CHANGING FROM CONTINUOUS FLOW IRRIGATION TO CABLEGATION OR SURGE IRRIGATION

Israel Israeli
Department of Agricultural and Chemical Engineering
Colorado State University
Fort Collins, Colorado 80523

To properly apply graded furrow irrigation, some cut back method or tail water reuse systems are needed. The cut back practice is labor intensive and difficult to implement because the flow relieved by the cut back is only sufficient for advance on partial sets. Tail water reuse systems are expensive to install, require additional energy and take land for the tail water reuse pit. A possible answer to these problems is using the relatively new methods of surge irrigation or cablegation. Graded furrow irrigation efficiencies can be improved significantly with a relatively low investment by converting to surge irrigation or cablegation.

SURGE IRRIGATION

Surge irrigation is the intermittent application of water to furrows in a series of surges of constant or variable time spans. Usually the water is alternated between two sets of furrows until the irrigation is completed. Surge irrigation, in its modern form, is a relatively new irrigation technique and was first introduced by Utah State University (Stringham and Keller, 1979). However, the phenomenon of surge irrigation has been known to irrigators for more than two decades. Many irrigators found it impossible to complete the advance phase of furrow irrigation following a major cultivation because of the high water intake rate. They discovered that the advance phase could be completed by interrupting the stream furrow flow and then reapplying it hours or days later--a practice sometimes called "bumping."

Surge irrigation can be applied manually by alternating water between two sets of furrows. However to obtain full advantage of the surge phenomenon, more than several surges are needed and labor becomes prohibitive. In today's typical installation, surge irrigation is applied by using automatic "surge valves" or "surge gates" located between two sets of gated pipes (Figure 1) or two basins of a concrete ditch (Figure 2). Water is alternated between the right side and left side of the surge valve or surge gate. By alternating the water between the two sides, a series of on and off times is created and each furrow receives water during the on time; while during the off time, the water is shut off, and is turned on to the other side. The time span of each surge can vary according to field and soil characteristics. Water is alternated between the two sets of furrows until irrigation is completed.

Surge irrigation is composed of two phases: advance and cutback. The advance phase is the phase in which water is advanced to the end of the dry furrow. Usually advance takes four to six surges to complete depending on the field length, soil characteristics and stream size. The cut back phase is the phase in which the required irrigation depth is applied. The cut back in surge irrigation can be accomplished in several ways. Description of the phases of surge irrigation and determination of on-times can be found in Israeli (1988).

CABLEGATION

Cablegation is a system of gated pipe in which the gated pipe is used as both the supply and distribution pipe. The gated pipe is sized large enough to carry the available flow without filling the pipe's cross section. The main idea of cablegation is automation of both changing sets and the cut back procedure in gated pipe irrigation. Automation of gated pipe irrigation is achieved by leaving open holes (gates) positioned 30° from vertical and letting a travelling plug, which restricts the water from flowing behind it, to open one gate at a time. Actually starting and shutting off gates is done by the rise and decline of the water level in the gated pipe as shown in Figure 3. Water flows in the gated pipe below the open gates until it reaches the plug and starts to back up behind the plug. The section of the gated pipe upstream from the plug fills with water which flows out of the holes (gates).

Since flow is only sufficient to partially fill the pipe and the pipe is laid on a descending slope, the water level in the pipe drops gradually and the pipe becomes partially full at a certain distance upstream from the plug. At the point where the water level drops below the hole (gate), water flow from this gate stops. A unique characteristic of cablegation is that the flow from each hole starts at a maximum rate and gradually decreases with time to zero. Therefore, a continuous cut back effect is applied automatically. A complete description of cablegation can be found in Kemper et al. (1983).

The following table lists and compares the advantages and disadvantages of cablegation and surge irrigation compared to continuous furrow irrigation.

CABLEGATION	SURGE IRRIGATION
1. Reduced deep percolation at the upper end of the field because of cut back. If the system doesn't have a positive cut off, then deep percolation can be increased.	1. Faster advance to the end of the field and therefore reduced deep percolation at the upper end of the field.
2. Reduced tail water because of cut back.	2. Reduced tail water because of cut back.
3. Allows lighter application of water.	3. Allows lighter application of water.
4. Improves water distribution uniformity along furrows.	4. Significant improvement of water distribution uniformity along furrows.
5. Water savings of 20-30% as compared to continuous furrow irrigation.	5. Water savings of 30-50% as compared to continuous furrow irrigation.
6. Labor savings by eliminating the need to change sets.	6. Labor savings depends upon the number of valves used.
7. Requires preparation and precise installation and fine tuning.	7. Doesn't require special preparation or precise installation. Fine tuning can be easily achieved.
8. Requires higher level of management.	8. Requires higher level of management.

INSTALLATION

Surge and cablegation systems can be installed as portable (non-permanent) systems. However to fully obtain the advantages of cablegation, a precise installation is required. Temporary, unprecise installation of cablegation will result in uneven water distribution along the gated pipe. Surge irrigation implementation, however, usually doesn't require any special preparation and is straightforward. Implementation of surge irrigation in concrete ditches is usually simple in ported ditches, but requires special preparation in other concrete ditches.

Surge

Gated pipes are needed to implement surge irrigation. Implementation of surge with gated pipe irrigation systems is straightforward. In other surface irrigation systems, gated pipe will have to be acquired. However any type of gated pipe can be used including the inflatable plastic tubes which are inexpensive to purchase. Other than gated pipes, only the surge valve is needed. Surge valves are manufactured by several companies. A typical valve has a controller powered by a battery recharged with a solar panel. The valve can be located in the middle of two sets of gated pipe as shown in Figure 1 or at the upper end of the field and a delivery pipe must be used to supply the lower set of gated pipes as shown in Figure 3. The valve can be located in the middle of two sets on a cross slope if rigid gated pipe is used and the water pressure is high enough to allow even water distribution on both sides.

Implementation of surge irrigation in concrete ditches is depicted in Figure 2. In ported ditches only a surge gate is needed. In other concrete ditches, notches need to be made at adjusted levels. The gate can be controlled by the same controller that is used for the surge valves. All surge controllers manufactured today are programmable and capable of executing several different programs. A program means a sequence of on times and off times for each side or in other words, when to change sides. Programming the controller is as simple as programming a microwave oven. Some programs require only one input from the user. Surge irrigation can also be implemented on farms which have earthen ditches. Water can be delivered from the ditch to a surge valve via a pipe installed in the ditch bank.

Cablegation

A cablegation system is composed of several components as shown in Figure 3. The main component is a control box which can be an integral part of the irrigation system such as a concrete diversion box or a portable metal box. A speed regulated reel is an essential part of the control box, and its function is to control the speed of the plug which travels in the gated pipe. A rigid gated pipe must be placed on a precise down slope grade. The discharge from each gate depends on the hydraulic head which decreases continuously upstream from the plug. Cablegation systems are very sensitive to variations from the designed grade. Therefore cablegation systems should be implemented as a permanent installation to obtain the full advantages of the system. However, pipes placed on steep slopes can tolerate more variation from the designed grade than those placed on flat slopes. Although it is not essential, cut off valves or specialized siphon tubes are recommended for use as gates to prevent prolonged water dribbling as flow from gates decreases.

A design for a portable control box is available which can be built in any metal shop and can be used with existing gated pipe. This type of portable implementation can be achieved with minimum expense. However, the pipe must be placed on a precise grade if the slope is less than 0.5 percent. Placing the gated pipe on a precise grade will insure uniform water distribution along the gated pipe, i.e., each gate will discharge equal amounts of water.

COMPARISON OF SURGE AND CABLEGATION TO CONTINUOUS IRRIGATION IN COLORADO

Surge irrigation and cablegation were compared to continuous furrow irrigation in several locations in Colorado. At the Thompson Valley Young Farmers Educational Farm, intensive data collection was done. Four irrigation systems were installed on the two fields as shown in Figure 5. Water inputs and outputs to the different fields were measured during each irrigation event. Water inflows and outflows in individual furrows were checked in some irrigation events and yield samples were taken at the end of the season. Estimates of the labor required to operate the different systems are shown in Table 1. Water applied by the different irrigation systems, water used by the crop, irrigation efficiencies and yields are shown in Table 2.

Labor required to operate cablegation and surge irrigation was less than continuous irrigation. However when first installing new technology such as surge or cablegation, more labor is required to fine tune and adjust the system to local conditions. Water application efficiencies were higher with surge irrigation while crop water use efficiency was highest with the cablegation system. The north field with continuous irrigation produced the highest yields probably because it has the best soil and has the smallest slope on the farm. More detailed discussion of the results from the comparison of surge and cablegation to continuous furrow irrigation can be found in Israeli (1988). A significant energy and water savings by surge irrigation was observed by Mr. Larry Beckman from Idalia, Colorado. During the 1987 growing season, he used one surge valve to irrigate corn. The water source was a deep well. He immediately observed that with the same flow, 160 rows could be irrigated instead of 120 rows that were normally irrigated with continuous irrigation. According to Mr. Beckman, his power meter showed a reduction of 71,000 Kwh as compared to previous years.

REFERENCES

Israeli, I. 1988. Surge Irrigation Guide. Extension Bulletin, Cooperative Extension, Colorado State University, Fort Collins, Colorado.

Israeli, I. 1988. Comparison of surge and cablegation to continuous furrow irrigation. ASAE Paper No. 88-2014. Presented at the Summer Meeting, Rapid City, South Dakota.

Kemper, W. D., D. C. Kincaid, R. V. Worstell, W. H. Heinemann, Tom Trout, J. E. Chapman, F. W. Kemper, and M. Wilson. 1983. Cablegation Type Irrigation Systems: Description, design, installation and performance. USDA-ARS Western Regional Handbook.

Stringham, G. E. and Jack Keller. 1979. Surge flow for automatic irrigation. Proc. 1979 Irrigation and Drainage Division Speciality Conference, Albuquerque, New Mexico. July.

TABLE 1. Labor required for the Thompson Valley Young Farmers Educational Farm.

Method	No. of irrigations	Labor per irrigation (hours)	No. of sets	Area acres	Labor per irrigation (hours/acre)
Surge	9	6	2	12.2	0.49
Continuous North	6	6	2	10.0	0.6
Cablegation	11	2	1	9.0	0.22
Continuous South	6	9	3	13.0	0.69

TABLE 2. Irrigation water applied and yields at the Thompson Valley Young Farmers Educational Farm.

	Gross water applied (in/acre)	Net water applied (in/acre)		Crop water use (in)	Average efficiency (%)		Yield (bu/acre)	
		Irr.	Rain	AET	Applic.	Crop water use	Hand sample	Avg. of irrig. area
Surge	30.0	25.2	6.2	21.6	85	.60	154	128
Continuous North	62.5	34.4	6.2	20.6	55	.30	165	148
Cablegation	22.4	16.8	6.2	20.8	75	.73	156	104
Continuous South	45.0	20.3	6.2	19.9	45	.39	130	91

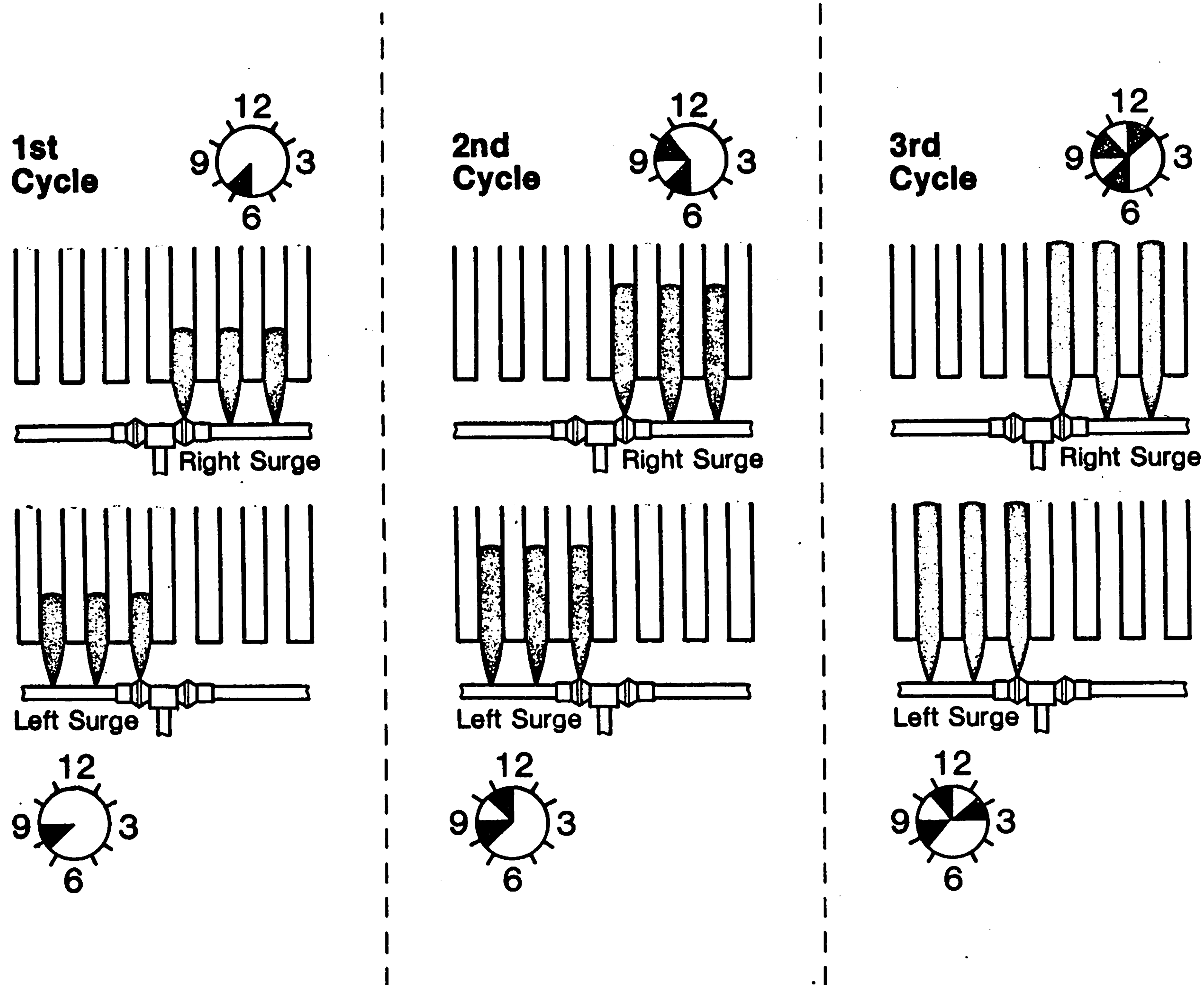

FIGURE 1. Surge valve in the middle of two sets of gated pipes.

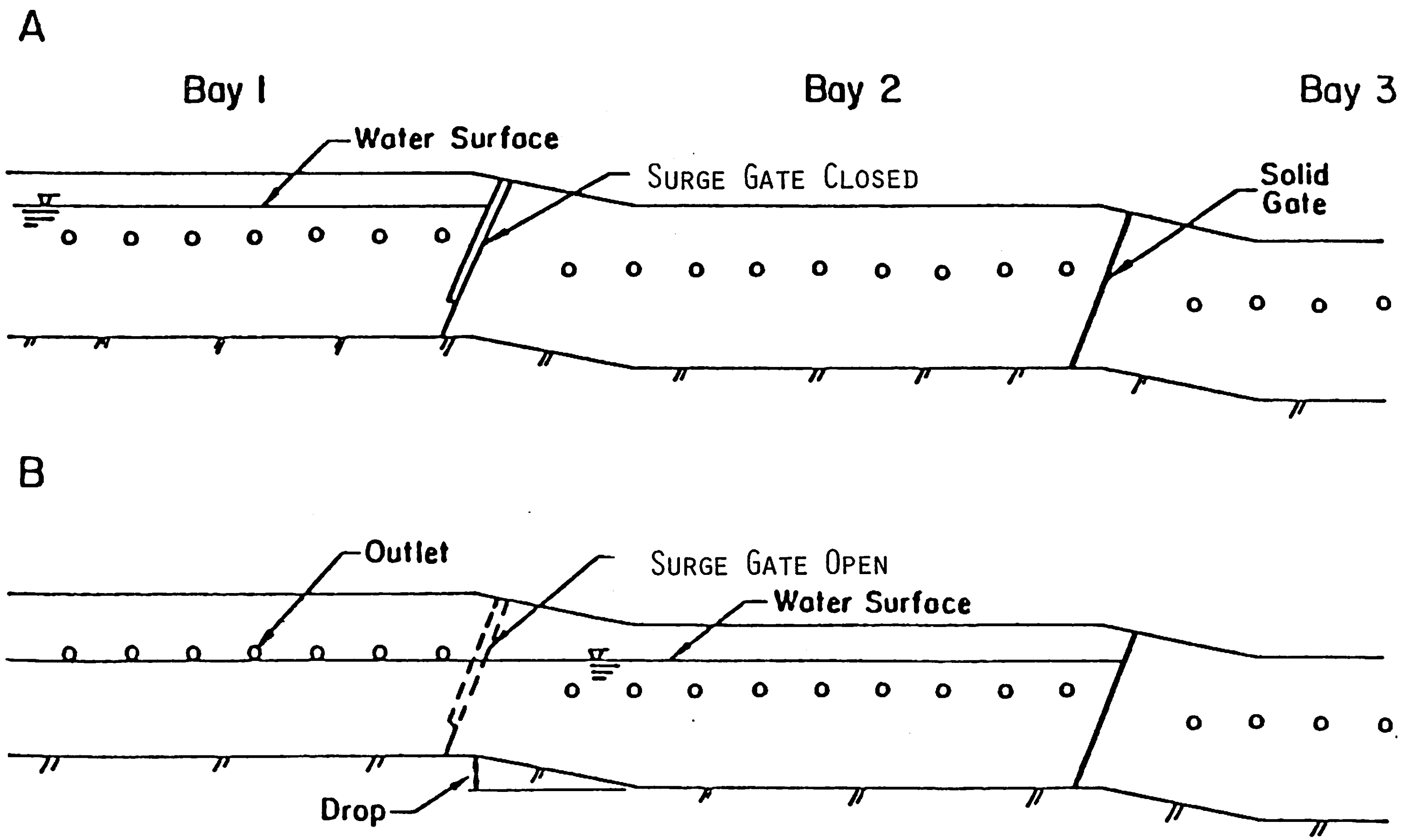

FIGURE 2. Schematic diagram of applying surge in concrete ported ditches.

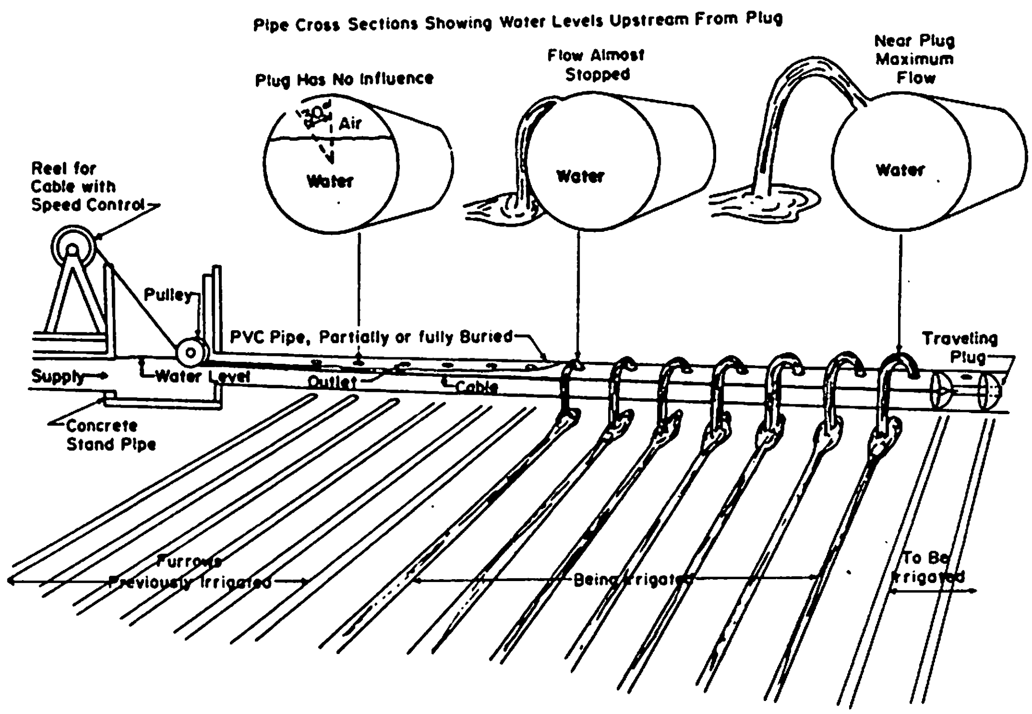

FIGURE 3. Layout and components of a cablegation system (Kemper et al., 1983).

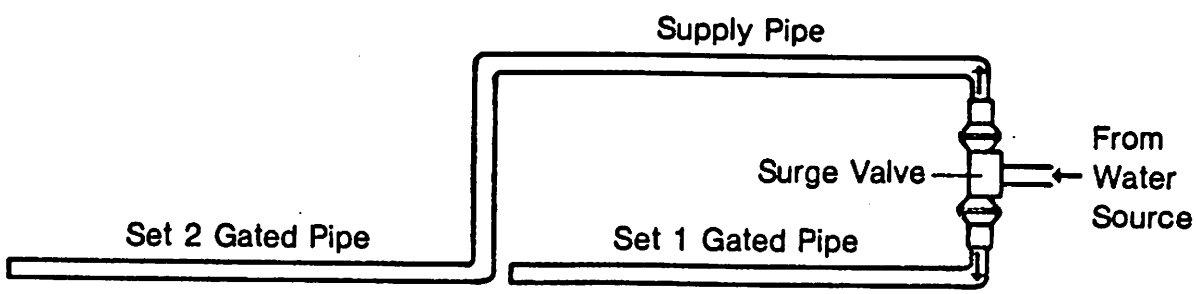

FIGURE 4. Locating the surge valve at the upper end of the field.