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WATER MANAGEMENT - SOUTHERN HIGH PLAINS OF TEXAS

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I. Introduction.

A. Summary.

Irrigators, researchers, and industry have applied improved irrigation-water management techniques in this Southern High Plains Water District so that the net depletion of the Ogallala Aquifer has been cut in half.

II. History.

The Ogallala Aquifer extends throughout the High Plains of Texas. It ranges in total thickness from a few feet up to 900 feet. The saturated thickness of the formation ranges from a few feet to as much as 600 feet, or at least did it prior to the large-scale development of irrigation in the area.

The first irrigation wells that were drilled in the Southern High Plains of Texas were drilled in the early 1900s. As of about 1916, an inventory of irrigation wells in the area reported less than 100 wells in existence. Very little drilling activity occurred until the mid-1930s, when small irrigated areas began to develop, principally in the areas of Lubbock, Plainview, and Muleshoe, where the water the was generally shallow and the formation was rather generous in yielding water to wells. Most wells were hand dug and were either lined with rock or a wooden shaft, similar to a mine shaft, to prevent cave-in. Extensive irrigation development began in the late 1940s with the availability of internal combustion engines and steel casing. Additionally, young men returning from World War II had learned much and were eager to develop the land and pursue a career in farming.

The development expanded from these small, localized areas in every direction, until the entire area was fully developed by the early 1970s.

In the early days of irrigation, there was very little technology available for handling irrigation water, and much of the management of the water was by manual labor, principally with shovels.

In addition to the limitations of technology available, the knowledge about the Ogallala Formation was extremely limited, at least to the general public;

and most people envisioned that the water from the formation originated from snow melt in the Rocky Mountains. It was easy to make such an assumption, inasmuch as the temperature of the water that was being pumped out of the formation was in the low to mid 60s on the Fahrenheit thermometer. On a hot summer day with temperatures of 90 degrees or above, one could easily believe that because the water was so cold, it had to come from snow melt.

Many believed that underground rivers flowed under the area, and they documented their belief with stories of farmers pumping small fish from irrigation wells. They could prove these stories, because they had seen the fish in the open, unlined ditches being used to transport the water from the well to the field. (The actual origin of these fish was from farmers who had gone to do some fishing or had purchased, or some other way acquired, small fish for bait. Upon their return to the area, it was great fun to place them in somebody's irrigation ditch.)

To say the least, very poor water-use efficiency prevailed throughout the area.

Water-level declines began to occur very rapidly throughout most of the area. Average annual declines for the entire area of two to four feet was adequate to prove to most that the ground-water resources of the aquifer were being mined.

Considerable debate began regarding the necessity to improve the irrigation practices, or at least to eliminate the obvious waste. Very little improvement occurred throughout the late 1940s and early 1950s, although the waste was so obvious that people passing through the area professed that you could ride a motor boat from Lubbock to Amarillo in the borrow ditches by the side of the highway.

Debate in the Texas Capitol began over the exploitation of the ground-water resources and whether something needed to be done by the state to stop the waste and to prevent the rapid depletion of the ground-water resources in the area.

In 1947, the State Legislature proposed to put the ground-water resources of Texas under the guardianship of the State to eliminate and restrict the water use to the extent necessary to stop any further depletion. Metering water use, allocation of given quantities of water for each acre irrigated, fines, and jail time for waste offenders were discussed. The people of the High Plains did not agree with this radical thinking; and, as with most legislation, a compromise was reached. Legislation passed in 1949 allowed the establishment of underground water conservation districts. The law, presently codified as Chapter 52 of The Water Code, Vernon's Civil Statutes of the State of Texas, provides for underground water conservation districts to:

- "... make and enforce rules to provide for conserving, preserving, protection, recharging, and preventing waste of the underground water..."

- "... make surveys of the underground water reservoir or subdivision and surveys of the facilities for development, production and use of the water..."

- "... develop comprehensive plans for the most efficient use of the underground water..."

- "... carry out research projects, develop information, and determine limitations which should be made on withdrawing underground water..."

- "... collect information regarding the use of underground water and the practicability of recharging the reservoir..."

- "... publish its plans and the information it develops..."

- "... acquire land to erect dams or to drain lakes, draws, and depressions; construct dams; drain lakes, depressions, draws, and creeks; and install pumps and other equipment necessary to recharge the underground water reservoir..."

- "... require that records be kept and reports be made of the drilling, equipping, and completing of water wells and of the production and use of underground water..."

- "... require permits for the drilling, equipping, or completing of wells, or for substantially altering the size of wells or well pumps..."

- "... require that accurate drillers' logs be kept of water wells and that copies of drillers' logs and electric logs be filed with the district..."

- "... provide for the spacing of water wells and ... regulate the production of wells..."

- "... enforce its rules by injunction, mandatory injunction, or other appropriate remedy in a court of competent jurisdiction."

In accordance with this legislation, the creation of underground water conservation districts was to be confirmed by a vote of the local people. At the time of the confirmation election, the people were also to elect their own governing officials and approve a maximum ad valorem tax to be levied against the real property within the district to support the activities of the district.

The High Plains Underground Water Conservation District No. 1 was created in 1951 under this Act and, as far as we know, was the first district of its type ever created in the United States of America, certainly in Texas. The High Plains Underground Water

Conservation District, following its creation, moved slowly but deliberately toward the accomplishments of the directives as outlined by the legislation and in doing so, made serious efforts to reduce the obvious waste of water, as well as less obvious waste.

III. Management Program.

In the early days of irrigation in the Southern High Plains of Texas, a farmer drilled his well on the high point of his farm. The water from the well was transported to the field in an open, unlined ditch, where losses to seepage and evaporation were from 10 percent to 30 percent per 1,000 feet. Water was allowed to flow from the open, unlined ditch down the furrows for approximately 12 hours prior to its being directed into a new set of furrows. In six to eight hours, the water would reach the end of the furrow and begin to flow out the end of the furrow and escape from the farm as irrigation tailwater. The reason that water was allowed to continue to flow down the furrows and out the end of the rows for so long was to allow the water time to soak into the soil to wet it to a depth of about four feet, which is the depth most field crops' roots extend. The tailwater losses were approximately 20 percent of the water pumped. Free-water surface evaporation losses from the water in the furrows as it flowed through the field ranged from 10 to 20 percent, depending upon the temperature and wind velocities. Of course, the amount of shading provided by the crop also was a factor in calculating the evaporative losses.

The decline of the water table in the Ogallala Aquifer in the 1950s and 1960s in the fully-developed irrigated areas ranged from two to four feet per year. In years in which precipitation was average or above average, the decline averaged about two feet per year. In years when precipitation was below average, water-level decline was greater.

The introduction of sprinkler irrigation systems in this area was originally not done as a conservation method, but to allow for the irrigation of coarse-grained or sandy soils for which the infiltration rates were too high for furrow irrigation. Irrigation-application losses from early-day sprinkler systems ranged from 40 to 60 percent. Early-day systems consisted of a four- to six-inch aluminum pipe lying on the ground with one-half to three-quarter inch pipes sticking up, with spray nozzles attached. They were operated at pressures of 30 to 50 pounds per square inch. Water was sprayed up into the air, often creating a fine mist, which was very susceptible to evaporation.

The first serious program undertaken by the Water District to reduce waste was to address open-ditch losses. First, the losses had to be measured. Not only was it necessary to document the loss, but an economic analysis had to be made to prove to the farmer that the installation of pipe would be a profitable investment. A pipeline manufacturer had to be located and persuaded to build pipeline manufacturing plants in the area. Federal cost-assistance was obtained for pipelines to encourage rapid adoption of this water conservation practice. This was all accomplished in a few years, and the installation of underground pipe to convey the water from the well to the field became commonplace in the late 1950s. More than 10,000 miles of underground pipe have been installed in the Water District service area since the Water District was created.

The second major Water District program to reduce waste was a campaign to reduce irrigation tailwater losses. Again, it was necessary to document the actual loss of irrigation tailwater, as well as do an economic analysis. The big problem was to develop a cost-effective method to capture and return the waste water to the field. Irrigation tailwater losses were measured by using V-notch weirs at hundreds of locations over a period of several years. This was followed by the design and construction of demonstration tailwater pits and the installation of pump-back systems to recover this formerly lost water. In those days, there were no pumps designed to handle trash, plant roots, etc. Industry had to be strenuously encouraged to develop suitable equipment to handle the trash in the water, before tailwater return pits could become effective.

More than 3,000 tailwater-return systems were installed during the 1960s and 1970s. Some are even being installed today; but mostly, tailwater pits are becoming dinosaurs, as more efficient equipment is put into place, which totally eliminates irrigation tailwater losses.

In the area of sprinkler irrigation, little progress was made on irrigation efficiency until the late 1970s, even though probably 20 different types of sprinkler irrigation systems were introduced and utilized in this area. The first big advance in irrigation efficiency occurred in the sprinkler industry when Dr. Bill Lye at the Texas Agricultural Experiment Station at Lubbock, Texas, developed and introduced the Low Energy Precision Application (LEPA) system in the mid-1970s. His design of a center-pivot irrigation system included droplines extending from the main water supply line down into the furrow. Water was no longer sprayed up into the air. Naturally, with advances, problems occur, or perhaps new opportunities are recognized. The water delivered into the furrows caused erosion of the soil. Socks were tied onto the ends of the droplines, as were many types of emitters in attempts to reduce the erosion problem. Special nozzles were eventually developed to minimize the soil erosion problem. Again, research and industry working together met the needs of the irrigation farmer.

The third major effort to reduce water loss was in the introduction of time-controlled surge valves for use with furrow irrigation systems. Surge valves change the flow of water at timed intervals between two sets of rows being irrigated. Each time the valve alternates the flow of water back and forth between the sets of furrows, the water moves very rapidly across the previously-wet furrow length. This prevents deep percolation below the root zone at the upper end of the field. This process allows for a more uniform wetting of the root zone soil profile. It effectively increases the uniformity of irrigation application and eliminates the need to run water through the field for such a long time, which in turn decreases losses due to irrigation tailwater, deep percolation losses, and free-water surface evaporation losses.

IV. On-farm irrigation application and distribution-efficiency evaluations.

Even though major advances had been made in water-use efficiency throughout the area by the mid 1970s, it was recognized that each farm is unique and that further refinement to irrigation systems were needed to improve water-use efficiency. No one knew for sure what their irrigation efficiencies were, but almost everyone agreed that it needed to be improved.

In 1978, the Water District, in cooperation with the USDA Soil Conservation Service, developed an agreement to seriously evaluate all types of irrigation systems and make a serious effort to assist the individual farmer in improving his irrigation-application and distribution efficiency. A fleet of mobile field water conservation laboratories were designed and equipped to carry to the field and do on-site evaluations. Staff members of both the Water District and the USDA-SCS were trained to conduct a complete water-application and distribution-efficiency evaluation, regardless of what type of irrigation system or farming situation they found when they were invited to a farm to conduct an irrigation-efficiency evaluation.

The evaluations began with a measurement of the pump's yields, which included a measurement of the pumping level and the fuel being consumed to produce the amount of water the pump was producing. The next part was a calculation of any losses which might be occurring in the pipeline system. In essence, the well yield was compared to the quantity of water being delivered at the end of the pipe to the field; and in many instances, it was determined that pipeline leaks were causing significant losses. The records of these losses, if any, were reported to the farmer. Generally, if losses were found, the farmer lost no time in getting them repaired.

The next phase of the evaluation involved the identification of the soil type, its water-holding capacity, and the quantity of water that it contained at one-foot intervals down to four feet prior to the irrigation application evaluation. In essence, a determination was made as to how much water needed to be applied to bring the soil moisture to field capacity in the four-foot soil root zone. Additionally, these pre-irrigation soil moisture availability measurements were made throughout the field to obtain a bench mark to compare irrigation-application efficiency once the irrigation application was completed. If irrigation tailwater was being lost, then it would be measured during the irrigation application. The quantity of water being applied to each furrow was measured as was the advance rate of the water moving down the furrows. The quantities of water which infiltrated into the soil between measuring stations were determined and recorded. The difference in the quantity of water being produced and the quantity of water stored in the top four feet of soil throughout the field provides a very good estimate of the amount of water being lost during the irrigation application. The amount of water measured or being lost as irrigation tailwater and to deep percolation was subtracted from the total amount lost, providing a value to be attributed to losses to evaporation. Additionally, the uniformity of the irrigation application was determined during the evaluation. The objective during irrigation is to wet the soil root-zone profile uniformly throughout the field.

Following the evaluation, the results were written up and presented to the irrigator with recommendations as to how he might improve his irrigation application to reduce his losses and obtain a more uniform application of water.

Evaluations of sprinkler irrigation systems began with the same measurements on the well yields, the pipeline losses, and the soil. The actual irrigation-application and distribution evaluation was somewhat different. We first set out catch cans, which were one-quart oil cans. They were set at 100-foot intervals across the field where the center pivot system would pass over them. The quantity of water collected in each can was measured and compared to the quantity of water that had been pumped through the system to determine what losses occurred from the point of discharge of the system to that which was collected in the cans. Additionally, a graph was made to illustrate the quantities caught at each station to give the irrigator an idea of the uniformity of his irrigation application. The farmer was provided a written analysis of the irrigation evaluation, which included a separate report on his application and distribution efficiencies. In many instances, the quantity of water being lost equaled almost half of that being pumped. In addition to the loss of water, the uniformity of the water being applied along the system was, to say the least, poor. The farmer would become quite concerned with the inefficiencies of his system and would present a copy of the document to the person who sold him the equipment who, in turn, would complain to the engineers who designed the system. Ultimately, this led to industry, researchers, and farmers working together to develop and manufacture systems which were much improved. This took several years and a lot of hard work and effort by many people. However, all major players contributed significantly to the development and utilization of systems which have losses not greater than 20 percent, and in some cases, as little as five percent.

V. <u>Conclusion</u>.

Has it worked?

First, I would like to make a point that crop yields in recent years are as good or better than have ever been produced in the area. In fact, in three of the last five years, cotton yields have been almost record yields; and corn and wheat production have been good. The real proof of the pudding is displayed in the following chart, which illustrates the decrease in the net depletion of the Ogallala Aquifer within our District from 1966 through 1990.

May 3, 1991

ESTIMATED NET CHANGE OF THE OGALLALA AQUIFER IN ACRE-FEET BY CALENDAR YEAR FOR THE 5.5 MILLION ACRES IN THE 15 COUNTIES SERVED BY THE HIGH PLAINS UNDERGROUND WATER CONSERVATION DISTRICT NO. 1

1965-1991

1966-1967	- 2,215,678 acre-feet	
1967-1968	- 2,288,778 acre-feet	5-Year Average
1968-1969	- 824,960 acre-feet	- 1,662,396
1969-1970	- 875,758 acre-feet	acre-feet
1970-1971	- 2,106,809 acre-feet	
1971-1972	- 1,430,993 acre-feet	
1972-1973	- 499,922 acre-feet	5-Year Average
1973-1974	- 953,868 acre-feet	- 1,200,287
1974-1975	- 2,078,848 acre-feet	acre-feet
1975-1976	- 1,037,805 acre-feet	
1976-1977	- 1,971,406 acre-feet	
1977-1978	- 1,540,461 acre-feet	5-Year Average
1978-1979	- 1,179,705 acre-feet	- 1,422,421
1979-1980	- 517,206 acre-feet	acre-feet
1980-1981	- 1,903,331 acre-feet	
1981-1982	- 534,918 acre-feet	
1982-1983	- 625,090 acre-feet	5-Year Average
1983-1984	- 546,096 acre-feet	- 479,323
1984-1985	- 639,363 acre-feet	acre-feet
1985-1986	- 51,151 acre-feet	
1986-1987	+ 375,054 acre-feet	
1987-1988	+ 704,106 acre-feet	5-Year Average
1988-1989	- 398,993 acre-feet	- 194,993
1989-1990	- 782,340 acre-feet	acre feet
1990-1991	- 872,795 acre-feet	

The Ogallala Formation in the High Plains of Texas covers an area of 36,080 square miles which is about 23,091,200 acres. The Ogallala Aquifer had about 417 million acre-feet of water in storage in 1990. This is enough water to cover the 23,091,200-acre surface area with a layer of water about 18 feet deep. Prior to the development of large scale irrigation in the High Plains of Texas, the Ogallala Aquifer contained about 550 million acre-feet of water. The 550 million acre-feet of water would cover the 23 million acre area with a layer of water about 23 feet deep. Net depletion of the Ogallala Aquifer in the High Plains of Texas has been about 24 percent from pre-development to 1990.