SPRINKLER IRRIGATION

A. The purpose of this chapter of the Irrigation Guide is to familiarize the SCS field personnel with sprinkler irrigation, by providing information on the following aspects of sprinkler irrigation;

1. Advantages and disadvantages of sprinkler irrigation

2. Types of sprinkler systems available

3. Initial and yearly costs of various sprinkler systems in New Mexico

4. Principles of sprinkler irrigation planning

This chapter is not intended to be a design manual for sprinkler irrigation, since this information is available from any NEH-15, Chapter 11, and the Engineering Field Manual.

ADVANTAGES AND DISADVANTAGES OF SPRINKLER IRRIGATION

The major advantages of sprinkler irrigation are:

1. Land with irregular topogrophy can be sprinkler irrigated with a minimum of land leveling and topsoil disturbance.

2. Fields can be irrigated without excessive losses from deep percolation or surface runoff.

3. Light frequent applications of irrigation water can be supplied on soils of low water-holding capacity, shallow depth, or for the irrigation of shallow rooted crops. Complete seed germination and crop stands can also be obtained by sprinkler irrigation becuase of its ability to apply light uniform application.

4. A properly designed sprinkler system gives a more uniform distribution of water than most surface methods of irrigation, thus providing a higher seasonal water use efficiency.

5. Farm machinery is easier to operate in fields without borders or ditches.

6. Drainage problems due to over irrigation or seepage losses can be eliminated.

7. Liquid fertilizers and herbicides can be applied readily through the sprinkler system.

8. Small continuous irrigation water supplies can be used effectively whereas these flow rates are usually unsuitable to be used effectively by surface irrigation methods.

9. Sprinkler irrigation systems can be readily adapted to automated irrigation.

The major disadvantages of sprinkler irrigation are:

1. The initial cost of a sprinkler system may be high when compared with the initial cost of a surface irrigation system on lands already leveled for surface irrigation. The sprinkler system represents an additional capital investment.

2. Pumping costs are usually increased when converting to sprinkler irrigation because of the high nozzle pressure necessary.

3. Depending on the type of sprinkler system chosen, labor costs could be higher with some types of sprinklers than with labor costs of surface irrigation methods.

4. Continuous flow delivery, and small irrigation heads, necessary for sprinkler irrigation, are not available from most irrigation water companies or conservancy districts in New Mexico.

5. Constant high velocity winds will greatly affect the efficiency and uniformity of the sprinkler spplication

6. Sprinkler irrigation usually needs a higher quality irrigation water than that of surface irrigation methods. Many areas in New Mexico

have irrigation waters that cannot be used successfully with sprinkler irrigation systems.

FIELD EFFICIENCIES

The efficiency of a sprinkler irrigation system actually involves two distinct efficiencies: (1.) Evaporation losses, (2.) Pattern uniformity.

Evaporation losses are directly dependent upon the nozzle size, nozzle pressure, wind velocity, temperature, and relative humidity. Field studies in New Mexico have found that evaporation losses from sprinkler systems will run from 8 to 15 percent.

Pattern uniformity is directly dependent on wind velocity, nozzle pressure, and nozzle spacing. Field studies in New Mexico have found that pattern uniformity for a correctly designed sprinkler system will range from 80 to 90 percent.

Based on these studies and available SCS data, a sprinkler system efficiency of 65 percent is recommended for planning and design purposes in New Mexico.

MAXIMUM APPLICATION RATES

The maximum application rate of a sprinkler system, without runoff, is effected by the soil intake rate, slope, and plant cover. The following table is to be used as a guide, realizing that this maximum rate increases with adequate cover, and decreases with slope and depth of application.

TABLE NO. I

MAXIMUM PRECIPITATION RATES TO USE ON LEVEL GROUND	
Light sandy soils	0.75" to 0.5" per hour
Medium textured soils.	0.5" to 0.25" per hour
Heavy textured soils	0.25" to 0.10" per hour

Allowable rates, increase with adequate cover, and decrease with land slopes and time.

TYPES OF SPRINKLERS (NOZZLES)

Sprinklers spray the water on the land through the nozzles in the sprinkler heads. These are classified according to the pressure required for proper distribution of the water applied.

1. Low pressure sprinklers - These sprinklers operate at 5 to 15 pounds per square inch, with a wetted diameter of 20 to 50 feet and a recommended minimum application rate of .40 inches per hour. These sprinklers are adapted to small acreages and where gravity pressure can be utilized, but also confined to soils of intake rates exceeding .50 inches per hour.

2. Moderate pressure sprinklers - These are usually single nozzle sprinklers with an operating pressure of from 15 to 30 p.s.i., a wetted diameter coverage of 60 to 80 feet, and a minimum application rate of .20 inches per hour. Moderate pressure sprinklers are adapted primarily to under tree sprinkling in orchards.

3. Intermediate pressure sprinklers - This type of sprinkler may be either single or double nozzle design with operating pressures of 30 to 60 p.s.i., wetted diameter coverage of 75 to 125 feet, and a minimum application rate of .25 inches per hour. These sprinklers are probably the most popular because they can be adapted to a wide variety of soils and crops.

4. High pressure sprinklers - This type may be either single or double nozzle design with operating pressures of 50 to 100 p.s.i., providing a wetted diameter of coverage of 110 to 230 feet, and a minimum application rate of .50 inches per hour. Sprinklers of this type are primarily adapted to truck crops, field crops, and pastures in areas where distortion of the pattern from wind is not excessive. These sprinklers provide fast coverage with limited equipment.

5. Hydraulic or giant sprinklers - These sprinklers have a large nozzle with smaller supplemental nozzles to fill in the pattern gaps. They operate at pressures of 80 to 120 p.s.i., cover a wetted diameter from 200 to 400 feet, and have a minimum application rate of .65 incher per hour. Adaptability is primarily to irrigated pastures or tall growing crops where rapid coverage is desired and acceptable. They are limited to soils with high intake rates.

6. Under -tree, low angle sprinklers - This type of sprinkler is designed to keep stream trajectories below fruit and foilage by lowering the nozzle angle. The operating pressure varies from 10 to 50 p.s.i., provides a wetted diameter of 40 to 90 feet, and a minimum application rate of .35 inches per hour. These sprinklers are adapted to orchards where the irrigation spray from other types of sprinklers would damage soft fruit or where wind would distort over trees sprinklers. They are also adapted to very low operating pressures.

7. Perforated pipe sprinklers - With this type of sprinkler water is sprayed out of small pinholes closely spaced along the upper part of portable aluminum irrigation pipe. Usually several rows of perforations are used so the jets of water cover a rectangular strip 10 to 50 feet wide. They can be operated at pressures of 4 to 200 p.s.i., with the recommended minimum application rate of .50 inches per hour. These sprinklers are adapted to low growing crops of soils of relatively high intake rates, and to low operating pressures.

TYPES OF SYSTEMS

All sprinkler irrigation systems use a series of 1 or more types of nozzles to distribute the water. Water is conveyed to these nozzles through either stationary or moveable pipelines and the operations of these pipelines determined the type of sprinkler system used.

1. Hand-moved Systems - The lateral line and sprinklers are set at one location and are allowed to remain there until the desired irrigation is obtained. They are then moved by hand from this position to another position and the operation repeated. This is therefore a set type system. Quick coupled aluminum pipe, usually three to four inches in diameter, is the best for most portable laterals. This type of system is generally the cheapest type of system in regard to initial cost, however considerable labor is required to move the pipe from set to set.

Figure: - 1 shows the general layout and operation of a typical set-type distribution system, one of which is hand moved. It also shows the water source in the center of the field, although it could be at another point with the main line located through the center of the field.

When a lateral line reaches the end of the field it is disassembled and either moved back to its original location, or across the main line to the other location of the other lateral. The lateral lines must be moved back to the starting location so that the area which was sprinkled first will again be sprinkled first in the next irrigation set.

Generally to keep the labor costs as low as practical, the design of a hand moved system should be such that the reguired irrigation set is either 7 or 11 hours to allow 3 or 2 sets a day with an hour of moving time per set.

Advantages and limitations: The hand moved system can be used on irregular shaped hills and rolling terrain. Any nozzle from low to high pressure can be used to meet any intake rate requirements. For tall crops, this type of system is inconvenient and gives poor distribution.

2. Side-roll System - To decrease the amount and intensity of labor required, the lateral line is mounted on wheels. The pipe is the axle with the wheels usually spaced 30-40 feet apart and the sprinklers midway between. Wheels are available in different diameters with the largest wheel used for maximum clearance.

The operation of the side roll lateral is similar to the hand moved system. The lateral line is moved between sets by rolling wheels. The distance between lateral sets depends on the size of the sprinklers and the diameter of the wheels. Usually the distance will be from 50 to 80 feet. The connection of the lateral to the main line is usually made with a 10 to 15 foot section of flexible hose.

Most side-roll systems use an air-cooled gasoline engine located near the center of the live for moving. Some of the older type systems use a lever and rachet method for moving the lines. Because the pipe tends to twist somewhat in moving, it is necessary to provide for vertical alignment of the sprinklers by use of self-aligning risers with a counter weight to keep the sprinkler head vertical.

The side-roll system has been modified by some manufacturers by supporting the sprinkler lateral above the wheels on an "A" frame, and using a drive shaft to move the system instead of using the pipe as an axle. To gain greater coverage with lateral sets, some side-roll systems have been developed which use trailing sprinkler lines, each containing 1 to 11 sprinklers. These sprinklers provide for set distances up to 300 feet.

The field operation is the same as the hand moved or conventional side-roll lateral except that the coverage distance per set is considerably greater. The operation of these system is shown in figures 1, 2.

When the lateral reaches the end of the field it has to be moved back to the starting point or to an adjacent field and the trailing lines must be picked up and moved separately. Provision can be made to transport the trailing lines on the main line lateral line. These systems often have a main lateral line supported on tower assemblies to provide clearance for tall crops.

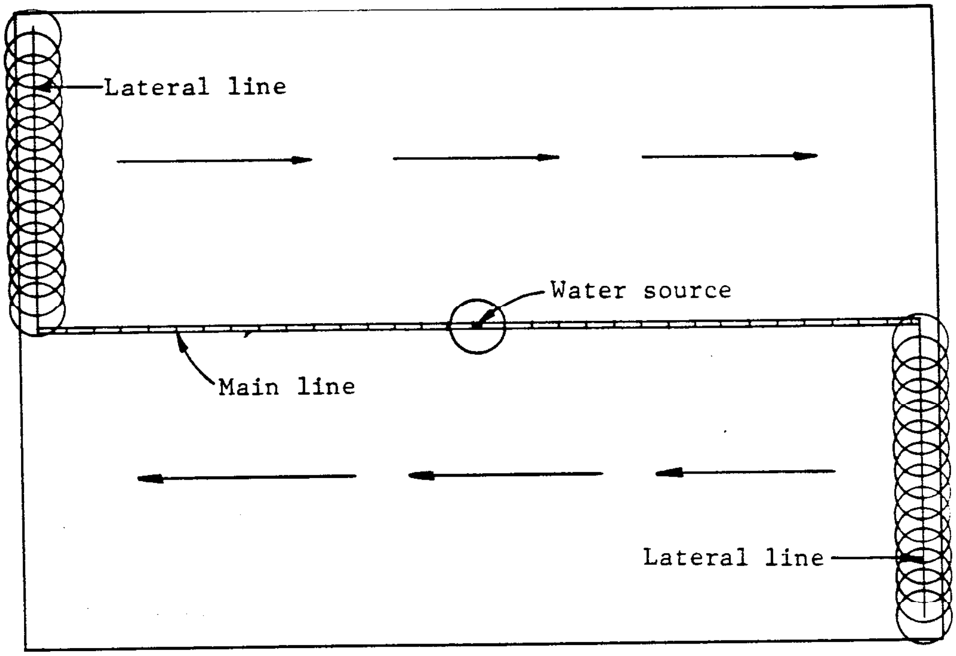


FIG. 1, Set-type irrigation system

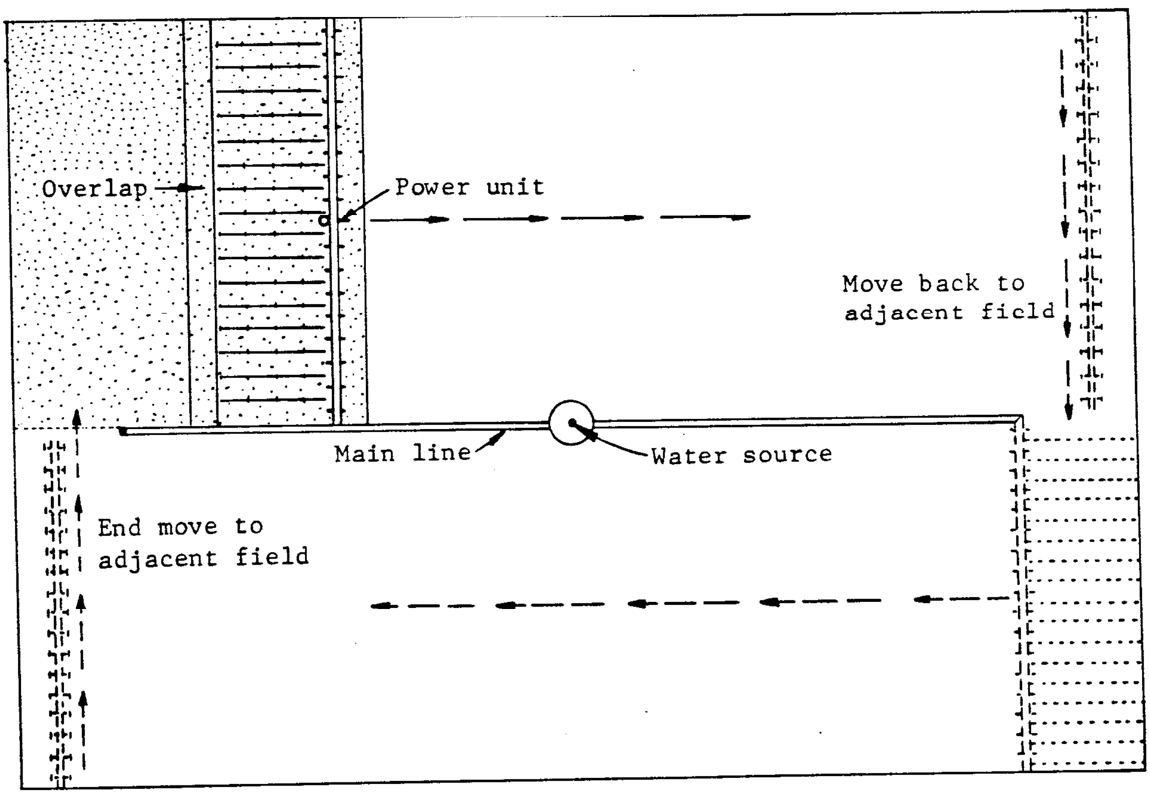


FIG. 2, Operation of trailing-line system

Advantages and limitations: These types of systems can be used on any soil type suited for sprinkler irrigation. They require rectangular fields, and except when mounted on tower assemblies, these systems are not adapted to tall crops. Alignment may be difficult on undulating topogrophy.

3. End - tow Lateral Systems - Another irrigation system using lateral sets is the end tow or tractor moved system. The lateral line has couplers semi permanently fastened together. The lateral line may be mounted on skid pans or small wheels to be towed from one set to the next. The operation of a typical end tow lateral is shown in figure 3, the main line which supplies the water for the system is located in the center of the field. A turn strip 100 to 200 feet wide is provided so that the lateral line can be turned as it is towed from one side of the field to the other. A typical system might have 60 foot sets so the lateral will need to be shifted 30 feet as it crosses the turn strip.

When the lateral reaches the last setting in the field it will have to move back to the starting position - the location of the first set.

To keep the sprinkler risers vertical during sprinkling and while the system is being moved, stabilizers are used on the lateral. As the lateral is towed across the ground the pipe will wear depending on the crop cover and the soils texture. Towline couplers usually provide for turning the pipe to distribute the wear around its circumference.

The turn strip may be grass or some harvestable crop so this land is not completely lost to production.

Advantages and limitations: This system is adapted to any soil type that is suitable for sprinkler irrigation, but it requires 100 to 200 feet turnways and narrow alleyways in irrigated grow crops. Rectangular fields are needed and this system is usually used only in alfalfa or irrigated pasture.

4. Rotating Boom System -

This system consists of a pipe and nozzle are that rotated about the center or balance point on a four wheel mounted turntable. A tower and cable arrangement holds the booms in place. The booms rotate by water pressure using a jet action controlled by various nozzle arrangements, nozzle sizes and water pressures. The arms are provided in a choice of lengths that give coverage of from one to four acres per setting. Application rates vary from about .4 to .8 inches per hour, with the usual rate being approximately .5 inches per hour. The unit can be pulled ahead to a new setting by a tractor attached to the boom carriage by a cable of sufficient length so that the tractor operates on dry ground. As the boom moves ahead, the feeder pipeline sections can be picked up and placed on the trailer that supports the boom. Settings should be such that a triangular pattern results with adjacent lanes.

Because of the large wetted diameter coverage there can be a problem with wind distortion of the pattern. Wind also can effect rotation

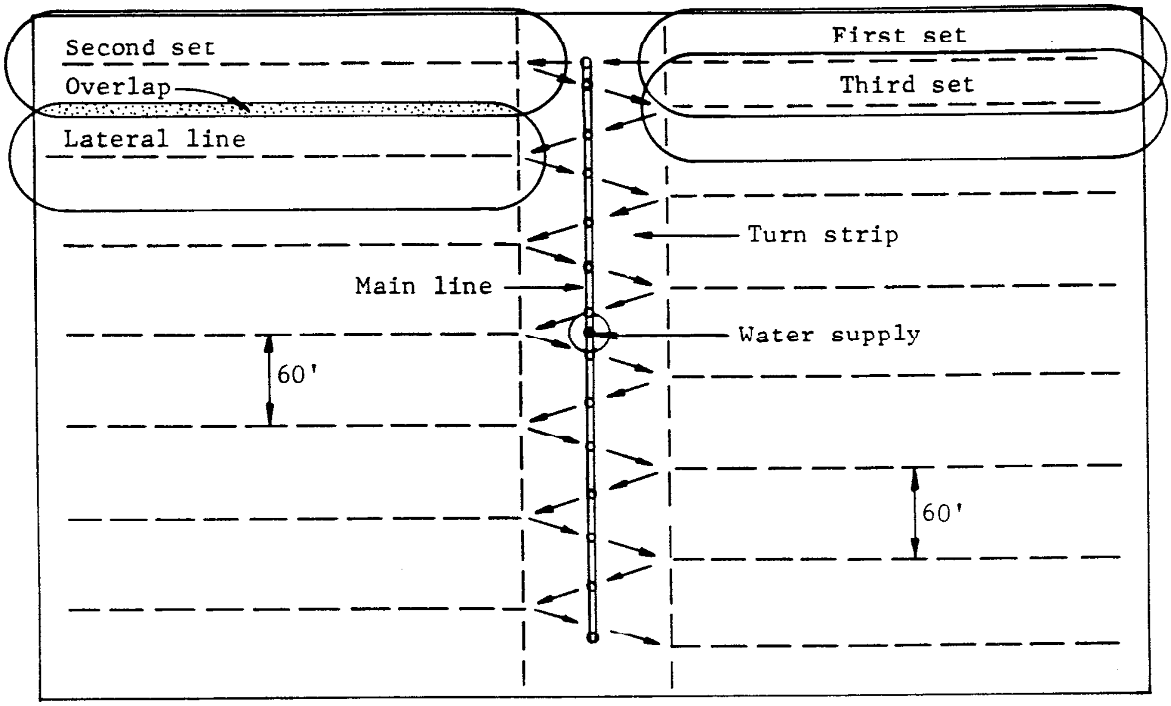


FIG. 3, End-tow system operation

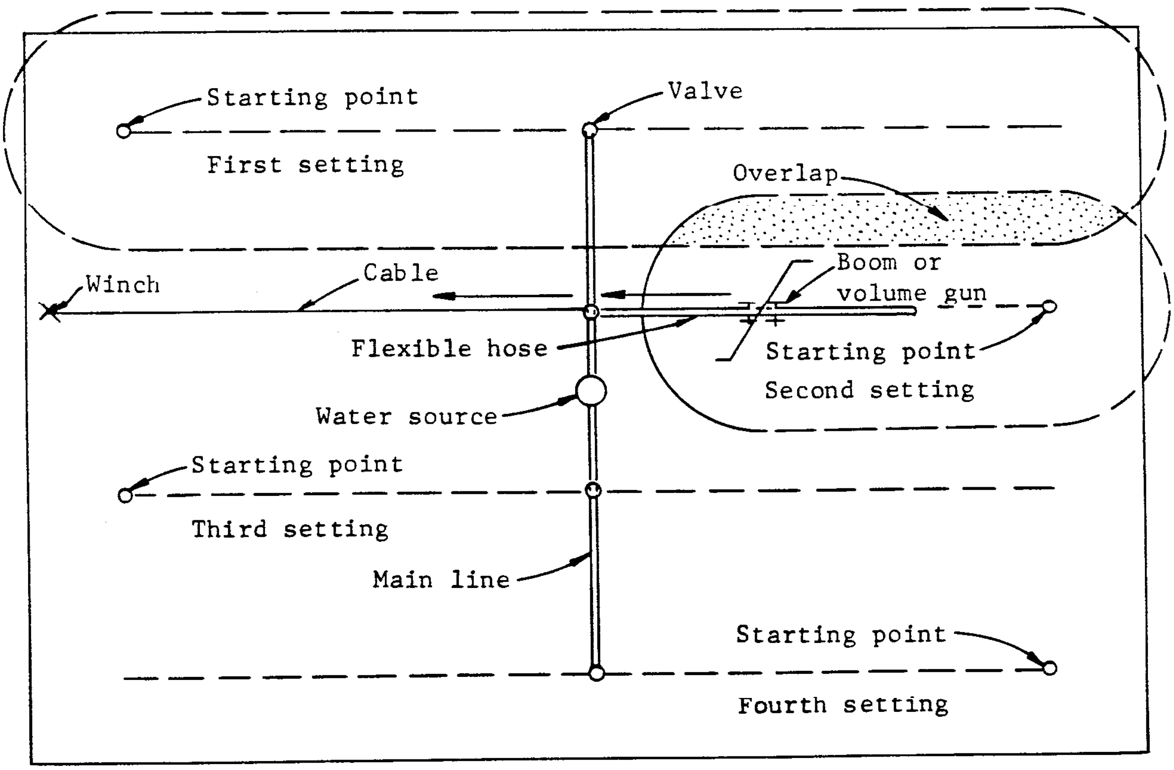


FIG. 4, Continuous move boom or volume gun speed of the boom. Under severe wind conditions the rotation may even stop with the boom reaches a position of right angles to the wind. Since water discharges from the nozzle at a uniform rate any variation in rotation speed will upset the sprinkler distribution pattern.

Advantages and limitations: Rotating boom systems can be used on irregularly shaped fields, but wind effects the rotation and water distribution pattern. Alleyways are required for row crops and the application rate may be too high for some soils.

5. Volume Gun System - The volume gun sprinkler consists of a single high capacity nozzle mounted on a 2 to 4 wheel trailer. The pump and power unit may also be mounted on the trailer, or it may be permanently placed at a central location. In some types, a tractor is used as a power unit. Volume gun sprinklers are usually larger than 3/4 inch diameter and the recommended operating pressure usually exceeds 90 p.s.i. This pressure will increase the horsepower requirement for the distribution system, and if the operating pressure is below the manufacturer's recommendation, the water distribution pattern will be uneven.

The wetted diameters of volume guns are extremely large compared to the 10 to 15 GPM sprinklers which are often used on lateral move sprinklers. Because of the large wetted diameter it is difficult to obtain proper overlap of the sprinkler patterns. Wind distortion of the pattern is also a factor in trying to accomplish good fieldwide water distribution. The volume gun, being of large diameter, can spray liquids containing some sediments and is well suited for delivering animal liquid wastes from collecting ponds to crop fields.

Advantages and limitations: Volume guns can be used on irregularly shaped fields and can distribute water containing small particle sediments. High operating pressures are required and the wind greatly effects the water distribution pattern. Alleyways are required for row crops and application rates are generally in excess of .65 inches per hour, therefore, being suited to only relatively high intake rate soils.

6. Continuous Move Boom System - With a flexible supply hose or open ditch to convey water and either a cable with power winch or slow moving water powered unit, the sprinkler can operate as it moves along a line. Speed of sprinkler travel can be varied and adjusted according to the amount of water to be applied. While the water discharge from the sprinkler nozzle is at a constant rate, the amount of water can be varied by the travel speed. The speed also can be adjusted so that moving the hose and sprinkler unit from one lane to the next will fit other farm operations.

The flexible hose is available in various diameter sizes. There is considerable friction loss in the hose which must be overcome by pump pressure. This additional pressure requires additional horse power and increases the operating cost of the system.

In addition to having sufficient strength to withstand the high operating pressure, the hose must be strong enough to be towed when full of water. Thus, a special type hose is needed for the continuous move sprinkler. Wear and abraision are also important considerations in the use of the hose. Periodic hose replacement is a sizeable maintainence cost and should be considered in the purchase of this type of system. If water is supplied by an open ditch, seepage losses may be high and field slope must be such that these ditches are practical to use.

Figure 4 shows the pattern of operation for a boom sprinkler with a continuous move. A winch is anchored at one end of the field and air-cooled gasoline engine winds up the cable which tows the sprinkler at a continuous rate along the lane through the field. A flexible hose supplies water to the sprinkler from the main line in the center of the field for a lane length of 1320 feet, 600 feet of hose is required. The lane where the sprinkler and hose operate should be smooth and well maintained. The boom sprinkler, as it moves through the field, should not tilt one way or the other because of an uneven lane. Tilting causes an uneven water distribution pattern.

Advantages and limitations: These are the same as for the rotating boom except rectangular fields are desirable. Overlap between sets is eliminated and friction loss is high in the flexible hose.

7. Continuous Move Volume Gun System - The same type continuous move operation is used with the volume gun as was explained for the boom.

The power to move the sprinkler may be supplied by self-propelled equipment or by a motor mounted on the sprinkler trailer which winds the cable on a drum. Another method has the motor and winch anchored at the end of the field. On some types of volume gun sprinklers using a continuous move principle, a sprinkler mechanism purposely does not water the lane directly in front of its travel so as to keep a firm track for the sprinkler cart or trailer.

As with continuous move boom sprinklers the overlap pattern between individual sets along the lane is eliminated. Therefore, the distribution pattern is better with a continuous move sprinkler than with the same sprinkler set at selected intervals.

Advantages and limitations: Same as for the volume gun operated at selected sets except that rectangular fields are desirable and the flexible hose causes high friction losses.

8. Solid Set Systems - The solid set system is gaining popularity particularly for high value crops, especially sod. With this system, the main line and the lateral lines remain in place during the growing season. Sometimes the solid set system is permanent, with the main line and lateral lines buried. With other solid set systems, the pipes are installed in the field after planting and remain there until harvest.

These systems may be used to supply water to meet crop demand and for the purpose of temperature modification, either for frost protection or hot weather cooling.

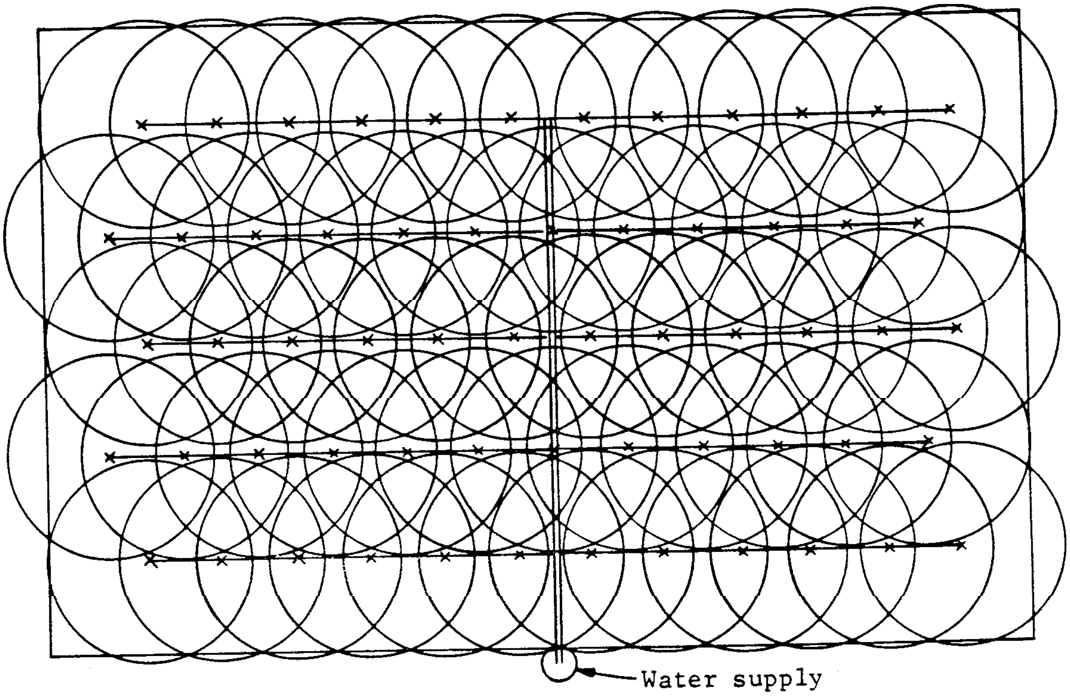


FIG. 5, solid set system

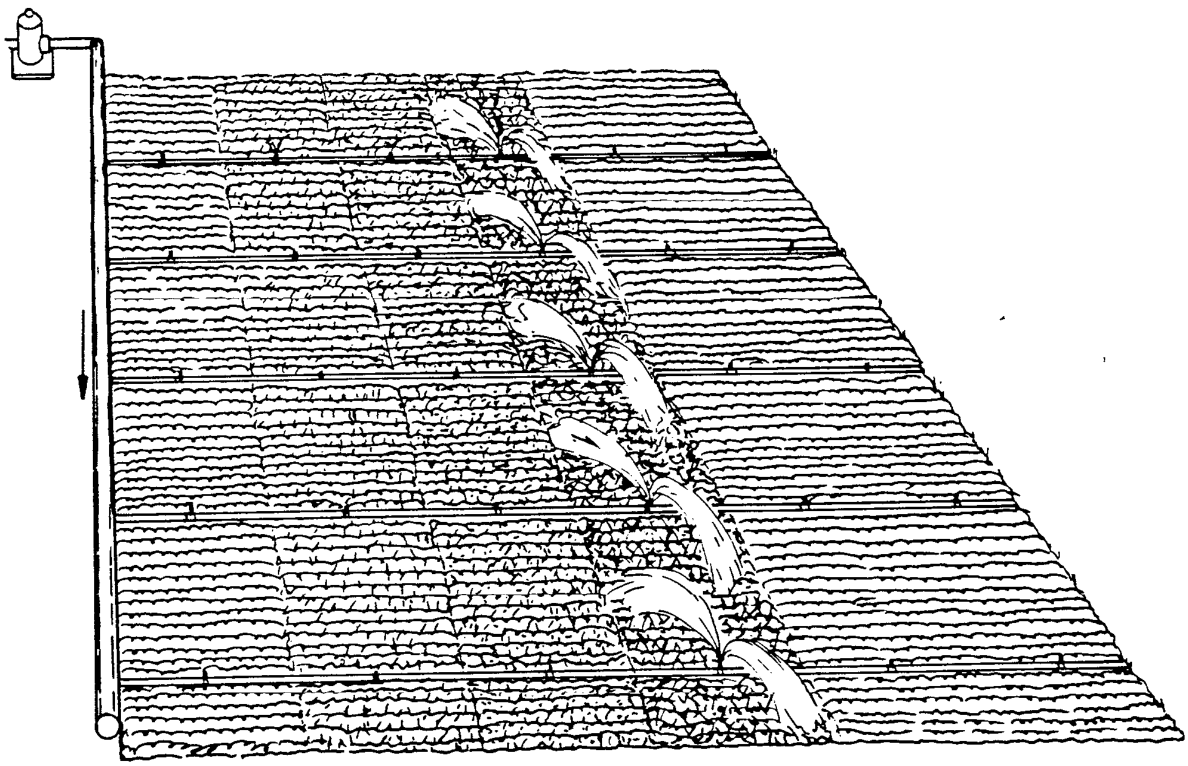


FIG. 6, Sequencing solid set

There are two main types of solid systems:

(a) All lateral lines operating simultaneously. This type may be modified to a rapid sequence system where water is applies for approximately three minutes to each 1/5 of the area and the irrigated area is covered each 15 minutes until desired application is made. See Fig. 5.

(b) The SEQUA-MATIC system is a group of sprinklers that are operated the required time then automatically shut off and another group turned on. This sequence is repeated until the field is irrigated. This type of system as shown in Fig. 6.

The average cost of the solid system distribution equipment is generally the most expensive type of sprinkler system available.

Advantages and limitations: The solid set system is adapted to irregular shaped fields and permits good sprinkler control with minimum labor after installation. Equipment investment costs are very high and lateral lines may interfere with field operations.

9. Center Pivot Self-Propelled System - This system consists of a single lateral mounted on wheels spaced on approximately 100 foot centers and supported by towers with cable or truss supports. Each of the towers has a device to provide power to the wheels. The type of power varies with manufacturer and can be provided by either water, hydraulic oil, electric motor, compressed air, or revolving water jets. The

operation of the center pivot system is shown in figure 7. An anchor pivot point is located at the center of the field around which the entire system pivots.

The speed of rotation of the center pivot system may vary from 12 hours to a week or more. The rate of water application is the same regardless of the speed of rotation. However, the faster the rotation speed the less the total water depth applied per rotation.

The speed of the center pivot sprinkler is usually controlled by the end tower. A system of alignment controls keeps all the others in line with the end tower.

With the center pivot system a circular or square field is required. On a quarter section (160 acres) approximately 125 arces are under irrigation by sprinklers on the line. If an end gun is used to irrigate the corners then approximately 132 acres are irrigated. End guns usually operate much below the specified pressure for that type of sprinkler and result in large drops and uneven distribution patterns. The large drops from the end gun also tend to create soil puddling and greatly increase the chance of water loss by runoff. The area irrigated under the end gun usually produces the poorest yield. The average cost of the distribution equipment is, in general, higher than for most other systems but less than solid set systems.

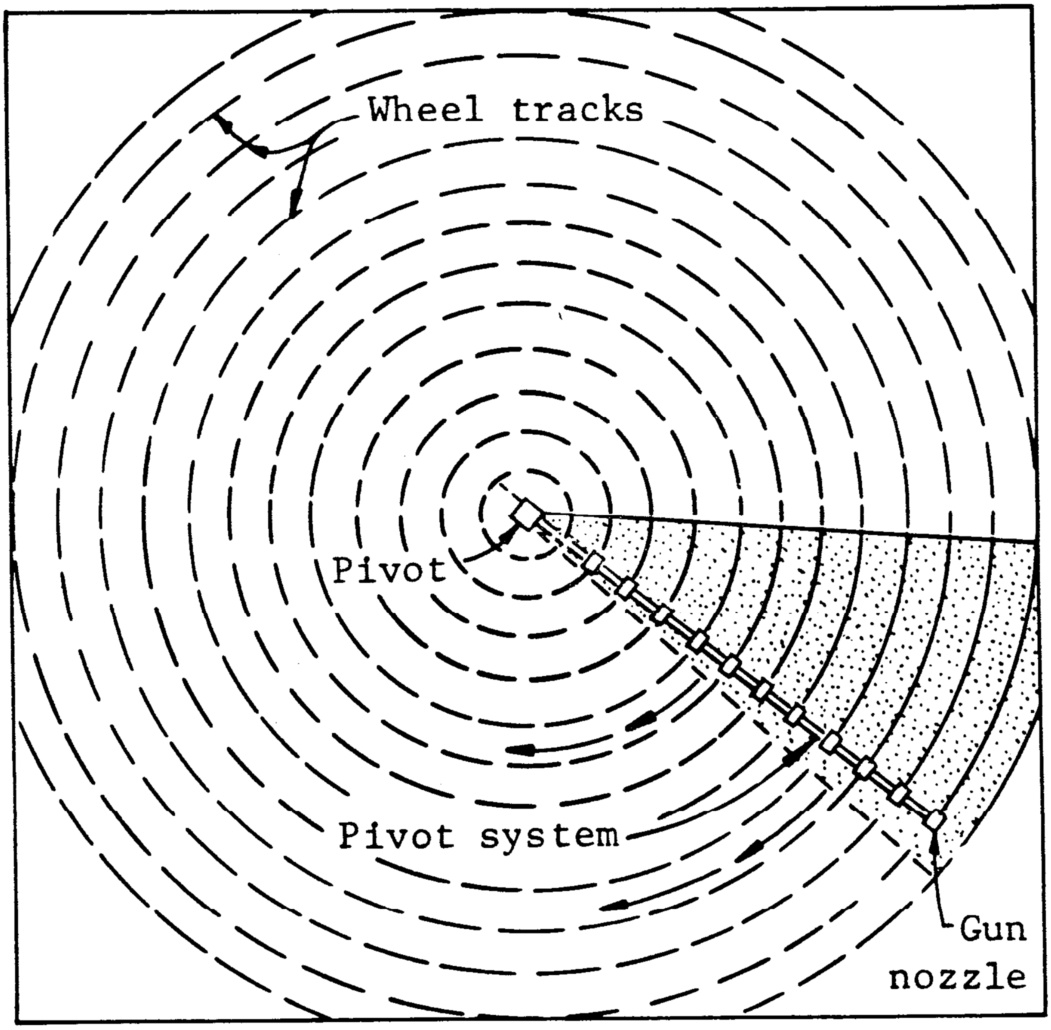


FIG. 7, center-pivot. (Gun nozzle used in corners only)

Advantages and limitations: The center pivot system, if kept in good repair, will require a minimum of operating labor. Circular or square fields with no obstructions are required. Application rate is high at the outer end of the line resulting in excess runoff of low intake soils. Required operating pressures vary from 30 to 70 pounds per square inch at the pivot depending on the length and diameter of the lateral pipe and nozzle type. There is a tendancy for wheels to cut deep ruts in some soils and for gully erosion of the wheel tracks to become a substantial problem. Some low pressure nozzle systems have a very high application rate which produces a great deal of surface runoff.

10. Continuous-Move Side-Roll System - This system consists of a single lateral mounted on wheels and towers, which are identical to those of the center pivot system. However, instead of rotating around a pivot point, this system moves continuously through the field in a lateral direction.

Speed control and alignment are again similar to the center pivot system. Water is supplied through one end of the system from a booster pump which also travels with the sprinkler. Since the booster travels with the sprinkler, either an open ditch or pipeline can be used as the primary water source. If an underground pipeline is used, a hose arrangement similar to that of the continuous move big gun is used.

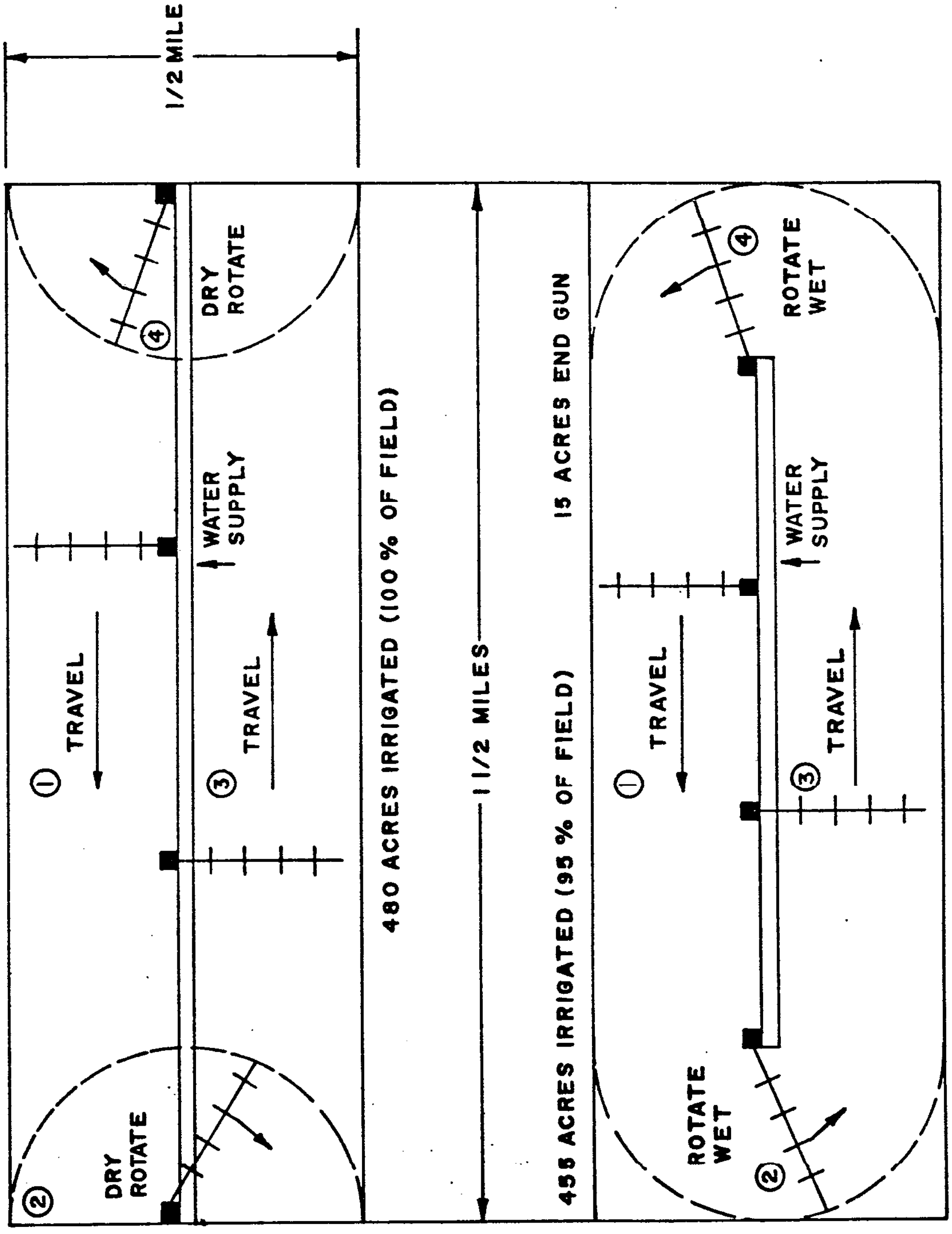


FIG. 7a - CONTINUOUS MOVE SIDE-ROLL SYSTEM

Nozzling arrangements available are similar to the center pivot systems shown in Fig. 11.

Advantages and limitations: The continuous move side-roll system requires rectangular fields with no obstacles. If a water source other than open ditch is used, friction losses in the portable pipe can cause high pumping costs. Application rate problems of the center pivot systems are eliviated somewhat, but low pressure spray nozzle arrangements can still develop very high application rates.

PLANNING RESPONSIBILITIES OF THE SCS IN SPRINKLER IRRIGATION

The SCS has three major responsibilities in the planning of a sprinkler irrigation system:

1. Determining the adequacy of existing water supply for the proposed acreage and system hardware.

2. Determine the adequacy of the proposed sprinkler hardware to meet the crop needs.

3. Assisting the cooperator to decide on a sprinkler system that is best suited to meet his objectives and at the same time meeting the established criteria of the SCS.

With these three major planning objectives in mind, the following planning data is to be used by the SCS to discuss sprinkler systems with the cooperator prior to any intense design being made by the SCS.

1. <u>NM-CONS-213</u> - This form should be filled out and discussed with the cooperator as outlined in the Overall System Planning Chapter of the Irrigation Guide. This form will show the farmer whether or not he has an adequate water quality and quanity to use a sprinkler system.

2. System sizing - Table 2 gives the usual maximum GPM capacity for various sizes of sprinkler hardware currently available. This chart should be used in conjunction with the water needs of NM-CONS-213 to assure the cooperator that he is planning an adequate amount of sprinkler hardware for his farm delivery system. For lateral move systems, the maximum lateral move is dependent upon the wetted diameter of the sprinkler nozzle and usual wind speed. Table 3 shows the usual wetted diameter for various sprinkler nozzles and Table 4 shows the maximum recommended lateral move.

For circular sprinklers, Table No. 6 is used to assure us that the water needs, computed on NM-CONS-213, can be met by the proposed system hardware.

System costs comparison: The cost comparisons shown in Table 7 are to be used by planners in discussing various sprinkler system alternatives with the cooperator. These costs may be updated by each field office as hardware, labor, and pumping costs change.

TABLE NO. 2 - LATERAL MOVE SPRINKLER SYSTEMS

Lateral Pipe Dia.	Nozzle Spacing on Lateral	Lateral Length (Approx)	Maximum GPM per Nozzle	Maximum GPM per Lateral	Lateral Set Move	Gross App. Rate	Net App. Rate at 65% Efficiency
4"	30'	1320'	5.4	243	50'	.35"/Hr.	.23"/Hr.
4"	40'	1320'	7.1	241	50'	.34"/Hr.	.22"/Hr.
4"	40'	1320'	7.1	241	60'	.28"/Hr.	.18"/Hr.
5"	40'	1320'	13.2	449	50'	.64"/Hr. 1/	.42"/Hr.
5"	40'	1320'	10.4	354	50'	.50"/Hr.	.33"/Hr.
5"	40'	1320'	13.2	449	60'	.53"/Hr.	.34"/Hr.
6"	50'	1320'	6.5 2/	702	120'	.42"/Hr.	.27"/Hr.
7"	50'	1320'	9.1 2/	983	120'	.58"/Hr. 1/	.38"/Hr.

1/ May be excessive for some soils.

2/ With four drag laterals.

SPRINKLER DISCHARGES FOR TYPICAL DOUBLE AND SINGLE NOZZLE SPRINKLERS

TABLE NO. 3

	DOUBLE NOZZLE SIZES													
	9/64 x 3/32		5/32 x 3/32		11/64 x 3/32		3/16 x 3/32		3/16 x 1/8		13/64 x 1/8		7/32 x 1/8	
NOZZLE PRESSURE PSI	DIAMETER	GPM	DIAMETER	GPM	DIAMETER	GPM	DIAMETER	GPM	DIAMETER	GPM	DIAMETER	GPM	DIAMETER	GPM
30	81	4.1	85	5.3	88	6.1	91	6.9	91	8.1	94	9.2	98	10.3
35	82	4.8	85	5.7	90	6.6	94	7.5	94	8.8	97	9.9	100	11.1
40	83	5.2	88	6.1	92	7.0	96	8.1	96	9.5	99	10.7	102	11.9
45	84	5.5	89	6.5	93	7.5	98	8.6	98	10.1	101	11.3	104	12.7
50	85	5.8	90	6.8	95	7.8	100	9.0	100	10.6	103	11.9	106	13.3
55	86	6.1	91	7.2	96	8.3	101	9.5	101	11.1	104	12.5	107	13.9
60	87	6.3	92	7.5	97	8.6	102	9.9	102	11.6	105	13.0	108	14.4

	SINGLE NOZZLE SIZES											
PSI	9/64		5/32		11/64		3/16		13/64		7/32	
30	81	3.2	85	3.9	88	4.6	91	5.5	94	6.5	96	7.6
35	82	3.4	87	4.2	90	5.0	94	6.0	97	7.1	100	8.3
40	83	3.6	88	4.5	92	5.4	96	6.4	99	7.6	102	8.8
45	84	3.8	89	4.7	93	5.7	98	6.8	101	8.1	104	9.4
50	85	4.0	90	5.0	95	6.0	100	7.2	103	8.5	106	9.9
55	86	4.2	91	5.2	96	6.3	101	7.5	104	8.9	107	10.3
60	87	4.4	92	5.4	97	6.6	102	7.8	105	9.2	108	10.6

NOZZLE PRESSURES ABOVE THE DASHED LINE ARE NOT RECOMMENDED AREAS

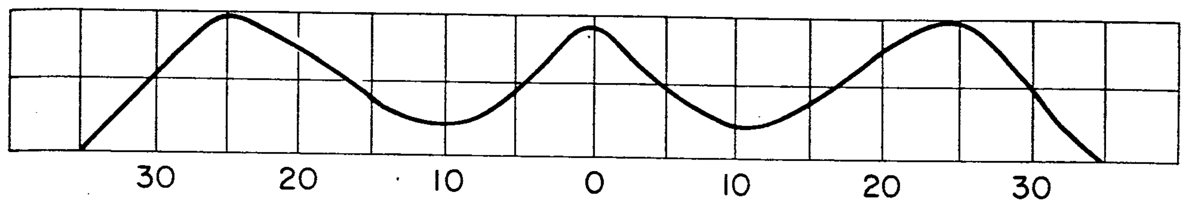
TABLE NO. 4

MAXIMUM SPRINKLER AND LATERAL SPACINGS		
AVERAGE WIND SPEED MPH	SPRINKLER SPACING	LATERAL MOVE
0	.5D	.65D
5	.5D	.6D
10	.5D	.5D
10+	.5D	.3D

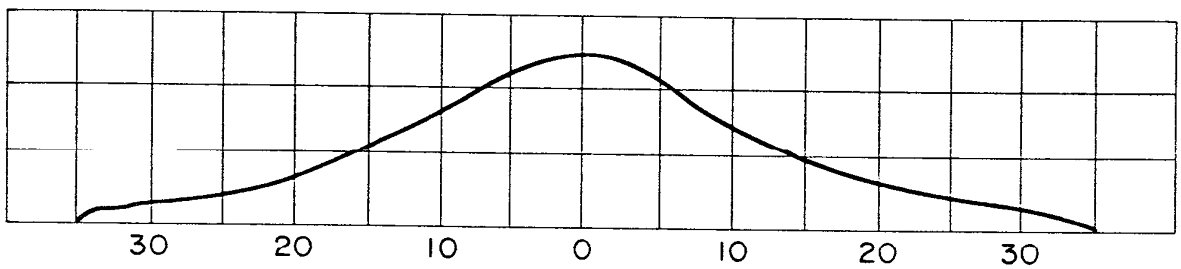
D = Wetted Diameter of Nozzle

TABLE NO. 5 - PRECIPITATION RATE, INCHES PER HOUR

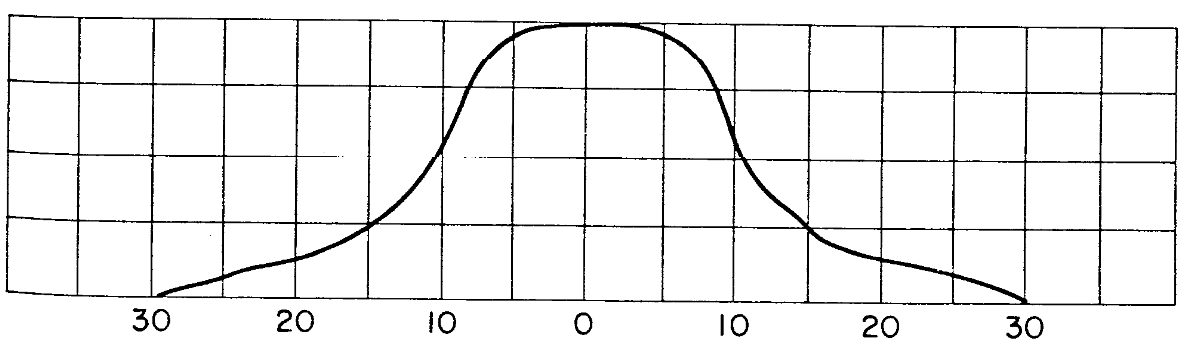
Spacing Feet	Gallons per Minute from each Full Circle Sprinkler											
	1	2	3	4	5	6	8	10	12	15	18	20
20 x 20	.24	.48	.72	.96	1.20	1.44	1.92					
20 x 30	.16	.32	.48	.64	.80	.96	1.28	1.60	1.93			
20 x 40	.12	.24	.36	.48	.60	.72	.96	1.20	1.45	1.81	2.17	
25 x 25	.15	.30	.46	.61	.77	.92	1.23	1.54	1.85	2.31		
30 x 30	.11	.21	.32	.43	.54	.64	.86	1.07	1.28	1.61	1.93	2.14
30 x 40	.08	.16	.24	.32	.40	.48	.64	.80	.96	1.20	1.45	1.61
30 x 45	.07	.14	.21	.29	.36	.43	.57	.71	.86	1.07	1.28	1.43
30 x 50		.13	.19	.25	.32	.38	.51	.64	.76	.96	1.15	1.28
30 x 60		.11	.16	.21	.27	.32	.43	.53	.64	.80	.96	1.07
40 x 40		.12	.18	.24	.30	.36	.48	.60	.72	.90	1.08	1.20
40 x 50		.10	.14	.19	.24	.29	.38	.48	.58	.72	.86	.96
40 x 60			.12	.16	.20	.24	.32	.40	.48	.60	.72	.80
50 x 50			.12	.15	.19	.23	.31	.39	.46	.58	.69	.77
50 x 60			.10	.13	.16	.19	.26	.32	.39	.48	.58	.64
50 x 70				.11	.14	.17	.22	.28	.33	.41	.49	.55



A-PRESSURE TOO LOW



B-PRESSURE SATISFACTORY



C-PRESSURE TOO HIGH

Figure 8 Effect of different pressures of typical U.S. sprinklers. Note changes in the distribution pattern. The zero position above is the sprinkler location.

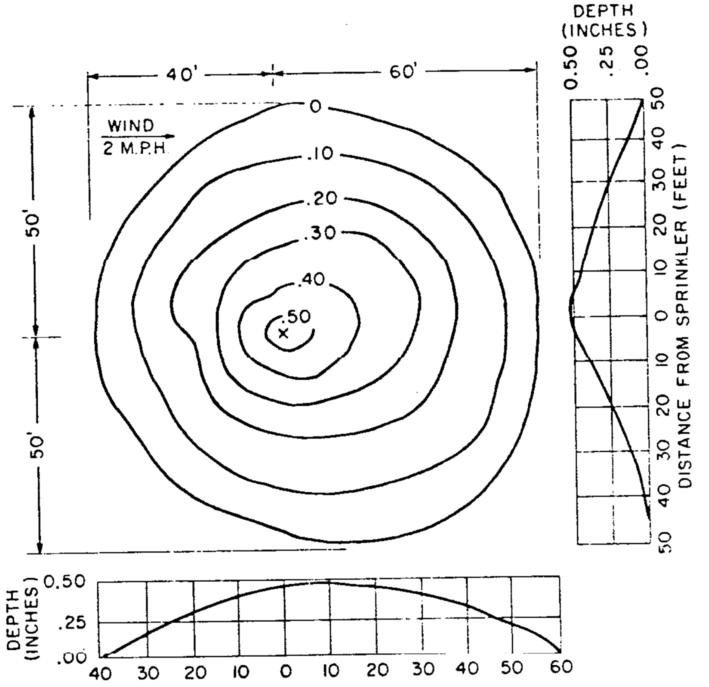


Figure 9 Distribution pattern from sprinklers operating under favorable conditions.

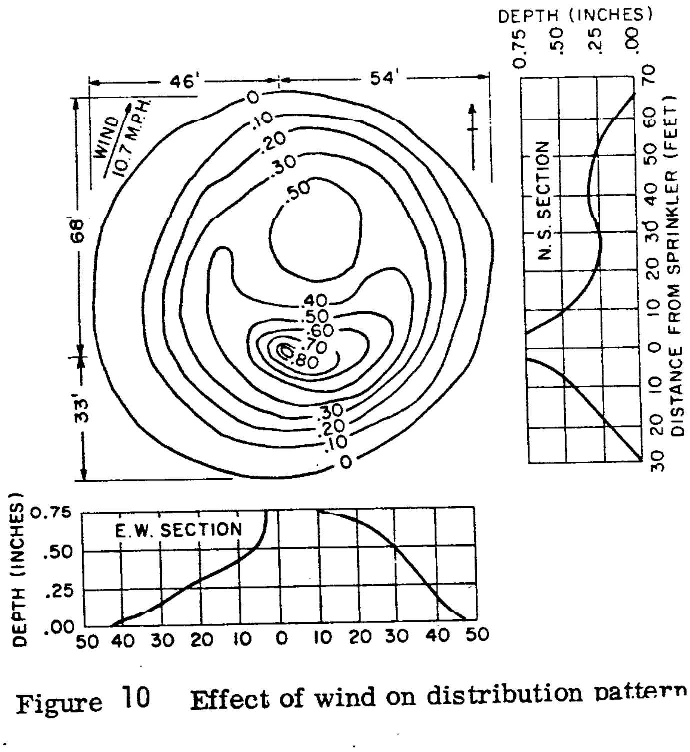


Figure 10 Effect of wind on distribution pattern

TABLE NO. 6

NET WATER APPLIED BY CIRCULAR SPRINKLER(INCHES)
IRRIGATING 125 ACRES AT 65% EFFICIENCY

DAYS PER REVOLUTION	GALLONS PER MINUTE TO PIVOT UNDER PRESSURE						
	600	700	800	900	1000	1100	1200
1.00	0.17	0.19	0.22	0.25	0.28	0.30	0.33
2.00	0.33	0.39	0.44	0.50	0.55	0.61	0.66
3.00	0.50	0.58	0.66	0.74	0.83	0.91	0.99
4.00	0.66	0.77	0.88	0.99	1.10	1.21	1.32
5.00	0.83	0.96	1.10	1.24	1.38	1.52	1.65
6.00	0.99	1.16	1.32	1.49	1.65	1.82	1.98
7.00	1.16	1.35	1.54	1.74	1.93	2.12	2.31
8.00	1.32	1.54	1.76	1.98	2.20	2.42	2.64
9.00	1.49	1.74	1.98	2.23	2.48	2.73	2.98
10.00	1.65	1.93	2.20	2.48	2.75	3.03	3.31
11.00	1.82	2.12	2.42	2.73	3.03	3.33	3.64
12.00	1.98	2.31	2.64	2.98	3.31	3.64	3.97
13.00	2.15	2.51	2.87	3.22	3.58	3.94	4.30
14.00	2.31	2.70	3.09	3.47	3.86	4.24	4.63

TABLE NO. 7

SPRINKLER SYSTEMS - COST COMPARISONS

FOR 125 ACRES

Items	4-4" Diameter Handmove	4-5" Diameter Siderolls	1-7" Diameter Sideroll w/5 Draglines	High Pressure Circular	Low Pressure Circular
Initial Cost	$ 6,800	$18,000	$23,000	$30,000	$30,000
Annual Payment on System (8% - 10 Years)	$ 1,013	$ 2,683	$ 3,428	$ 4,471	$ 4,471
Pumping Cost - 3 Ac. Ft. (Well Lift not Included)	(55 psi) $ 4,744	(55 psi) $ 4,744	(55 psi) $ 4,744	(55 psi) $ 4,744	(30 psi) $ 2,588
Labor - $2/Hr.	$ 6,054	$ 3,027	$ 1,162	--	--
Application Rate - "/Hr.	.3	.3	.4	.1 - 1.0	.1 - 5.0
Total Yearly Operating Cost	$11,811	$10,454	$ 9,334	$ 9,215	$ 7,059
Yearly Cost/Acre	$ 94	$ 84	$ 75	$ 74	$ 56

SPRINKLER SYSTEM PLANNING EXAMPLE

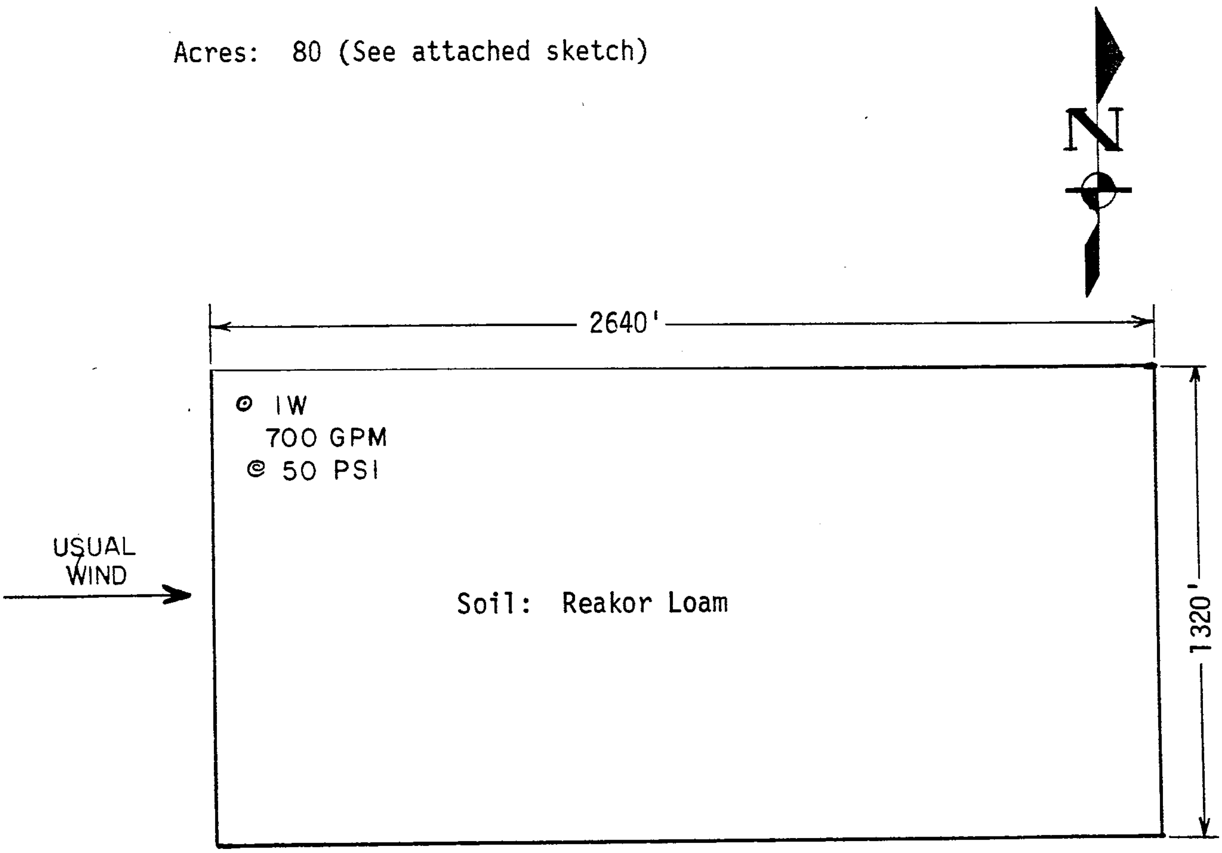
GIVEN

Crop: Grain sorghum

Location: Artesia Field Office

CU: .26 inches per day

Acres: 80 (See attached sketch)



DETERMINE:

1. Proposed main line layout

2. Proposed sprinkler hardware

3. Proposed nozzle size

4. Proposed nozzle pressure

5. Proposed lateral move

6. Proposed application rate - inches per hour

A. Proposed sprinkler hardware and main line layout - The cooperator has decided that, because of the field layout, a circular sprinkler system is not practical and he plans on using a sideroll system. Two alternatives for the main line layout exist:

(a) Run 1,320 feet of main line east from the well, then 1,320 feet of main line south through the middle of the field. This would have the laterals moving in a north-south direction.

(b) Run 2,600 feet of main line east from the well. This would have the laterals running in an east-west direction.

Because the usual wind is shown from the west, the laterals should always be moved at right angles to the wind to allow compensation for wind distortion of the pattern. Therefore, alternative (b) is selected.

From NM-CONS-213, it is found that at 65 percent efficiency and irrigating 22 hours per day, the needed GPM per acre is 8.2, to replace the CU of .26 inches per day.

80 x 8.2 = 656 GPM needed.

Therefore the existing 700 GPM well will suffice for the water needs. It must be emphasized that the well output should be the well output under pressure and not under free-flow conditions.

From Table No.2, it is shown that 2-5 inch diameter side rolls, will handle the 700 GPM flow.

B. <u>Proposed nozzle size</u>

Two 5-inch laterals are proposed. Since the total field length is 1,320 feet per lateral, the lateral length will probably be about 1,270 feet (1,320-50)

With 40 foot nozzle spacing, the number of nozzles per lateral would be $\frac{1270}{40} + 1 = 33$.

Total nozzles per lateral is 33.

Total nozzles on system is 33 x 2 = 66.

GPM per nozzle equals $\frac{700}{66}$ = 10.6 GPM. This is within the guidelines of Table 2.

If the GPM per nozzle exceeds 8-10 GPM, then a double nozzle should be used.

From Table No. 3, a 3/16 X 1/8 nozzle at 50 p.s.i., will produce 10.6 GPM.

4. Proposed lateral move

From Table No. 3, the 3/16 x 1/8 nozzle will have a wetted diameter of 100 feet at 50 p.s.i. With an average wind speed of 10 miles per hour during the irrigation season, Table No. 4 shows that a move of .5D is recommended. This would call for a 50-foot move, but a 60-foot move could probably be used if the lateral sets are staggered every other irrigation.

5. Proposed application rate

The application rate can be found from Table No. 5, or from the following formula:

$$\text{Application rate (inches per hour)} = \frac{96.3 \times (\text{gallons per minute per nozzle})}{\text{sprinkler spacing} \times \text{lateral spacing.}}$$

For 50 foot move: $\text{application rate} = \frac{96.3 \times 10.6}{40 \times 50} = .51$ inches per hour.

For 60 foot move: $\text{application rate} = \frac{96.3 \times 10.6}{40 \times 60} = .43$ inches per hour.

The above example can be expanded on Form NM-ENG-234 to provide a more complete sprinkler system design, but the planner has, using this simple example, discussed enough of the sprinkler details with the cooperator to assure himself that 2-5 inch diameter side roll sprinklers will suffice for the proposed 80 acres of grain sorghum.

CENTER PIVOT SELF-PROPELLED SYSTEMS

Planning Responsibilities:

Currently, the SCS responsibilities in planning center pivot systems are limited to:

1) Assuring adequacy of available water quality and quantity to meet proposed soil and crop needs.

2) Proposing cycle time per irrigation to meet soil and crop needs. (See Table No. 6).

3) Design of main pipeline.

4) Evaluation of existing sprinkler system nozzling and IWM.

In the very near future, SCS personnel in New Mexico will have access to a computer program in Albuquerque that will size center pivot nozzle sizes regardless of nozzle spacing or pivot pressure desired.