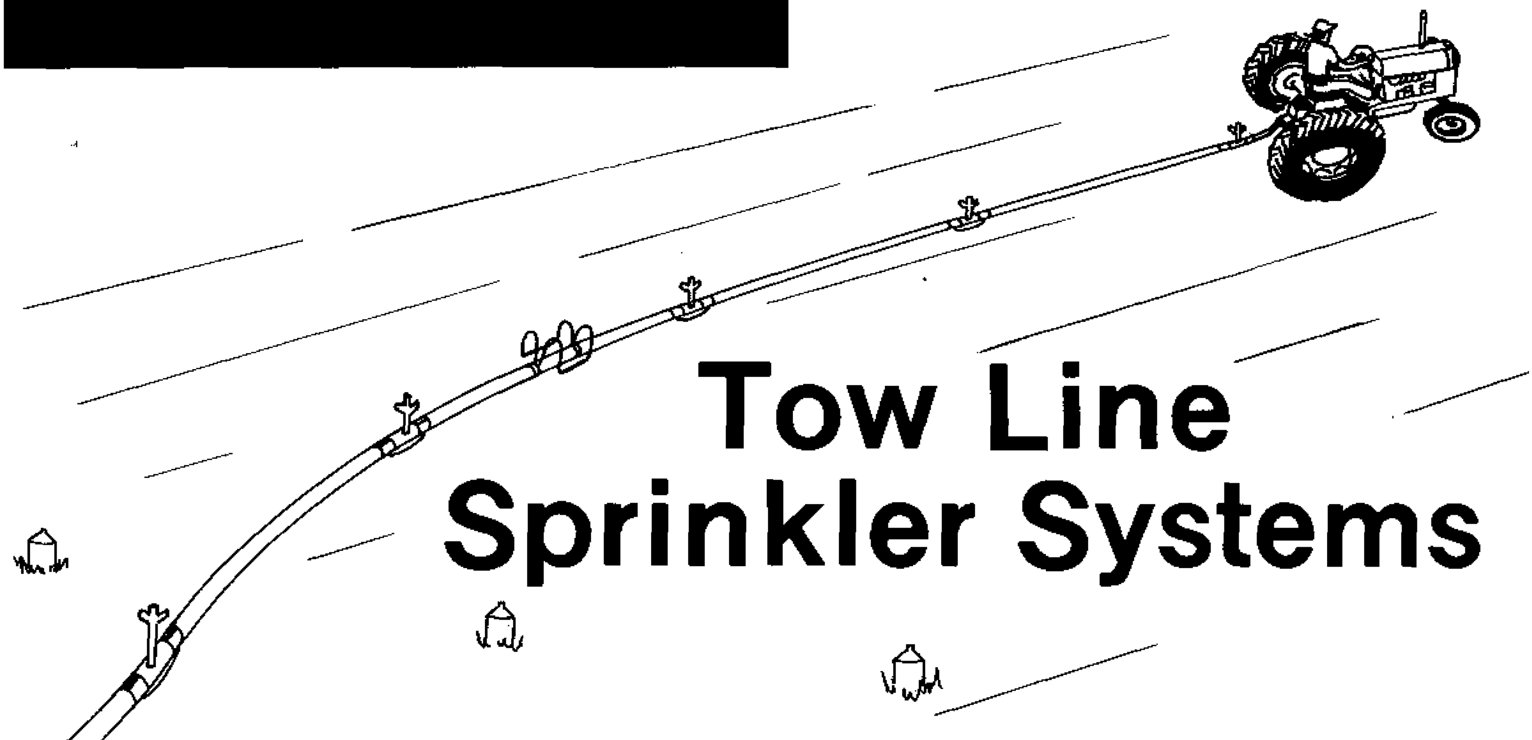
University of Idaho
College of Agriculture
Cooperative Extension Service
Agricultural Experiment Station

Current Information Series No. 222
March 1974



Tow Line Sprinkler Systems

R. A. Kohl, C. H. Pair and D. C. Larsen

A tow line sprinkler system consists of one or more sprinkler laterals made from 30 or 40 foot lengths of sprinkler tubing rigidly connected together. The laterals are towed from one set to the next with a tractor. Excluding the cost of the tractor, which is used for other farm functions, the tow line system is the most economical mechanical move system available and is convenient for pasture, hay and grain crops.

System Description

A tow line lateral usually consists of a quarter-mile length of 4-inch aluminum pipe in 40-foot sections rigidly coupled together. Three inch pipe has been used on short laterals and 30-foot lengths are sometimes used. Sprinklers on risers are located every 40, 60 or 80 feet along the lateral. Risers should be high enough that sprinklers will be above the mature crop. Automatic quick drain valves are located at each coupler to allow rapid drainage of water from the lateral. An empty line requires less force to pull to its next set, reduces wear on the system and eliminates most cutting of ruts into the soil.

Two carriage types are available. One is a skid plate attached at each coupler to slightly raise the pipe off the soil, protect the quick drain valve and provide a wear surface when towing the pipe. Two or three outriggers are required per quarter mile of lateral to keep the sprinklers upright. The other type uses small metal wheels at 40-foot intervals along the lateral to raise the pipe and allow it to be towed easily.

Lateral Movement

The lateral is moved to a new position as follows:

The supply line riser outlet or pump is turned off and the lateral is allowed to drain for 15 to 20 minutes. A time clock can be used to turn off the pump so the lines will be drained when the irrigator is ready to move them. The flexible coupler or hose connector to the mainline is disconnected. A tractor is connected to the end of the lateral nearest the mainline with a tow coupler and a pin or chain.

Fig. 1 illustrates the usual options available in moving laterals with a mainline through the center of the field. When towing the lateral, the driver guides the tractor across the mainline to a new position either one-half (1A) or a full set or lateral move (1B) away from its existing position on the mainline. After reaching the end of the field, the driver inserts a plug in the end of the lateral and returns to the mainline to attach the flexible coupler between the lateral and the mainline valve. The water now enters the lateral at the opposite end from the previous set.

If the mainline is at the end of the field, the lateral can be moved in two pieces and joined in the center with flexible couplers as shown in Figure 2.

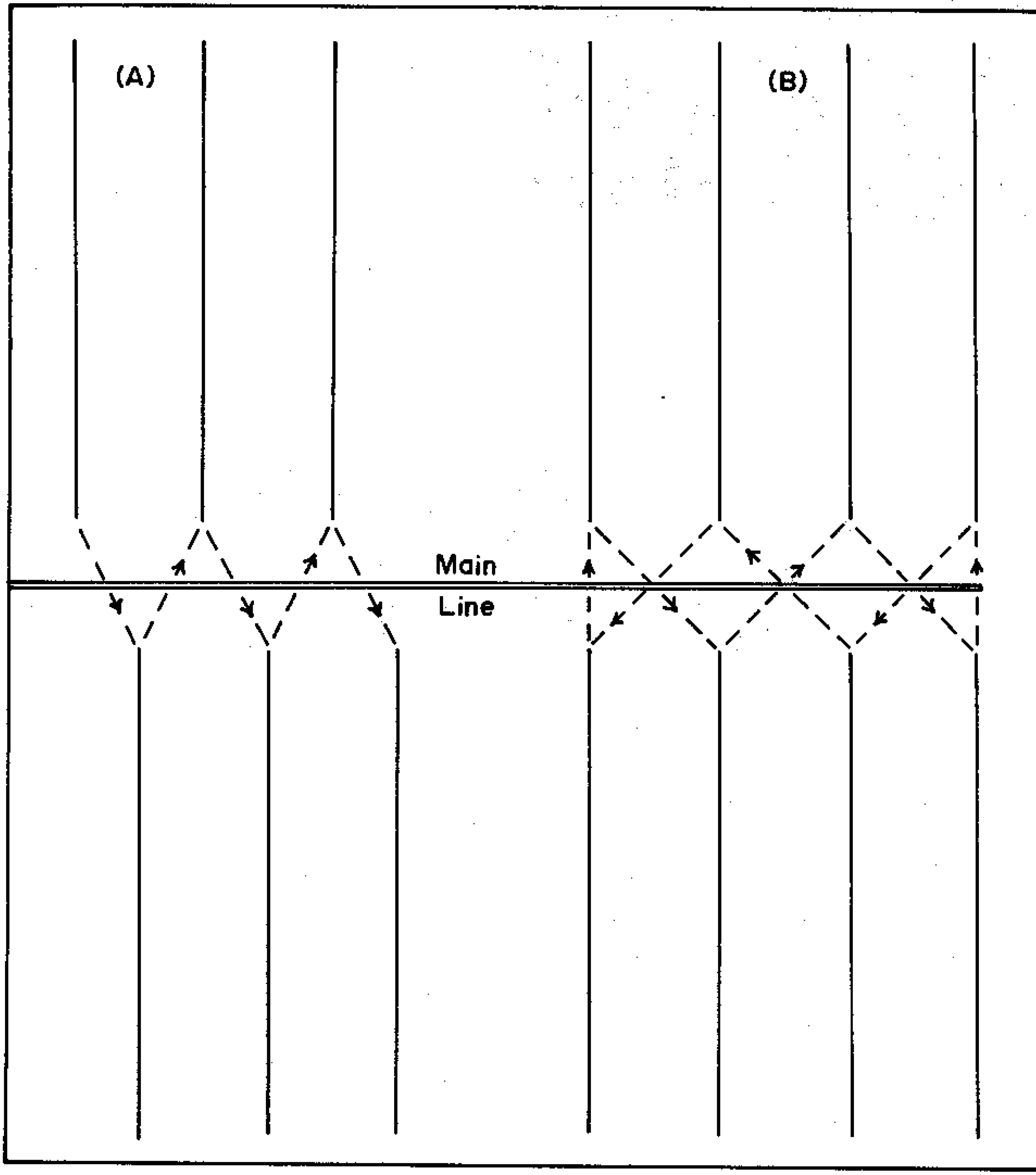


Fig. 1. With the mainline in the center of the field, the tow line can be moved either a half (A) or a full move (B) across the mainline.

The Authors

R. A. Kohl is soil scientist and C. H. Pair is agricultural engineer, Snake River Conservation Research Center, ARS-USDA, Kimberly. D. C. Larsen is extension irrigationist, University of Idaho Cooperative Extension Service. *The authors acknowledge the assistance of several farmers and dealers in southern Idaho who contributed information to this publication based on their experiences with tow line systems.*

Usable water storage x **rooting depth** = **Total usable storage**

For example, if alfalfa is being raised on a sandy loam soil with 3 feet of soil over bedrock, one obtains:

1.0 inch per foot x **3 feet** = **3.0 inches usable water storage**

If the usable water storage is now divided by the effective application rate, the time to fill the root zone is obtained:

$$\frac{\text{Usable water storage}}{\text{effective application rate}} = \text{time to fill root zone}$$

For the example, using an effective application rate of 0.22 inch per hour, the time required fill the root zone on the alfalfa crop would be 13.5 hours.

$$\frac{\text{3.0 inches}}{\text{0.22 inch per hour}} = \text{13.5 hours}$$

This would cause an inconvenient schedule. To work into the farming schedule, moves are made on a 12 or 24 hour interval less the move time. In this case an 11.5 hour schedule would be used.

The amount of water applied per irrigation is equal to the effective application rate times the time per set.

Effective application rate x **hours per irrigation** = **depth of water applied**

In this example:

0.22 inch per hour x 11.5 hours = 2.5 inches.

The number of days between irrigations during the peak use period is obtained by dividing the amount of water applied per irrigation by the peak consumptive use per day for the crop at the farm location (Table 1).

$$\frac{\text{water applied per irrigation}}{\text{peak use per day}} = \text{number of days between irrigations}$$

If the farm in the example were located near Pocatello, the peak use of alfalfa would be 0.30 inch per day. Then the irrigation interval during this period would be 8 days.

$$\frac{\text{2.5 inches}}{\text{0.30 inch per day}} = \text{8 days}$$

The area irrigated per lateral can be determined by multiplying the area covered per set by the number of sets and dividing the total by the area of an acre. With a 1300-foot lateral and 60 foot moves, the lateral will irrigate 78,000 square feet per set. In 8 days, it will irrigate 16 sets or 16 x 78,000 — 1,248,000 square feet. Since an acre contains 43,560 square feet, each lateral will irrigate 28.6 acres (1,248,000 ÷ 43,560 = 28.6).

Operational Problems

Tow line systems can operate over a wide range of surface topography. Sharp, cutup surfaces do require more outriggers to keep the system upright and increase the possibility of pipe breakage by causing greater strain on the pipe. However, tow lines have been operated satisfactorily on fields too rough for other mechanical move systems. More skid plates may be desirable under these conditions.

The tractor driver must make a gentle curve as he moves the lateral across the mainline toward the new position. Turning too short will kink the pipe, a frequent type of damage to the system. Raising the end of the pipe with the tractor hitch helps to alleviate this problem.

While skid plates or wheel dollies support the pipe at regular intervals, the pipe slides over the soil surface between these points. This soil contact causes pipe wear, especially on exposed sandy soils. Some systems are constructed to allow for pipe rotation to distribute wear around the pipe. The pipe should be rotated every 2 to 5 years, depending on manufacturer and soil conditions. One procedure is to rotate the pipe 180° so that the opposite side of the pipe touches the soil, turn back a quarter at the next rotation, then rotate 180° again. For maximum pipe life, follow the manufacturer's recommendation on pipe rotation.

Frequently, tow line systems are used on pastures where cattle are grazing. Cattle do not seem to bother operating laterals but they have damaged risers and sprinklers left in the field between irrigations. Loosening the bolts on the stabilizing outriggers and laying the sprinklers on the ground will minimize this damage. The use of short risers, 1 foot or less, on pastures appears to reduce damage if the lines are left upright.

Attaching the tractor to the system usually requires driving onto wetted soil. With heavy crop cover and soils with good support, this may not pose a problem. Where traction or rutting is a problem, two alternatives can be used. Some operators plug or stop the first sprinkler, thus not irrigating the field along the mainline. While this solves the problem, some crop is lost in this area. Another solution is to attach a chain or cable to the line, pull it out of the wet area and then attach the line directly to the tractor. This procedure requires a little more time but solves the problem without crop loss. The tractor wheels damage some of the crop. However, this is usually more than compensated for by labor saved in moving lines.

By using automatic quick drain valves and allowing 15 to 20 minutes drain time, a small (20 to 30 horsepower) tractor can move the system. However, the temptation exists — especially with hired labor — to use a large tractor at high speed, and to move the systems before drainage is completed. This greatly increases the possibility of pulling the lateral apart, particularly where there is a chance of catching skids or wheels in rocky areas.

Tow lines have worked well in rocky fields after rocks are cleared from the tow path. Rock outcroppings near the mainline present problems if the pipe must be moved diagonally across them. Either the outcroppings must be leveled or the pipe must be lifted over them.

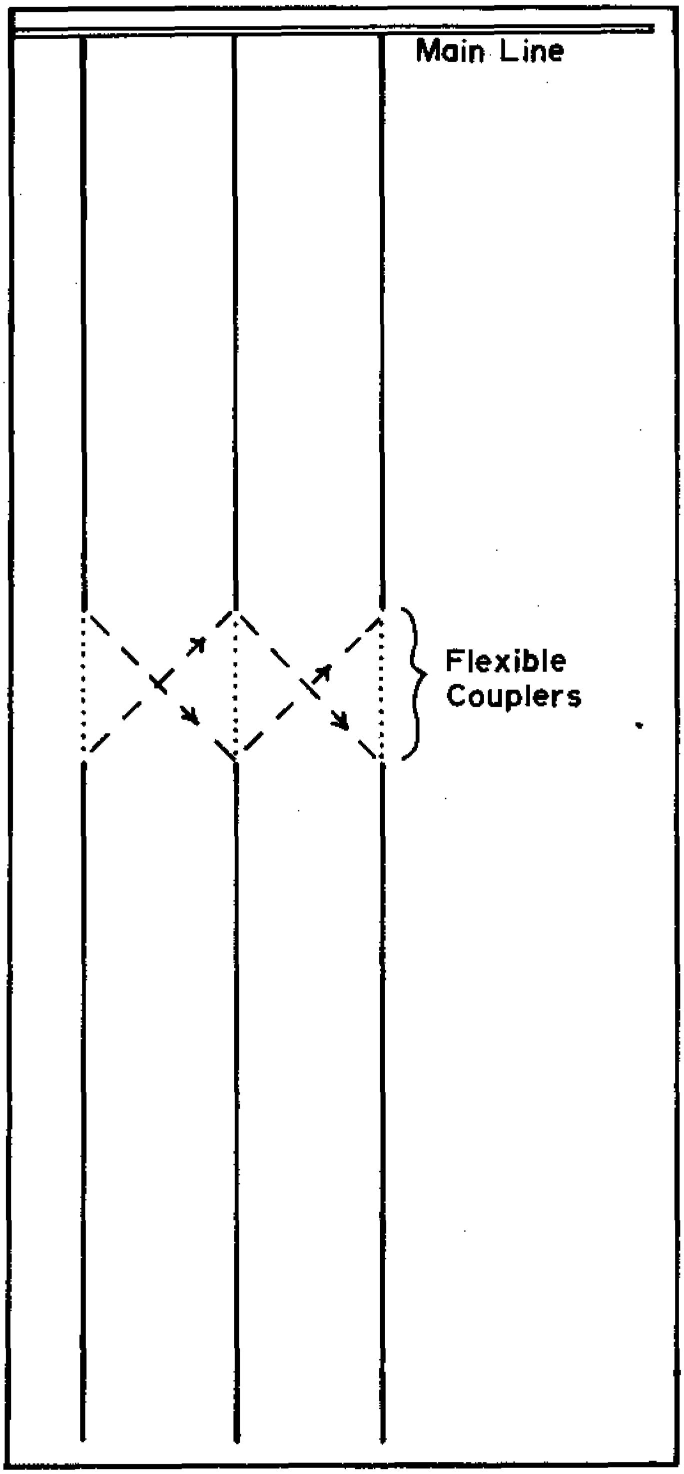


Fig. 2. When the mainline is located at the end of the field, the tow line must be split in the center and moved as two pieces. The two outer ends are then coupled in the center.

System Design Characteristics

Water Supply Requirements

The design of a tow line system depends on the water use by the crops to be grown. Table 1 lists the average peak crop water use for alfalfa in inches per day for different areas of Idaho and the design water requirements in gallons per minute per acre for two design efficiencies. Since alfalfa is one of the crops most frequently grown under tow lines, it may be used for design. The peak water use of grain and pasture crops is about 10% less than that of alfalfa. Most systems can be designed using the 70% figure if winds are not excessive. For every mile per hour of average wind speed over 5 miles per hour, the design efficiency should be lowered 1%. Thus, with an average 10-mile-per-hour wind, the design efficiency should be 65%.

The design water requirement listed in Table 1 should provide sufficient water to meet peak water requirements in most years. Where insufficient water is available, the system may be designed for the water available with the expectation of reduced yield. Another solution would be to raise crops whose periods of peak requirements do not coincide. For example, grain may be grown under the same irrigation system with alfalfa and pasture. As the grain crop approaches maturity, the tow lines may be moved to the alfalfa and the pasture to meet their peak requirements.

A farm completely devoted to pasture and alfalfa will require a larger peak flow of water than farms with mixed crops in the same area.

Table 1. Peak water requirement for alfalfa at different Idaho locations and the corresponding design water requirements in gallons per minute per acre at two application efficiencies.

Area	Peak water requirement	Design water requirement: 70% efficiency	Design water requirement: 65% efficiency
	(inches/day)	(gallons/minute/acre)	
Bonners Ferry	0.25	6.7	7.2
Caldwell	0.33	8.9	9.6
Council	0.29	7.8	8.4
Dubois	0.28	7.5	8.1
Grand View	0.34	9.2	9.9
Grangeville	0.29	7.8	8.4
Idaho Falls	0.29	7.8	8.4
Lewiston	0.34	9.2	9.9
Moscow	0.29	7.8	8.4
Pocatello	0.30	8.1	8.7
Twin Falls	0.33	8.9	9.6

Mainline Design

The mainline should be laid in a ditch or completely buried to facilitate towing the lateral across it. Mainline risers should be installed in line with lateral sets. Then the lateral would be towed across the mainline between risers.

Occasionally tow lines are installed on existing mainline systems at different spacings than the riser outlets. In this case, short posts or similar guards which do not catch the outriggers should be placed near the riser outlet to avoid damage caused by contact between the towed lateral and mainline riser. A portable mainline may be installed in a trench deep enough to place the risers below the soil surface to avoid scraping the lateral on the riser.

Lateral Design

When possible, the mainline should be laid across the center of the field. The laterals will then be half the length of the field. On fields with nonparallel sides, a few lengths of hand line can be added to the tow line to complete the field, but adding hand lines detracts from the mechanical move feature of the tow line. One system uses a quick release coupler clamp to join pipe lengths. This allows the irrigator to easily drop lengths of pipe when irrigating nonrectangular fields.

The selection of sprinkler spacing on the lateral, distance between lateral sets, sprinkler type, pressure and nozzle size are normally determined by a combination of economic, climatic and soil factors. With average windspeed less than 5 miles per hour, sprinkler manufacturers recommend that the maximum spacing of sprinklers along the lateral not exceed 40% of the diameter of coverage of the sprinkler and 65% of the diameter between laterals.

Medium-size agricultural sprinklers with 5/32, 11/64 or 3/16-inch nozzles, operated at their recommended pressure of 50 to 60 psi, have a diameter of coverage from 90 to 100 feet and are usually used on 40 by 60 foot spacings on tow lines.

Larger agricultural sprinklers with 7/32, 1/4 or 9/32-inch nozzles, operated at recommended pressures of 60 to 70 psi, have a diameter of coverage from 130 to 150 feet and should be used on a 60 by 80 foot spacing. These sprinklers are sometimes used at 80 by 80 foot and 80 by 90 foot spacings, although these exceed the manufacturers' suggested limits and are accompanied by poorer water distribution and yield reductions.

Generally, it is advisable to purchase a pump and mainline that are large enough to slightly exceed these recommended pressures so that system wear does not cause reduced water application efficiency in the future.

The choice between 60 and 80 foot moves involves a trade-off between smaller nozzles which require more laterals per farm, more moves per season and more tow paths as opposed to larger nozzles which require more pressure with an accompanying larger motor and increased power costs. Estimates of the comparative costs of irrigating the farm with the two spacings for one season will help in making the decision.

Sprinkler Size Selection

After the selection of sprinkler spacing and pressure, a nozzle size is selected that will apply water at a rate equal to or less than the infiltration rate of the soil. If the infiltration rate is exceeded, water will run off the slopes, leaving dry areas and creating wet spots in low places. The results will be decreased crop production, fertilizer leaching in low spots and possible soil erosion.

The sprinkler application rate at 100% efficiency can be obtained from sprinkler manufacturer's tables if the nozzle size, pressure and spacing are known. This value is multiplied by the application efficiency (for example 70% for low wind conditions) to arrive at the effective application rate.

Application rate at 100% x **application efficiency** = **effective application rate**

As an example, consider a 40 x 60 foot spacing with 3/16-inch nozzles operated at 60 psi. The application rate at 100% efficiency would be 0.32 inch per hour. The effective application rate would be:

0.32 inch per hour x 0.70 = 0.22 inch per hour.

The extra 0.10 inch per hour falls as spotty excess water due to sprinkler patterns.

The usable storage capacity depends on the crop, its rooting depth and the water holding capacity of the soil. Potatoes, beans and some other row crops are sensitive to water stress and yield can be reduced when more than 40% of the available water is depleted. Grain, pasture and alfalfa are more tolerant to water stress and can use 60% of the available water before production is seriously affected.

Table 2 indicates the approximate total water-holding capacity per foot of soil for various soil textures. The right-hand column indicates the approximate usable storage per foot of soil for hay and grain crops and can be used to estimate the amount of water available to the crop. The value in the right-hand column for the soil texture in the field must be multiplied by the rooting depth of the crop to obtain the total inches of readily available water in soil storage.

Table 2. Available water at field capacity and usable water storage for alfalfa and grain in soils of different textures.

Soil texture	Total available water at field capacity in inches per foot of soil	Usable water storage in inches per foot of soil
Sandy	0.8	0.5
Loamy sand	1.0	0.6
Sandy loam	1.7	1.0
Loam	2.0	1.2
Silt loam	2.2	1.3

A recommended practice when using 12-hour sets is to use an odd number of lateral sets in returning to the same location. Thus, alternate sprinklings at the same location will be made during the day one time and at night the next irrigation. Because winds are usually less at night, this practice increases the uniformity of cumulative applications and helps prevent the development of wet or dry spots.

The movement pattern used to return a system to its original position most conveniently consists of skipping every other set and filling them in on the trip back to the starting position (Fig. 1B). This pattern requires an even number of sets. The use of an odd number of sets or the half shift as in Fig. 1A usually requires taking the lateral apart after the last set and moving it back to the head of the field.

Cost

Quarter-mile tow line laterals complete with flexible couplers, sprinklers and end plugs cost about 165 to 170 percent as much as a hand line and 46 to 48 percent as much as a sideroll or wheel move lateral. If a hand line cost $1,000, a tow line would cost about $1,650 to $1,700 and a sideroll about $3,500. This does not include the cost of the pump and motor, water and mainline with riser outlets. If a tow line system with 80-foot moves between lateral sets is compared to the other systems with 60-foot moves, a larger pump and motor will be needed to increase line pressure 15 to 20 psi.

A good farm manager will consider the annual overhead costs of depreciation, interest on investment and insurance together with the annual operating costs of labor, power, maintenance and interest on operating capital.

The disadvantage of the tow line system is the damage done to row crops in the turning area. As a result, turning areas are usually planted to alfalfa. Tow lines work best in rectangular fields.

The major advantages of tow lines are their low cost for a mechanical move system and their ease and speed of movement.

Published and Distributed in Furtherance of the Acts of May 8 and June 30, 1914, by the University of Idaho Cooperative Extension Service, James L. Graves, Director; and the U.S. Department of Agriculture, Cooperating.

4M 3-74