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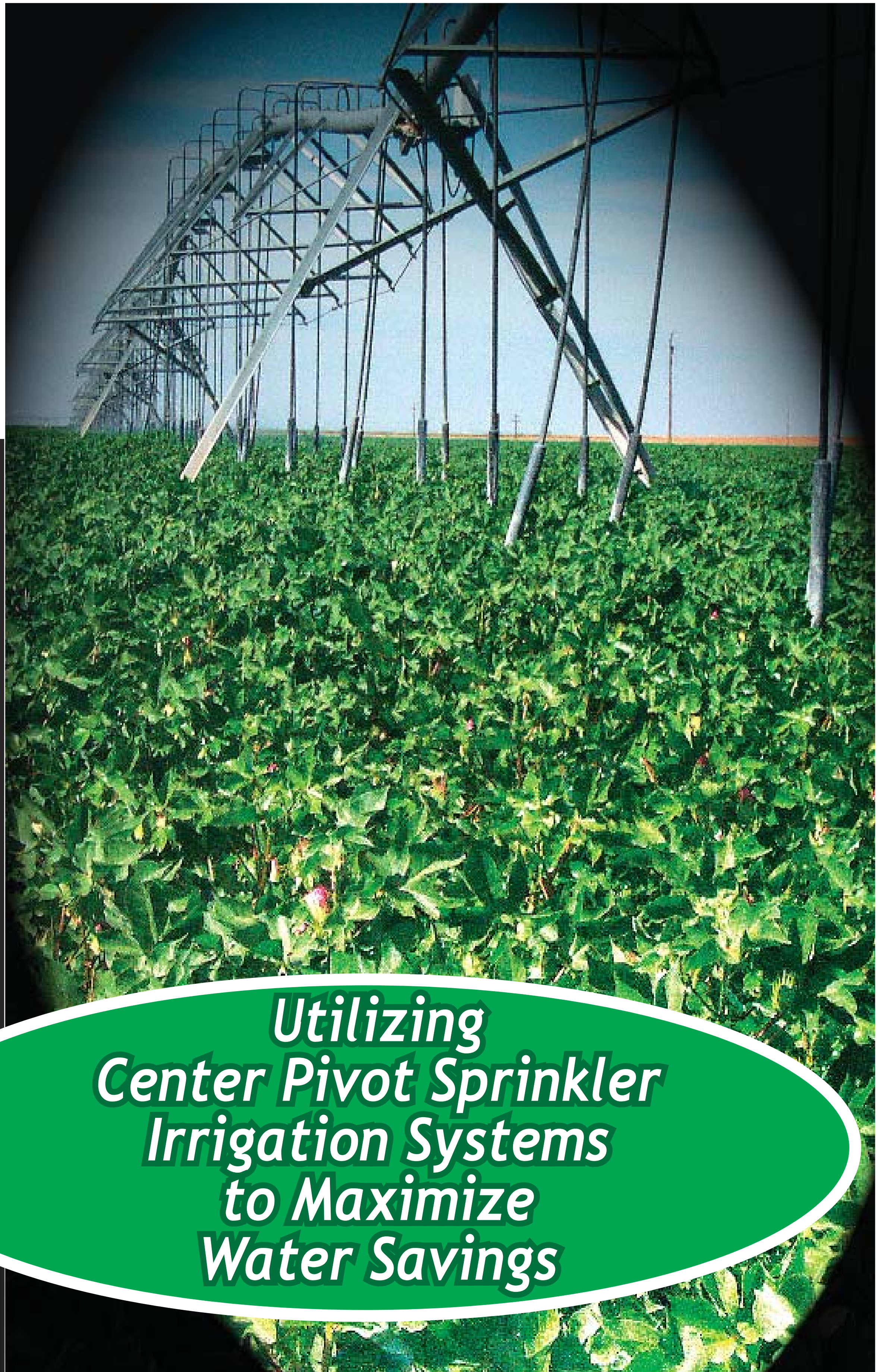


# Utilizing Center Pivot Sprinkler Irrigation Systems to Maximize Water Savings

NRCS Natural Resources Conservation Service

# ***Introduction***

Center pivot sprinkler irrigators of the Ogallala Aquifer on the High Plains of Texas are widely recognized by the irrigation industry for operating the most efficient sprinkler systems in the world. Most irrigators in this region have adapted high application efficiency sprinkler systems into their farming operations as a result of physical, economic, and social limitations on their businesses. The physical limitations of this sub-humid, semi-arid region which include low rainfall, low humidity, high wind, high temperature, and the Ogallala's finite use as an irrigation source, have resulted in their desire to conserve, for beneficial use, as much irrigation water as feasible. Economic pressures of high energy cost, labor cost, and low crop value have prompted irrigators to become economically efficient by utilizing low pressure mechanical irrigation systems as well. Social pressures to maintain the economic viability of the region by conserving the aquifer for use over a long period of time have created awareness by irrigators of their mutual dependency with the region's agricultural infrastructure.

To understand the progression of the development of center pivot sprinkler irrigation on the High Plains,the Ogallala Aquifer's formation, geology, history, and current status should be understood. The Ogallala Formation was deposited across the Great Plains by easterly flowing streams, which originated during the formation and erosion of the Rocky Mountains. Coarse-grained sand, gravel, fine clay, silt, and sand were deposited over the pre-Ogallala land surface, which was much like the present-day area of the Rolling Red Plains just east and in some areas west of the High Plains. These outflow materials from the Rocky Mountains were saturated with water. The base of the Ogallala, called the red beds, contains hills, plateaus, and stream valleys. This red bed base of the aquifer has a relatively high clay content and prevents or greatly limits the downward movement of water. The topography of the base causes variations in the depth of the water saturated thickness of the aquifer. In some parts of Nebraska, the saturated thickness exceeds 1,000 feet, while in other areas of the formation there is no saturation at all. Windblown materials of sands, silts, and clays from the Permian Basin, the Pecos River valley and other areas along the foothills of the Rockies were deposited over the top of the Ogallala Formation. These materials provide the rich soils on the land surface of the Great Plains today. Changes in climate and geologic conditions resulted in erosion patterns that caused the Ogallala Aquifer to be cut off from its original supply of water. The southern portion of the aquifer in Texas and New Mexico is now a plateau, cut off from groundwater recharge on all sides. Because the region is primarily in a semi-arid climate there is little rainfall recharge in most years. Most of the water in the Ogallala Aquifer of the High Plains of Texas was deposited there during the formation of the aquifer.

The Ogallala Aquifer covers 174,000 square miles of eight states and has long been a major source of water for agricultural, municipal, and industrial development on the Great Plains. Nebraska with 64,400 square miles and Texas with 36,080 are the largest. New Mexico, Oklahoma, South Dakota, and Wyoming all have less than 10,000 square miles of surface area underlain by the Ogallala. The amount of aquifer water in storage in each state is dependent on the actual extent of the formation's saturated thickness. In 1990, the Ogallala Aquifer in the eight-state area of the Great Plains contained 3.270 billion acre-feet of water. Out of this, about 65% was located under Nebraska, Texas had about 12% of the water in storage or approximately 417 million acre-feet of water, Kansas had 10% of the water, about 4% was located under Colorado, and 3.5% was located under Oklahoma. Another 2% was under South Dakota and 2% was under Wyoming. The remaining 1.5% of the water was under New Mexico.

# THE DEVELOPMENT OF SPRINKLER IRRIGATION ON THE HIGH PLAINS OF TEXAS

The first irrigation wells were dug in the early 1900's. By the 1930s, people had begun to realize the potential of the vast water supply that lay beneath them.By 1949 about 2 million acres of the southern High Plains were irrigated. Recurring drought in the fifties encouraged irrigation all over the High Plains. Technology changed too and over the High Plains the number of wells increased from 14,000 in 1950 to 27,500 in 1954. Irrigated acreage expanded from 1.86 million acres to 3.5 million in the same period. The irrigation boom peaked in the middle 1970s, decreased, then stabilized about 1980. Most of the irrigated acreage was surface or flood irrigated land. Since water pumped from the aquifer could not be replaced at the same rate that it was removed, the water table began to decline. Monitoring of the water level in the aquifer's southern High Plains area showed rapid declines in the water table in the early 1950s, the 1960s, and the 1970s. Declines of a foot or more per year were recorded throughout the 1950s; and during the late 1950s at the peak of irrigation development, some monitoring wells declined as much as five feet in a single year. In the earliest days of irrigation on the Texas High Plains very little water conservation equipment or technology was available and large amounts of water was lost to evaporation and deep percolation. Rapidly declining aquifer levels combined with high energy costs in the early 1970s caused the abandonment of many acres of irrigated land. Other irrigators became aware of the need for efficient irrigation systems that could reduce energy costs. The center pivot sprinkler was a perfect fit.

Center Pivot sprinklers had been installed on sandy soils on the High Plains since the 1950's. This type of pivot used pressured water to power the wheels and move the pivot. Operating at around 100 psi these pivots used wide spaced impact nozzles that sprayed water high into the air resulting in high evaporation losses and non-uniform application patterns. They were not energy or water efficient and were not the solution for the irrigator's dilemma. In the early 1970's new electric and hydraulic oil powered pivots were appearing on the High Plains. While these center pivots were a great leap forward in sprinkler irrigation and energy conservation, most utilized wide-spaced, high elevation nozzles.

Irrigation efficiency evaluations conducted through a joint effort of the Soil Conservation Service, now known as the Natural Resources Conservation Service (NRCS), the High Plains Underground Water District #1, and local Soil and Water Conservation Districts showed a tremendous need for better pattern and spray nozzle designs by pivot manufacturers. This joint effort, in cooperation with pivot manufacturers, irrigators and state extension personnel led to the greatest advancement of sprinkler irrigation technology with the development of the modern high efficiency, low pressure, close spaced nozzle pivot designs that are so prevalent today on the High Plains of Texas. The irrigators of the Texas High Plains embraced these systems as one of the solutions for aquifer conservation. During the 1980's and 1990's, due to continued aquifer declines and rising labor costs, many thousands of acres of surface irrigated land were converted to these highly efficient center pivot sprinklers. Today most of the irrigated lands on the High Plains in Texas utilize these advanced efficiency, low pressure center pivot sprinklers.

The irrigators of the Texas High Plains are perhaps the most efficient irrigators in the world. They have realized that the first step in water conservation is to utilize high efficiency irrigation systems that allow control of irrigation application amounts. They also realize that the future of the Ogallala Aquifer and the region depends on their stewardship of the land.

L E P A

# LOW ENERGY PRECISION APPLICATION

## SYSTEM MANAGEMENT

Low Energy Precision Application (LEPA) systems are only applicable on crops planted with furrows or beds. Circular rows are used with center-pivot systems and straight rows are to be used with linear systems. For ease of farming operations, some straight rows are allowed near the center of the center-pivot systems.

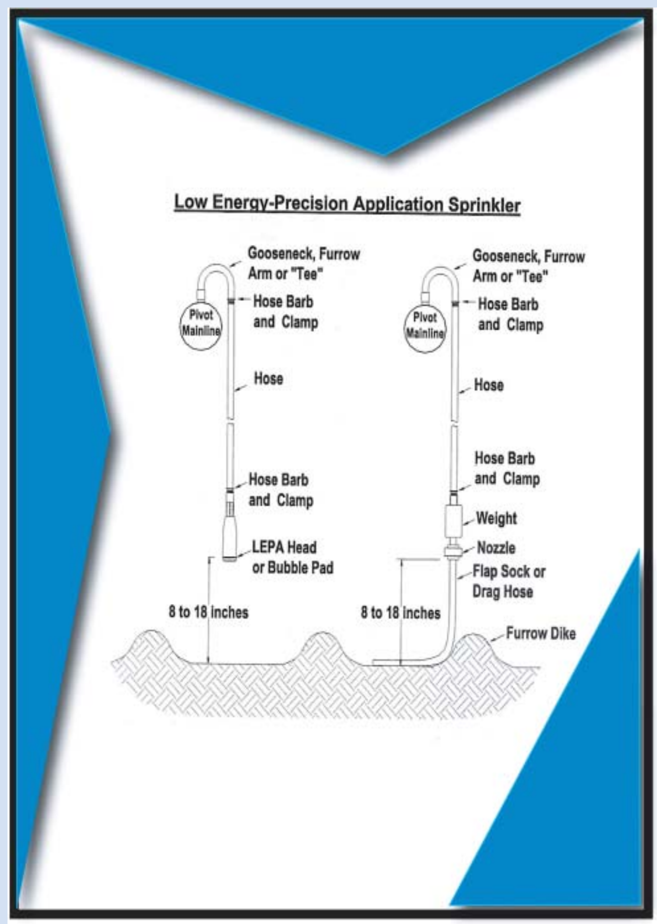
The land slope for a LEPA system should not exceed 1.0 percent on more than 50 percent of the field. LEPA systems should employ some method of providing surface basin storage such as furrow diking or pitting or implanted reservoirs. Water is not applied in the tower wheel track.

- REQUIRED CU (Coefficient of Uniformity) – 94 percent
- APPLICATION METHOD - Water shall discharge through a drag sock or hose on the ground surface, or through a nozzle equipped with a bubble shield or pad.
- NOZZLE SPACING – No greater than two times the row spacing of the crop.
- NOZZLE HEIGHT – Less than 18 inches in Bubble Mode. Nozzle height is not applicable when using drag hoses. All application device heights above the soil surface should be uniform when the system is operating.
- ROW ARRANGEMENT – Circular rows
- SLOPE OF FIELD – 1 percent or less

All materials used in the installation of the LEPA system shall be new and free from defects when converting an existing sprinkler system to LEPA. With the exception of weights, none of the existing sprinkler system shall remain as part of the new LEPA below the existing furrow arms or goosenecks. The LEPA shall be comprised of all new components including the flexible drop hose, any rigid pipe used on the drop, pressure regulators (if needed), gate valves (if needed), nozzle bodies or bracket assemblies, sprinkler or bubbler-type nozzles and drag socks or surface hoses.

*Furrow diking is used as a preferred management strategy method for providing surface basin storage.*

***Terry county producer Steve Ellis uses LEPA irrigation applying proper management to include circular rows and furrow diking. He said, "I need to be as efficient as possible with my irrigation water. Keeping the water applied on the ground rather than spraying it in air just makes good sense."***



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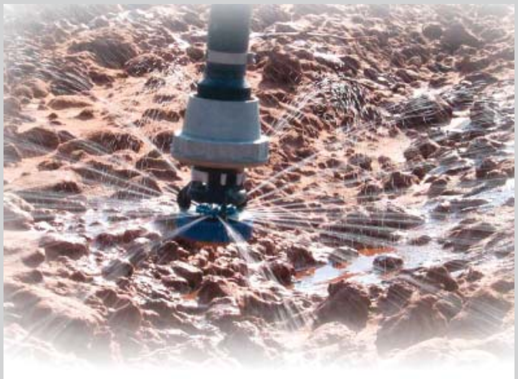


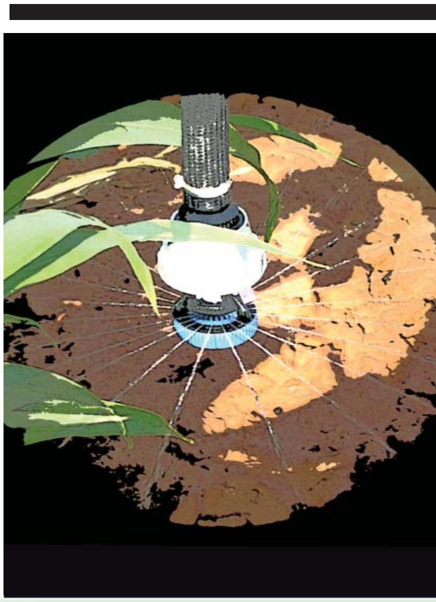
# LOW-ELEVATION SPRAY APPLICATION

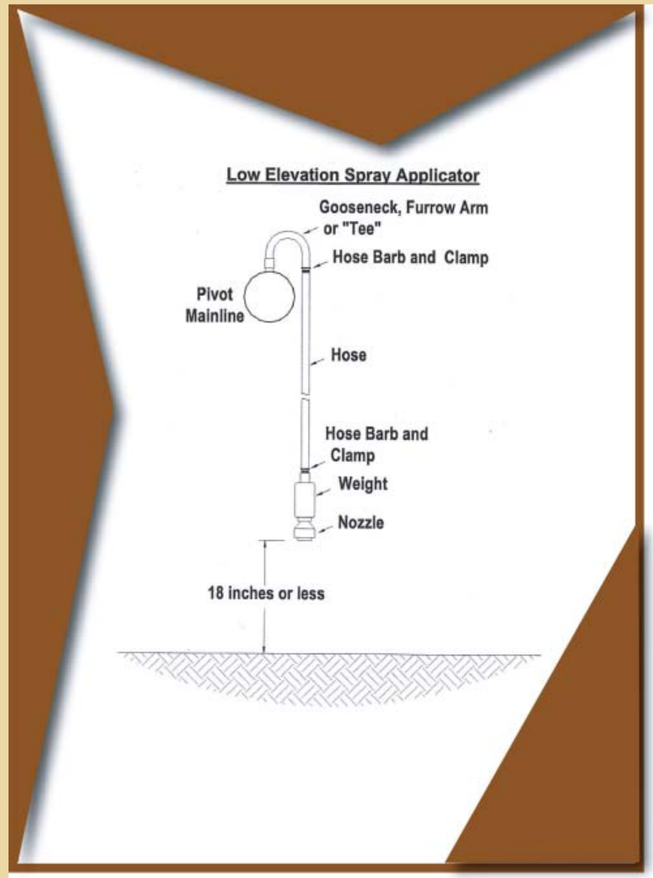
## SYSTEM MANAGEMENT

For optimum efficiency, circular rows should be used with center-pivot systems and straight rows should be used with linear systems. When farming in a circle pattern, straight rows can be utilized near the center of center-pivot systems for ease of farming operations.

The land slope for a LESA system should not exceed 3.0 percent on more than 50 percent of the field. Tillage and/or residue management should be utilized as necessary to control excessive translocation (> 30 ft.) of applied irrigation water. This could include furrow diking or pitting, in-furrow chiseling, or residue management such as limited or no tillage. Terraces may be needed on steeper slopes (> 2 percent) to control rainfall and irrigation induced erosion.

- REQUIRED CU (Coefficient of Uniformity) – 94 percent
- NOZZLE SPACING – No greater than two times the row spacing of the crop.
- NOZZLE HEIGHT – Less than 18 inches above the soil surface. All application device heights above the soil surface should be uniform when the system is operating.
- ROW ARRANGEMENT – Any row arrangement

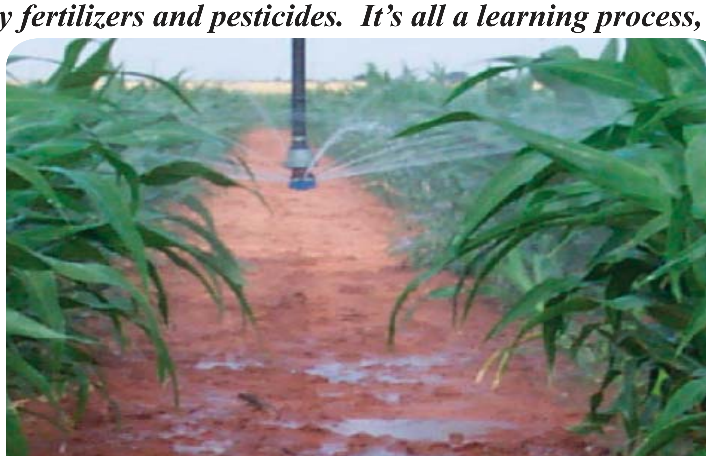



When converting an existing sprinkler system to Low Elevation Spray Application (LESA), all materials used in the installation of the sprinkler system including the LESA sprinkler nozzle package shall be new and free from defects.

Nozzle spacing shall not be greater than two times the row spacing of the crop. Nozzle heights shall not exceed 18 inches above the soil surface when the system is operating. All LESA nozzle heights shall be uniform when the system is operating.
After installation, the system shall be pressure tested at the system operating pressure. All leaks shall be repaired to insure a leak-free system.

***Cochran county producer Russell Greener converted from sideroll irrigation to center pivot sprinklers utilizing LESA nozzles after being approved for the Environmental Quality Incentives Program (EQIP). Greener pre-waters using the bubble mode option to concentrate the water down his rows. He is pleased with the results he has experienced with his system. Greener said, "With this system, it only takes five days to apply one inch with less evaporation. It's a more efficient system that provides labor savings, and gives me the ability to chemigate through the system when I apply fertilizers and pesticides. It's all a learning process, and the more we experience, the better it gets."***



# LPIC

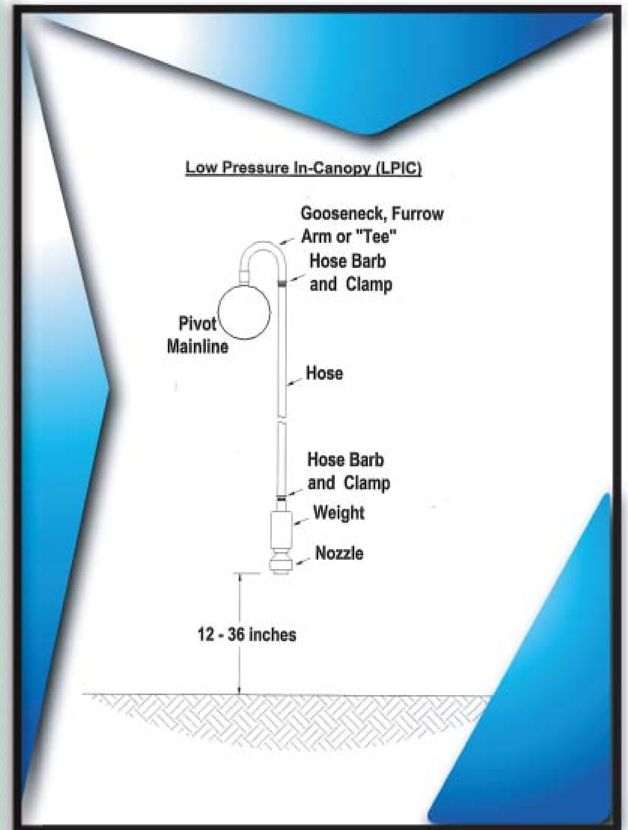
## Low Pressure In Canopy

## System Management

For optimum efficiency, circular rows should be used with center-pivot systems and straight rows should be used with linear systems. When farming in a circle pattern, straight rows can be utilized near the center of the center-pivot systems for ease of farming operations. The land slope for a LPIC system should not exceed 3.0 percent on more than 50 percent of the field. Field runoff should be controlled.

Tillage and/or residue management should be utilized as necessary to control excessive translocation (> 30 ft.) of applied irrigation water. These could include furrow diking or pitting, in-furrow chiseling, or residue management such as limited or not tillage. Terraces may be needed on steeper slopes (> 2 percent) to control rainfall and irrigation induced erosion.

- REQUIRED CU (Coefficient of Uniformity) - 90 percent
- NOZZLE SPACING – Optimum is two crop rows, but drops may be spaced up to 10 feet apart.
- NOZZLE HEIGHT – should be within the planned crop canopy. Lower nozzle heights will require a closer nozzle spacing to insure a high distribution uniformity.
- ROW ARRANGEMENT – Any row arrangement
- SLOPE OF FIELD – 3 percent or less




All materials used in the installation of the sprinkler irrigation including the Low Pressure In Canopy (LPIC)sprinkler nozzle package shall be new and free from defects.

LPIC sprinkler systems offer operators a high efficiency alternative application system when LEPA and LESA specification cannot be met. The LPIC system fills a niche on certain soil types, topography and row arrangement where LEPA and LESA systems are not the best choice.

Mike Tyler checks one of his cotton crops where he is using LPIC irrigation.

***Dawson County producer Mike Tyler has experimented using several irrigation methods. Low Pressure In Canopy (LPIC) has become his application and management choice. He converted to no-till farming about five years ago, planting a cover crop of wheat to protect his young cotton seedlings. Tyler said, "I use dual pads, a coarse pad and a chemigation pad, to irrigate in normal or chemigation mode. After I produce a stand, I can easily flip the pads to apply a chemigation spray mode application." Water is Tyler's limiting factor on his farms, and the LPIC system enables him to apply water more efficiently.***

# MESA

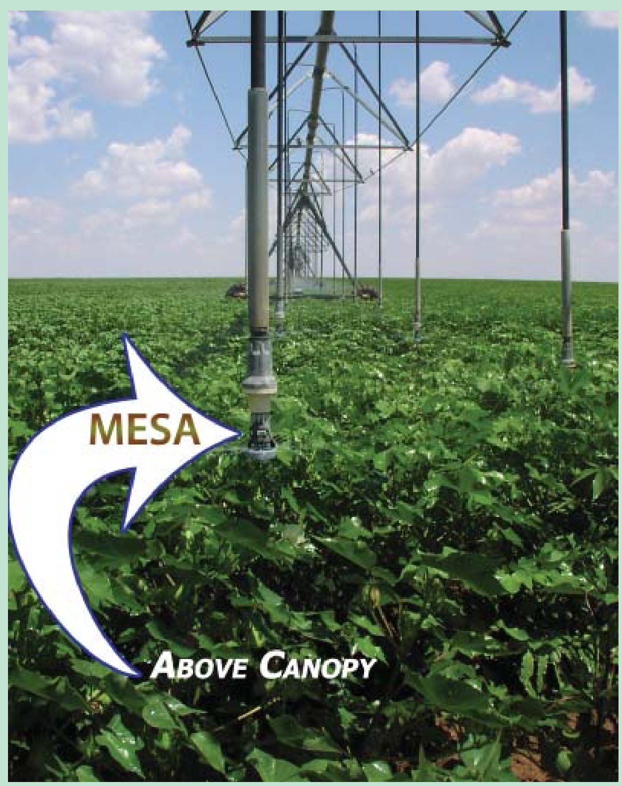
Mid-Elevation
Spray Application

## SYSTEM MANAGEMENT

Water distribution is greatly affected by nozzle spacing and height for MESA irrigation systems. In general, closer spaced nozzles will yield higher uniformity. Nozzle heights should be set above areas of high leaf concentrations.

Application rates shall be set such that runoff, translocation, and deep percolation are eliminated, or additional measures, such as furrow diking, in-furrow chiseling, conservation tillage and/or residue management shall be applied.

- REQUIRED CU (Coefficient Uniformity) – 90 percent
- NOZZLE SPACING – Optimum is two crop rows, but drops may be spaced up to 10 feet apart.
- NOZZLE HEIGHT – Above the crop canopy preferably within 3 to 7 feet of the soil surface depending on crop height.
- ROW ARRANGEMENT – Any row arrangement
- SLOPE OF FIELD – 3 percent or less

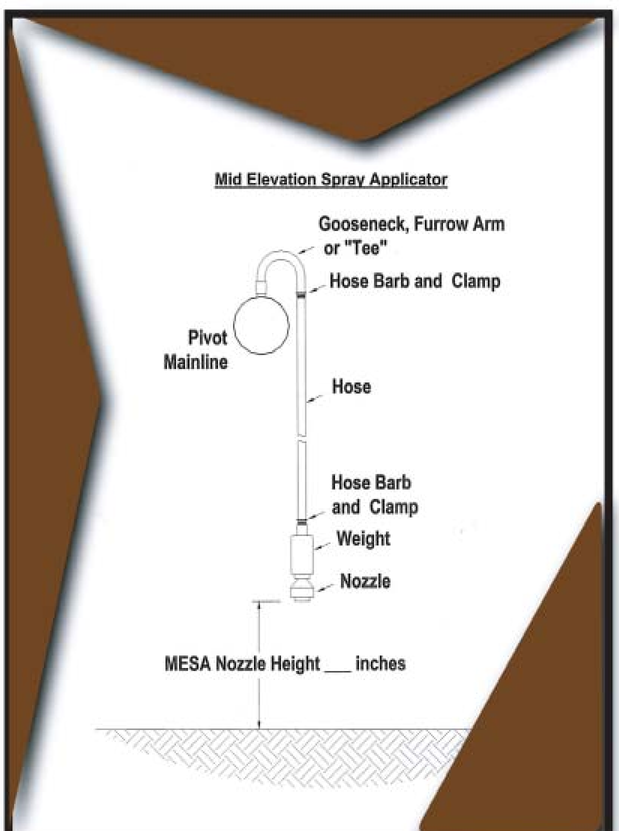


In the installation of the Mid-Elevation Spray Application (MESA), all materials used when converting an existing system to MESA shall be new and free from defects with the exception of weights. None of the existing sprinkler system shall remain as part of the new MESA system below the existing furrow arms or goosenecks. The MESA system will be comprised of all new components including the flexible drop hose, any rigid pipe used on the drop, pressure regulators (if needed), gate valves (if needed), nozzle bodies or bracket assemblies, sprinkler nozzles and splash and/or spray pads.

The existing weights, water outlets on the sprinkler mainline and furrow arms or goosenecks may be used provided they are not leaking and are in good condition. New mainline outlets to facilitate the location of the drops between crop rows shall be installed following the sprinkler system manufacturer's recommendations.

Don Blair rotates cotton and peanuts on his farms near O'Donnell.

*Lynn County producer Don Blair utilizes the Mid-Elevation Spray Application (MESA) on his sloped land. When asked how he determined which irrigation drop nozzle system would best fit his operation, he explained, "Experience is the best teacher. I chose to use the MESA system after listening and learning from those individuals already using the system." Blair is pleased with his MESA system that allows him full irrigation coverage over his crop.*




# ENVIRONMENTAL QUALITY INCENTIVES PROGRAM (EQIP)

is a federally funded cost-share program, which was reauthorized in the 2002 Farm Bill. The purpose of the program is to provide a voluntary conservation program to farmers and ranchers that promotes agricultural production and environmental quality.

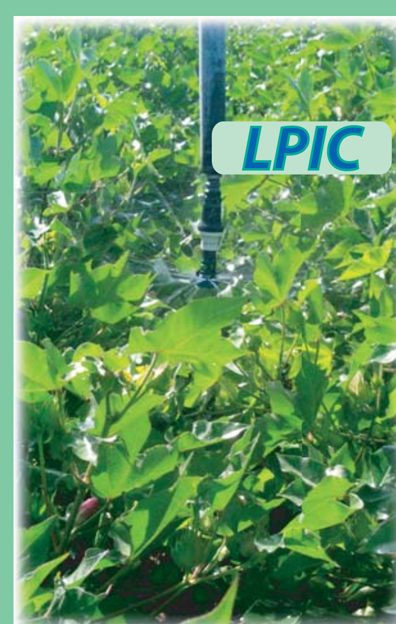
The installation of new Low Energy Precision Application (LEPA), Low Pressure In-Canopy (LPIC), Low Elevation Spray Application (LESA), Mid-Elevation Spray Application (MESA) sprinkler systems, or the conversion of existing systems to these more efficient systems, are eligible for cost-share in the EQIP program if they are identified as a priority by the local work group in that county.

EQIP cost-share expenditures require the participant to move to a higher level of conservation. Replacement of an existing center pivot sprinkler with a new or refurbished center pivot sprinkler is not eligible for EQIP cost-share. Re-nozzling a pivot that maintains the same level of conservation, is not eligible for cost-share. These conservation practices are considered normal operation and maintenance.

Sprinkler systems vary greatly in size, cost, and adaptability. They must be properly designed, maintained and managed to operate efficiently.

## *Center Pivot Sprinkler Irrigation Systems*



# Local Work Group Planning Meetings

One of the guiding principles of the 2002 USDA Farm Bill is that conservation programs are locally led. Through stake holder meetings the public is given an opportunity to help local conservation leaders set program priorities.

Each county in Texas holds public meetings annually. These meetings are led by the local Soil and Water Conservation District and provide an opportunity for participation and comments from a broad range of local agencies, organizations, businesses and individuals that have an interest in natural resource conditions and needs.

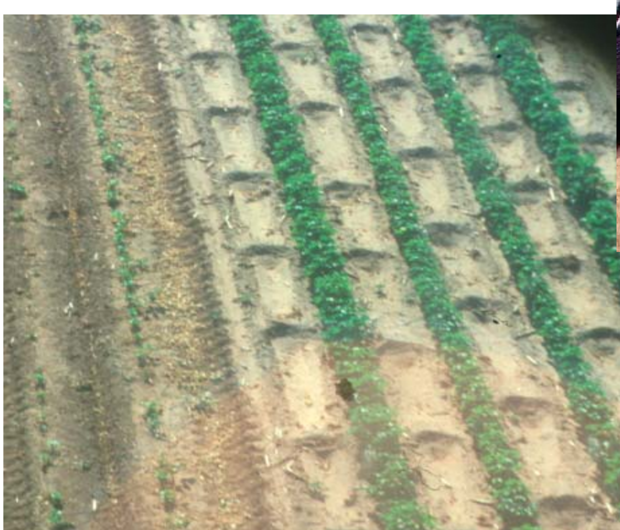
The Local Work Groups make recommendations regarding the resource concerns to be addressed, eligible practices, cost share rates, and ranking for county based EQIP funding.

# Irrigation Water Management

*(IWM) is knowing when to irrigate and how much to apply. Factors to consider in water management planning include soil, water quanitiy, and quality, crops, climate, available labor, and economics. These considerations are all interrelated.*

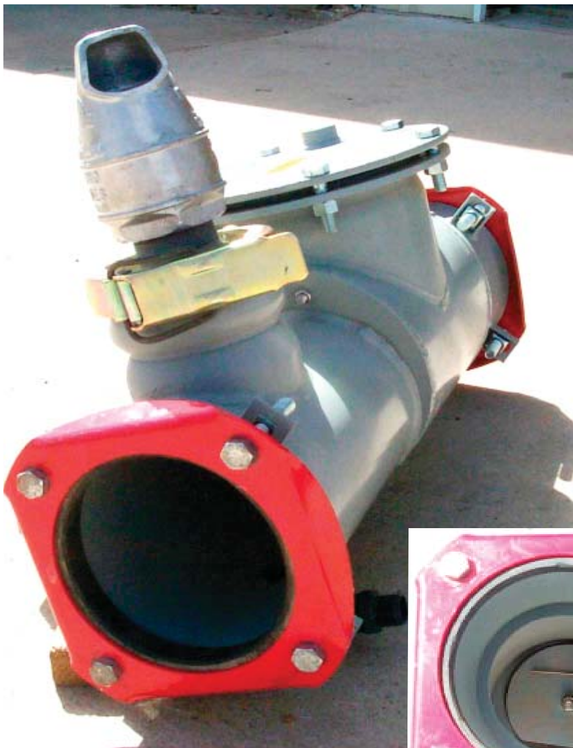
Soil provides physical support for the plant and serves as a reservoir for nutrients and water. The chosen irrigation method must suit the soil intake rate. The feel and appearance of soil vary with texture and moisture content. Soil moisture conditions can be estimated, with experience, to an accuracy of about five percent. Soil moisture is typically sampled in one-foot increments to the root depth of the crop at three or more sites per field. It is important to apply water according to crop needs in an amount that can be stored in the plant root zone of the soil.

*(Below)* Furrow diking conserves irrigation and rainfall amounts. This conservation management choice reduces runoff and helps keep the water on the field. Water is stored in the dikes and infiltrates into the soil.



*(Above)* The flowmeter, with its high accuracy, can also be used as a water management tool helping to reduce water costs, preventing over-irrigation and reducing leaching of chemicals and fertilizers into the ground.

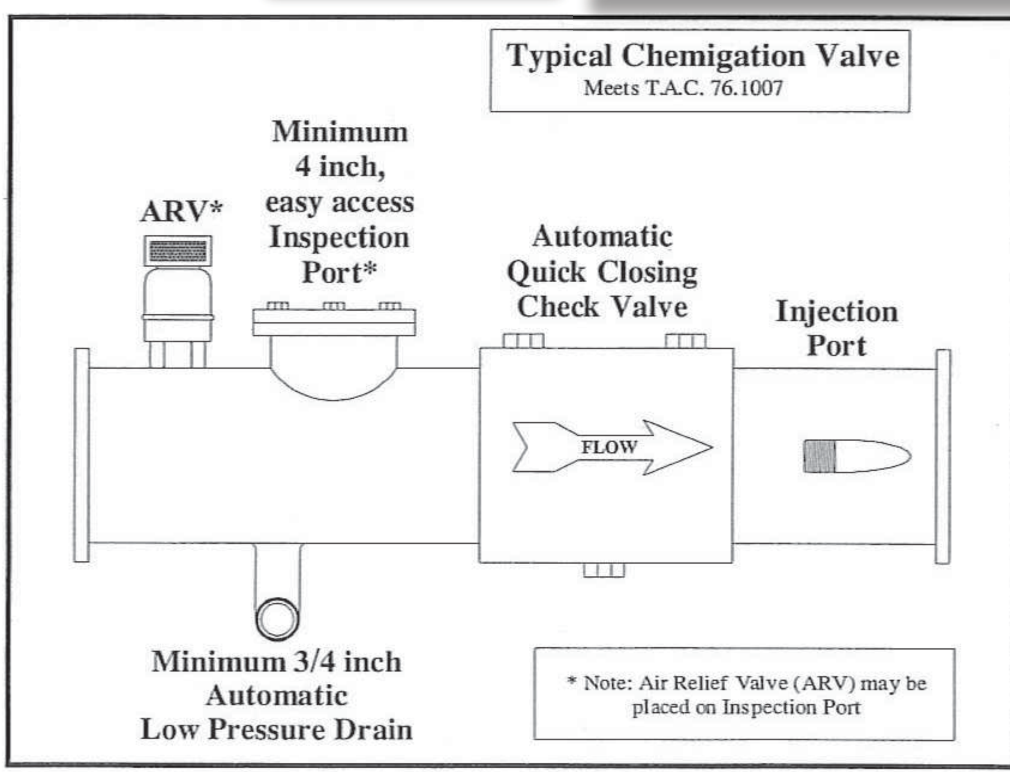
# CHEMIGATION SAFETY VALVE



Chemigation Valves are required by the State of Texas on all irrigation systems that inject fertilizer, herbicide, pesticide, or any other chemical. A chemigation valve (which includes an in-line, automatic quick-closing check valve) is required between the point of chemical injection and the well(s) to prevent pollution of the groundwater.

Some local groundwater rules may require a chemigation valve at each well.

The Texas Administrative Code, which became effective January, 2000, has specific requirements for Chemigation Valve components. Refer to Texas Administrative Code 76.1007 for complete information.



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Wes-Tex Resource Conservation and Development Area Inc. (RC&D)

Blackwater Valley Soil and Water Conservation District
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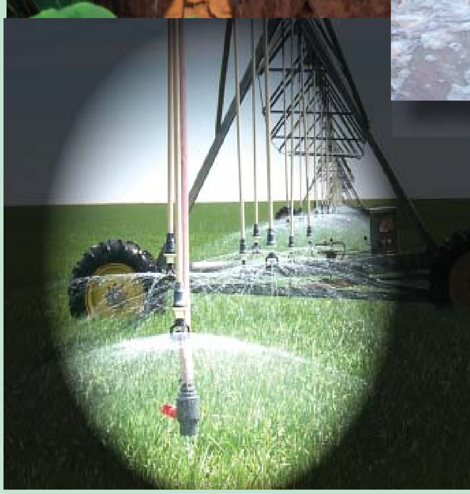
Dawson County Soil and Water Conservation District
Gaines County Soil and Water Conservation District
Lynn County Soil and Water Conservation District
Terry County Soil and Water Conservation District

High Plains Underground Water Conservation District
Llano Estacado Underground Water Conservation District
Mesa Underground Water Conservation District
Sandyland Underground Water Conservation District
South Plains Underground Water Conservation District



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**The Environmental Quality Incentives Program provides technical, educational and financial assistance to eligible farmers and ranchers to address soil, water and related natural resource concerns on their lands in an environmentally beneficial and cost effective manner. The program provides assistance to farmers and ranchers in complying with federal, state and tribal environmental laws, and encourages environmental enhancement.**

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