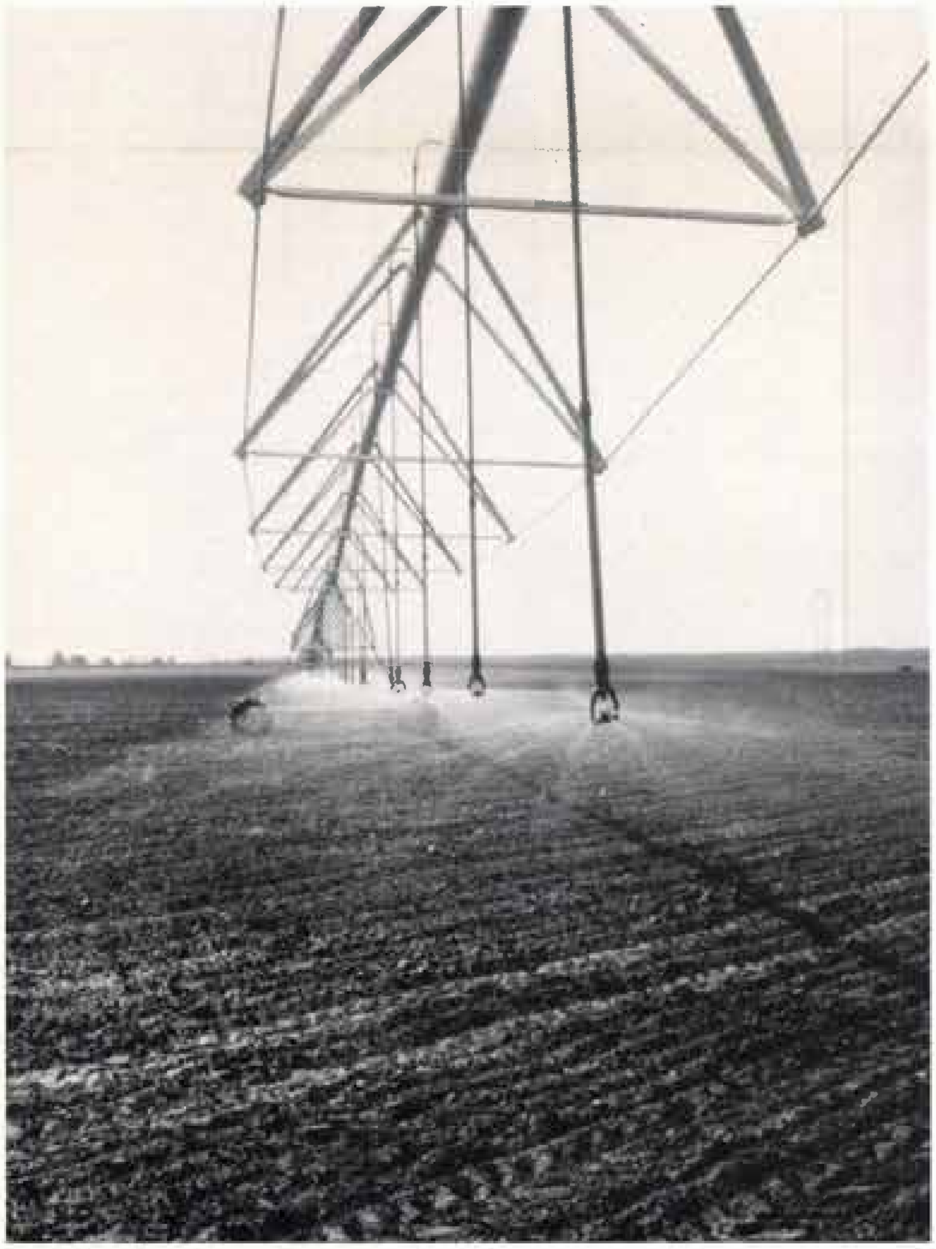
Formation for future use was $11.11 per acre-foot.

If the stored water is used in the future to irrigate cotton, an increase in the yield over dryland yields should be from 30 to 50 pounds of lint per acre per inch of water applied. Assuming a 30 pound lint increase per acre-inch of water applied, an acre-foot of water applied would increase the yield on an acre of land by 360 pounds of lint. At a value of $0.50 per pound of lint, every acre-foot of water saved now has a potential value of $180 in increased yields.

SURGE VALVES BENEFIT FURROW IRRIGATORS — A time-controlled surge irrigation valve managed correctly in conjunction with a furrow irrigation system can eliminate irrigation tailwater losses, minimize deep percolation losses and reduce the length of time that water in the furrow is exposed to evaporation. Water savings of 10 to 40 percent have been measured after the addition of surge valves to conventional furrow irrigation systems.

SIDEROLL SPRINKLER evaluations have shown an average application efficiency of 47 percent. This means that 53 percent of the water pumped through the sprinkler is lost to wind drift and evaporation! Sideroll systems are rapidly being replaced with more efficient systems in the High Plains.

HIGH PRESSURE CENTER PIVOTS — A high pressure above-line discharge center pivot irrigation system has a water application efficiency of about 60 percent. Wind drift and evaporation losses equal about 40 percent. The majority of the High Plains high pressure center pivot systems have been converted to dropline systems.



PARTIAL DROPLINE CENTER PIVOTS — With a modified dropline center pivot, the water is discharged between the ground and the pivot, and the water application efficiency rating is about 80 percent. With this type of system, loss to wind drift and evaporation is about 20 percent of the water pumped.

FULL DROPLINE CENTER PIVOT SPRINKLER SYSTEMS — A center pivot equipped with full drops, known as a low energy precision application, or LEPA, can achieve water application efficiencies of up to 95 percent. Since water is applied at low pressure directly above the furrow, wind drift and evaporation losses are virtually eliminated. As a result, only about five percent of the water pumped through the system is lost to evaporation before it reaches the ground. To maximize uniform water application, most irrigators use furrow dikes and/or chiseling in the water furrow with the LEPA system.

Committee will review Edwards water management alternatives

A special joint legislative committee has been charged with reviewing and developing specific data on the Edwards Aquifer, examining present institutional arrangements for water resource management in the region, and examining alternative methods of managing the aquifer.

Lt. Gov. Bill Hobby appointed Senators Cyndi Krier, R-San Antonio (Co-Chairman); Bill Sims, D-San Angelo; Gonzalo Barrientos, D-Austin; Frank Tejeda, D-San Antonio; Judith Zaffirini, D-Laredo; Ken Armbrister, D-Victoria; and John Montford, D-Lubbock to serve on the committee.

Texas Speaker of the House Gib Lewis named Representatives Terral Smith, R-Austin (Co-Chairman); Eldon Edge, D-Poth; Orlando Garcia, D-San Antonio; Harvey Hilderbran, R-Uvalde; Edmund Kuempel, R-Seguin; Libby Linebarger, D-Manchaca; and Jeff Wentworth, R-San Antonio, to the committee.

Hobby said he hopes the committee "will produce recommendations that reconcile the demands on the aquifer, which is a key source of water for many Texans." The committee was created by HCR 142, passed in the regular session of the legislature this year. The resolution cites the "continuing controversy" over water management alternatives in the Edwards region, and says the controversy "would benefit from dispassionate review at the state level, including the involvement of independent scientific expertise."

Source of spring water often determines its ownership

EDITOR'S NOTE: What many consider to be a proper use of water may actually be illegal.

Statutory and case law determines who has the right to use publicly-owned (state) water. Privately-owned water use is basically unrestricted as long as the owner does not waste or withdraw the water negligently.

Part Two of this article, reprinted from the Texas A&M University *Real Estate Journal*, examines the ownership of water flowing from springs and water from artesian wells. Part One of this two-part series appeared in the October 1989 *Cross Section* — **CEM.**

". . . the right to use water, and not necessarily its abundance in a region, will have a strong impact on future land values."

By Judon Fambrough

Water flowing from springs may be either state or private water. However, water flowing from springs arising on private property is presumed to be private without evidence to the contrary. *Bartley v. Stone*, 527 S. W. 2d 754 (Tex App. 1975).

Second in a Two-Part Series

Water flowing from a spring is more apt to be declared state water. The larger the spring, the greater its contribution to the flow of a stream and the greater its value to downstream riparian landowners. The water also is more apt to be declared state water if its source is either the underflow of a stream or an underground stream, rather than percolating groundwater.

The flow of a spring from percolating groundwater belongs to the landowner. However, ownership appears to be lost if the landowner does not capture the flow before it enters a watercourse. This possible loss of ownership has caused the Texas Water Commission to issue the following ruling.

"Spring water which originates from ordinary percolating waters is private water ...(and) may be captured by the landowner at any time before it enters a watercourse. However, at such time as private, percolating spring water enters a watercourse and commingles with state water in the watercourse, it will be presumed that any water used from the watercourse is state water and not private, percolating spring water. Private, percolating spring water which is allowed to enter a watercourse and commingle with state water retains its private property characteristic only if the landowner maintains control over the spring water and can identify it both as to amount and location in the watercourse." *Texas Water Commission, Modified Final Determination, In the Matter of the Adjudication of the Clear Fork Brazos River Watershed of the Brazos River Basin* (Jan. 10, 1985).

There is little law regarding a landowner's right to use privately owned spring water. Apparently, the landowner can make the same reasonable, beneficial use of it as diffused surface water.

Artesian Wells

Little, if any, case law exists on artesian wells. Section 11.201 of the Water Code defines an artesian well as "an artificial well in which the water, when properly cased, will rise by natural pressure above the first impervious stratum below the surface of the ground."

The code further provides that a person is entitled to drill an artesian well on his or her land for domestic use or for stock raising without applying for a permit. The well must be capped if the water contains minerals or other substances injurious to vegetation or agriculture.

The landowner must keep all drilling records and file an annual report before March 1. The report must contain the data required by Section 11.207 of the code.

The obvious impact of the statute is to classify water from artesian wells as state water. However, the ownership of water from artesian wells, like spring water, must be determined by its source. If the source is percolating groundwater, it is privately owned. If the source is an underground stream, it is state water.

Water is rapidly becoming a scarce natural resource in Texas. Although Texas is attempting to implement a state-wide plan for water use, the water supply dwindles in the face of an ever-increasing demand. Consequently, the right to use water, and not necessarily its abundance in a region, will have a strong impact on future land values.

This article traces the right to use state water until a certificate of adjudication is issued. It does not discuss the rights associated with the certification such as its transferability and the consequences of subdividing land to which it attaches.

This article is for information only and is not a substitute for legal counsel.

Judon Fambrough is an attorney, member of the State Bar of Texas and Senior Lecturer with the Real Estate Center at Texas A&M University.

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THE Cross SECTION

Published monthly by High Plains Underground Water Conservation District No. 1, 2930 Avenue Q, Lubbock, Texas 79405—Ph. 762-0181

Volume 35—No. 12 Publication Number USPS 564-920, Second Class Postage paid at Lubbock, Texas *December 1989*

Water District Election slated

On January 20, 1990, voters will go to the polls to choose Board members and County Committee members to represent Directors' Precincts One, Two and Five of the High Plains Underground Water Conservation District No. 1.

The Board of Directors meet monthly to consider Water District business. They oversee all Water District activities, including legal, financial and business matters. Board members set long-range goals and direct staff activities through the Water District manager.

County Committees meet regularly to recommend approval or denial of applications for water well permits and agricultural water conservation equipment loans. Committee members help keep Directors advised on water-related needs of their county. Also, they serve as a local contact person for water conservation problems or opportunities in their community.

Candidates for a Water District Board member or County Committee member must be at least 18 years old, a Texas resident and a resident of the Precinct for which they are seeking office for at least six months. Qualified candidates may obtain an application to have their name placed on the ballot from any county Water District office, beginning November 30, 1989. Completed applications must be returned to the District headquarters by December 29, 1989.

Absentee polling will begin January 2, 1990, and continue through January 16, 1990, at the following locations:

ABSENTEE VOTING

Precinct One consists of Lubbock County and those portions of Crosby and Lynn Counties within the Water District service area.

Crosby County — Ralls Chamber of Commerce, 808 Avenue I (East side of Square), Ralls, Texas 79357. Robby Lyle is the clerk.

Lubbock County — High Plains Underground Water Conservation District No. 1 office, 2930 Avenue Q, Lubbock, Texas 79405, (806)

See ABSENTEE Page Four

Cliff Johnson appointed Water Commissioner

Governor Bill Clements has appointed Cliff Johnson of Palestine to serve as a member of the Texas Water Commission until August 31, 1991. Johnson replaces John O. Houchins of Houston, who resigned from the Commission October 1st to re-establish his law practice.

Johnson, 38, was born in Galveston and attended schools in Palestine. He earned his Bachelor of Business Administration degree from the University of Texas at Austin in 1973. Following graduation, he returned to East Texas to pursue a career in real estate.

In 1985, he was elected to the Texas House of Representatives from District 11 (Anderson, Cherokee and Freestone Counties). As a state representative, he served as a member of the Appropriations and Calendars committees, as well as Chairman of the Budget and Oversight Subcommittee of the House Natural Resources committee.

He resigned his House seat to join Governor Clements' staff as Legislative Director in 1988. He was serving in this position at the time of his October appointment to the TWC.

Johnson joins Chairman Buck J. Wynne of Dallas and John E. Birdwell Jr. of Lubbock on the three-member Texas Water Commission.

Commissioner Johnson resides on his family farm in Palestine with his wife, Nita, and their daughter and son.

Cliff Johnson

Sonny Kretzschmar, Tommy Knowles named to Texas Water Development Board positions

Sonny Kretzschmar and Dr. Tommy Knowles have been named to new positions at the Texas Water Development Board, according to Walter W. Cardwell III, Chairman. The Texas Water Development Board is the state agency responsible for planning and financing water supply, wastewater treatment, and flood protection for the state.

Sonny Kretzschmar

Sonny Kretzschmar has been named the new TWDB Executive Administrator. Kretzschmar was appointed acting Executive Administrator earlier this year when M. Reginald Arnold II was seriously injured in an automobile accident. Arnold will serve as a Special Assistant to Kretzschmar upon his return to the Texas Water Development Board.

Kretzschmar received his Bachelor of Science degree in Agricultural Engineering from Texas A&M University in 1966. He is a registered professional engineer and was formerly employed as an engineer with the USDA-Soil Conservation Service and the Texas State Soil and Water Conservation Board in Temple.

He joined the Texas Department of Water Resources in January 1978 as the Executive Assistant to the Executive Director. He served as the Assistant Executive Director of the Texas Department of Water Resources until 1985 when he joined HDR Infrastructure of Austin.

Kretzschmar was appointed Deputy Administrator of the Texas Water Development Board in 1987.

Sonny Kretzschmar

Dr. Tommy Knowles

Dr. Tommy Knowles

Dr. Tommy R. Knowles is the new Director of Planning for the TWDB. He has served as Interim Director of Planning since the former Director of Planning, Dr. Herbert Grubb, resigned in November 1988.

Knowles has been associated with the state's water agencies since 1985. He has most recently served as Chief of the TWDB Water Availability Data and Studies Section.

He graduated with honors from Texas Tech University, where he earned a B.S. in Agricultural Engineering, an M.S. in Civil Engineering and a Ph.D in Water Resources.

Technical Division collects data for hydrologic atlas update

Technical Division staff members will be making depth-to-water measurements in selected water wells to gather data needed to update the 1985 High Plains Water District hydrologic atlas series to reflect 1990 groundwater conditions.

"Our field staff is attempting to measure the depth-to-water in approximately one well per square mile. The accuracy of the maps depends largely upon having a high density of reliable measurements. Most of the wells to be measured were last measured in late 1984 and early 1985 during the data collection for the 1985 hydrologic atlas series," says Don McReynolds, Technical Division Director.

"We plan to use the two sets of measurements made in the same wells to construct new maps for the atlases which will illustrate the change in water levels which have occurred during the five-year period," he says.

The 1990 atlases will be the third edition of the series, which is updated every five years. Each hydrologic atlas features one county or portion of a county within the High Plains Water District service area. Contour maps in each atlas packet reflect the altitude of the land surface, the altitude of the base of the Ogallala Formation, the altitude of the water table and the intervals of saturated thickness within the individual county.

By using the descriptive text and maps in the hydrologic atlases, landowners can estimate the amount of water in storage under their land; how far from land surface to the water table; and how deep wells should be drilled to reach the base of the aquifer. Also, they can estimate the amount of saturated thickness under their land and the probable direction of flow of groundwater under their land.

Producers are reminded that Technical Division staff members will be traveling from well site to well site in blue and white Water District vehicles. The continued cooperation of the landowners and operators within the 15-county High Plains Water District is appreciated as this important data is collected.

Soil moisture survey aids pre-plant irrigation decisions

As the 1989 crop harvest is completed and taken to market, many producers are starting to think about preparations for next spring's planting. Among the important questions to consider is whether or not to irrigate before planting. If irrigation is needed, then the producer must determine how much water will be needed to fill the soil profile to field capacity.

High Plains Underground Water Conservation District No. 1 field staff have begun collecting data at 271 soil moisture monitoring sites across the 15-county Water District service area to make the producers' pre-plant irrigation decision a lot easier. With this information, irrigators can make a better estimate of the amount of water needed to fill the soil profile to field capacity — instead of under-irrigating or over-irrigating.

The neutron moisture meter, used by Water District personnel to measure soil moisture conditions, is one of the most accurate soil moisture measuring devices available. Readings are taken at six-inch intervals throughout the five-foot soil profile by inserting a neutron probe into a previously-installed aluminum access tube.

The resulting data is used to construct soil moisture availability and deficit maps which illustrate the estimated moisture available in the soil profile for plant use and the amount of water needed to bring the soil profile to field capacity.

Soil moisture monitoring sites are chosen to represent typical dryland or irrigated farming conditions in a specific area. Soil types, the saturated thickness of the Ogallala Aquifer and crop water requirements are among the factors considered by District personnel when establishing a soil moisture monitoring site.

The soil moisture monitoring site network has been continually updated through the replacement of lost sites and/or the addition of new sites.

"Sometimes soil moisture monitoring locations need to be changed to provide better data for an area," says Ken Carver, Assistant Manager. "For example, cropping patterns may change or a site may be located in a low area which holds water. The soil moisture data from this site would not accurately reflect the rest of the area.

"There are 22 soil moisture monitoring sites on land enrolled in the Conservation Reserve Program (CRP) that have been planted to grass and will have to be replaced," he adds.

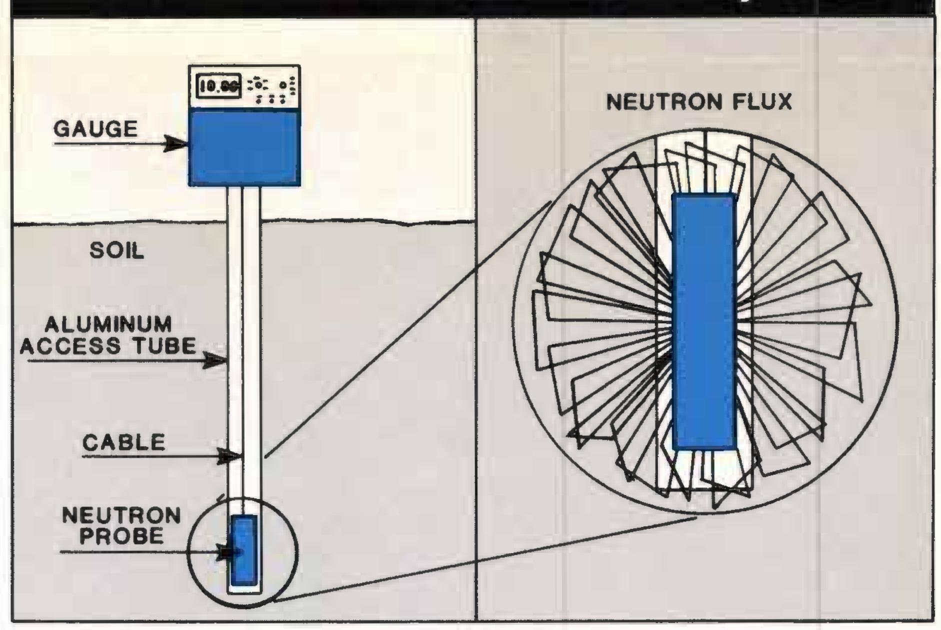
Carver says new soil moisture sites were added in Randall County in 1989, and additional sites are planned for Castro, Deaf Smith, Lamb, Lynn and Potter Counties in the future.

Water District personnel Jerry Funck, Obbie Goolsby, Arnold Husky and Mike Risinger will be out in the fields taking soil moisture readings from November to January. Blue and white Water District vehicles are easily identified, and personnel will be happy to answer landowners' questions while collecting the soil moisture data.

Producers who monitor the soil moisture in their own individual fields can obtain more detailed soil moisture information. "Soil moisture conditions can vary even between neighboring fields, depending on rainfall, irrigation and farming conditions. Gypsum blocks and tensiometers are two methods individuals can use to check soil moisture conditions," says Mike Risinger, Soil Scientist with the USDA-Soil Conservation Service and coordinator of the District's soil moisture monitoring program.

Producers desiring further information about soil moisture monitoring devices can request copies of the Water Management Notes, *Irrigating By The Block: Soil Moisture Blocks and Resistance Meters* and *Tensiometers: A Gauge for Measuring Soil Moisture*, from the Water District office.

Neutron Moisture Meters: How they work



The probe is lowered into a buried aluminum access tube where neutrons are emitted and collide with atoms in the soil. The collision slows down the neutrons. The neutron meter is designed to count the slowed neutrons created primarily when the neutrons collide with the hydrogen atoms in water. The density of the neutron flux is therefore dependent upon the amount of water in the surrounding soil. The results of the count are displayed on the front panel of the gauge, as an index of soil moisture.

Season's Greetings

With every good wish for a Happy Holiday season and a prosperous New Year from The Board of Directors, County Committees, County Secretaries and Staff

High Plains Underground Water Conservation District No. 1

THE Cross SECTION

THE CROSS SECTION (USPS 564-920)

A MONTHLY PUBLICATION OF THE HIGH PLAINS UNDERGROUND WATER CONSERVATION DISTRICT NO. 1

Second Class Postage Paid at Lubbock, Texas
District Office at Lubbock

POSTMASTER: Send address changes to:
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CARMON McCAIN, Editor
DIRECTOR, INFORMATION/EDUCATION

New chain-diker reduces runoff which boosts crop yields

EDITOR'S NOTE: Any question regarding this column should be addressed to Science Writer, Department of Agricultural Communications, Texas A&M University, College Station, Texas 77843. The chain-diker described in this article is being commercially offered by Jones Manufacturing under the *Multi-Dike* label. For more information, contact Don Jones, P.O. Box 1577, Vernon, Texas 76384 or call (817) 552-6311 — **CEM.**

By Robert L. Haney
TAES Science Writer

A promising new tool that could increase wheat production by 11 percent and seeded grass stand establishment threefold is now in commercial production.

The chain-diker was developed by an agricultural engineer, Harold T. Wiedemann of Vernon, with the Texas Agricultural Experiment Station (TAES), in cooperation with an Australian inventor.

The concept of modifying an anchor chain with paddles originated with its inventor, Bruce A. Smallacombe, Capella, Queensland, Australia. He patented it in Australia, Canada and the United States. Smallacombe received the Inventor of the Year Award for Australia in 1985 for this water conservation device.

His modified anchor chain technology, which is similar to the disk-chain device developed by Wiedemann for clearing brush, has served as the basis for cooperative research in the USA. Smallacombe contacted Wiedemann, and the present device was built and perfected in the TAES engineering workshops at the Texas A&M University Agricultural Research and Extension Center near Chillicothe-Vernon.

The concept of utilizing small dikes between rows to trap rainfall for enhanced dryland row crop production (also called basin tillage) was tested in the 1930s, but lack of adequate equipment and poor weed control delayed its commercial use.

But modern machinery has solved much of the hardware problem. Currently, furrow diking has increased dryland cotton and grain sorghum production about 20 percent at the TAES Research Center near Vernon, during a four-year period.

However, there had been no feasible method previously to dike wheatland to reduce runoff and conserve moisture for wheat production. Basin tillage (pitting) has also enhanced seeded grass establishment on rangeland, but again, the equipment developed in the past has not been satisfactory, Wiedemann said.

The broadcast diker uses specially shaped blades welded to a large anchor chain. As it is pulled over flat-tilled land, the chain rotates and the blades leave a broadcast pattern of diamond-shaped basins about four inches deep. These basins do not hinder subsequent farming operations.

Units can be built up to 90 feet wide and require little maintenance or pulling power. They are designed to be operated behind a chisel, disk or drill at 5 to 5.5 miles per hour and fold to be easily towed between fields, Wiedemann said.

The chain-diker also is well suited to being pulled behind a disk-chain for rangeland seedbed preparation. The disk-chain is a unique tool to disk rough land. Combined, they provide tillage, land smoothing, and basin formation even on debris-littered sites, Wiedemann said.

Commercial units were designed for simplicity and trouble free operation. Anchor chain that is 2.75 inches in diameter was selected, based upon experience of Smallacombe. Two steel plates, that are .5 inch thick, 4 inches wide by 11 inches long, were bent slightly and welded lengthwise on opposite sides of each link to form paddles.

The chains were attached to a 10-inch by 10-inch toolbar by flexing arms. Large swivels with heavy-duty roller bearings allow the chain to rotate when pulled. Toolbar mobility is accomplished by support wheels attached to the outer ends of the toolbar and the rear of the towing frame.

To raise the chain above the ground, the toolbar is rotated by extending a hydraulic cylinder mounted on the towing frame. Rotating the toolbar also lifts the attached support wheels and lowers the transport wheels. Two universal joints built into the toolbar allow it to be folded.

Because the transport wheels are mounted at a slight angle, the toolbar folds to the rear as it is towed forward. Backing the unit unfolds the toolbar. A cable brace is used to prevent the toolbar from folding rearward during normal operation.

Folding the toolbar to the rear for transporting safely places the chains and blades inward and prevents accidental contact from outside of the equipment. The equipment, when folded, is suitable for trailing behind other implements.

DIAMONDS IN THE DIRT — Diamond-shaped basins created by this chain-diker reduce rainfall runoff and conserve moisture for wheat production. Research has shown that chain-diking benefits the establishment of seeded grassland as well.

Units measuring 26, 45, and 60-feet wide have been built in the U.S. Retail cost of the units average about $325 per foot of width, Wiedemann said. In comparison, chisels and disks retail for $600 to $850 per foot of width.

Basin size and number were measured in a clay loam soil near Vernon, during operation of the commercial-sized units. In a soil tilled by chiseling and disking, basins were 15.5 x 10.2 x 4.1 inches deep. There were about 18,000 basins per acre.

Power required to pull the various diking units was measured in very fine sandy loam and clay loam soils. Chain diking was done immediately after plowing. Units tested were the 26, 45, and 60-foot models.

Preliminary figures indicate that a drawbar power of 0.8 to 0.9 horsepower per foot of width was required to pull the chain-diker at 5 miles per hour in plowed wheat stubble. That would figure out, on the above models (if you use 0.85 hp/ft) as 22 hp for the 26-foot model, 38 hp for the 45-foot unit, and 51 hp for the 60-foot model.

Under many conditions, Wiedemann said, the same plowing gear can be used when towing the chain-diker behind a primary tillage implement, while other conditions require a reduction of one gear.

As mentioned earlier, wheat yields in 1989 were increased 11 percent from chain-diking (42.9 bu/ac versus 38.8). Establishment of seeded grass was determined on a clay loam site on the W.T. Waggoner Ranch near Vernon. The site was rootplowed for brush control and smooth chained to break up brush debris and partly smooth the land.

Seedbed preparation treatments included 1) chain diking following disk chaining, 2) disk chaining, or 3) smooth chaining three times. Grass densities were significantly better in the disk-chain-diker treatment (11.0 plants/m^2) than either the disk-chain alone (3.7 plants/m^2) or the smooth chaining (2.4 plants/m^2).

Chain diking accounted for a threefold increase in grass density and raised the stand count above the level needed for it to be accounted a success.

The Waggoner Ranch presently is operating chain-dikers on about 30,000 acres of their wheatland, Wiedemann said. One unit has diked more than 10,000 acres. They dike after every tillage operation and follow their grain drills.

This research has resulted in a small manufacturing business located at Vernon to market the chain-diker unit in the U. S., Wiedemann said.

Absentee voting in Water District election begins January 2nd

Continued From Page One

762-0181. Becca Williams is the clerk.

Lynn County — New Home Co-op Gin, New Home, Texas 79383. Diana Nettles is the clerk.

Precinct Two contains the portions of Cochran, Hockley and Lamb Counties which lie within the High Plains Water District service area.

Cochran County — High Plains Water District office, 108 N. Main Avenue, P.O. Box 1015, Morton, Texas 79346, (806) 266-5185. Mary Helen Butler is the clerk.

Hockley County — High Plains Water District office, 1012 Austin Street, Box 968, Levelland, Texas 79336, (806) 894-6127. Jim Montgomery is the clerk.

Lamb County — High Plains Water District office, 103 E. 4th Street, Littlefield, Texas 79339, (806) 385-4265. George Harlan is the clerk.

Precinct Five includes those portions of Floyd and Hale Counties lying within the Water District's service area.

Floyd County — High Plains Water District office, 108 W. Missouri, Box 186, Floydada, Texas 79235, (806) 983-3728. Verna Lynne Stewart is the clerk.

Hale County — High Plains Water District office, 1617 Main, Box 285, Petersburg, Texas 79250, (806) 667-3951. J.B. Mayo is the clerk.

For more election information, contact Becca Williams at the Water District Office, 2930 Avenue Q, Lubbock, Texas 79405 or call (806) 762-0181.

Voters approve water-related State Constitutional amendments

Texas voters approved two water-related State Constitutional Amendments, and Yoakum County voters finalized the creation of their underground water conservation district during a special election held November 7, 1989.

PROPOSITION TWO

Proposition Two was approved with a vote of 686,475 in favor of and 482,582 against the amendment. Proposition Two authorizes the Texas Water Development Board to issue an additional $500 million in water development bonds. Of the $500 million in bonds issued, $250 million will be used for municipal water supply loans and facilities acquisition; $200 million will be used for water quality enhancement projects; and $50 million will be used for flood control.

The Legislature may provide that $100 million be used for subsidized loans and grants to economically distressed areas of the state for water and wastewater treatment facilities.

Voters within the High Plains Water District supported this Constitutional Amendment as shown in Table One.

PROPOSITION 18

Proposition 18 did not have the margin of support that Proposition Two received.

Of the 1,076,109 votes cast on this proposition statewide, the amendment passed by a slim 423 votes. 538,266 favored the amendment while 537,843 voted against it. Experts believe that voters would have passed the amendment by a greater margin if they had had a better understanding about the amendment and its water conservation benefits.

Within the High Plains Water District, the amendment passed by an almost 2-to-1 margin as shown in Table Two.

Amendment 18 repeals subsection (e) of Article III, section 50-d of the Texas Constitution to eliminate the 1989 expiration date on the pilot agricultural water conservation equipment loan program.

Approximately 150 producers within the High Plains Water District have improved their irrigation application efficiencies since 1985, using funds from the pilot ag loan program. These improved efficiencies have resulted in savings in excess of 25,000 acre-feet of groundwater — enough water to supply a city of 150,000 for about one year.

SANDY LAND WATER DISTRICT

In Yoakum County, voters approved the Sandy Land Underground Water Conservation District by a 2-to-1 margin.

Directors elected are L.J. Sanders Jr., David Turnbough, Don A. Parrish, R.E. Bearden, and Brad Palmer.

TABLE ONE
WATER DISTRICT RESULTS FOR PROPOSITION 2

COUNTY	FOR	AGAINST
Armstrong	161	183
Bailey	264	231
Castro	432	354
Cochran	181	182
Crosby	344	189
Deaf Smith	705	514
Floyd	422	304
Hale	1472	470
Hockley	605	514
Lamb	632	419
Lubbock	9032	3399
Lynn	331	199
Parmer	432	406
Potter	5699	2524
Randall	7829	3548
TOTALS	28,541	13,436

TABLE TWO
WATER DISTRICT RESULTS FOR PROPOSITION 18

COUNTY	FOR	AGAINST
Armstrong	169	147
Bailey	255	227
Castro	415	333
Cochran	149	193
Crosby	309	203
Deaf Smith	642	547
Floyd	377	334
Hale	1314	568
Hockley	534	575
Lamb	595	432
Lubbock	8237	4226
Lynn	274	222
Parmer	433	373
Potter	5185	2688
Randall	7132	3892
TOTALS	26,020	14,960

Results taken from reports in the *Amarillo Daily News* and the *Lubbock Avalanche-Journal,* November 8, 1989

THE CROSS SECTION (USPS 564-920)
HIGH PLAINS UNDERGROUND WATER
CONSERVATION DISTRICT NO. 1
2930 AVENUE Q
LUBBOCK, TEXAS 79405

SECOND CLASS PERMIT