Texas A&M AgriLife Extension

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Surge Flow Irrigation

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Surge flow irrigation has the potential to increase furrow irrigation efficiencies to levels usually associated with sprinkler and drip irrigation systems. This is possible because surge irrigation is more often efficient and can achieve faster water advance down the furrow than conventional furrow irrigation. In some cases, you can—with the same amount of water—irrigate twice the area at the same time by using an automatic surge valve.

In many situations, surge allows you to apply more precise levels of water. Instead of applying 4 to 6 inches, as you may with conventional furrow irrigation, you can put out as little as 1 to 2 inches.

For most soil types, surge reduces the volume of water needed during the first few irrigations following tillage. Its effectiveness on subsequent irrigations has varied. Surge typically improves efficiencies from 8 to 30 percent.

However, it is difficult to predict whether it will work for a particular field and situation. Adequate furrow stream (flow rate per furrow) is also necessary to see benefits.

So how does surge work?

In surge, water is applied in a series of on-off cycles or watering periods. Applying the water in timed cycles:

- increases the rate of water advance down the furrow
- reduces deep percolation losses
- increases the uniformity of the wetting front along the furrow
- produces a more even depth of water penetration into the soil

Why does alternating on-off cycles of water increase furrow irrigation efficiencies? The prevailing view is that there are two factors involved: surface sealing and intake rate. In many soils, once wetted, a surface seal forms as it dries out. Also during irrigation, the soil intake or infiltration rate decreases as the soil moisture level increases. Soil roughness is also a factor. The largest benefits of surge irrigation occur during the first few irrigations following tillage when the soil is still rough. Air entrapment during the wetting cycle may also contribute to the faster advance times seen with surge.

Surge system components, configuration, and operation

In a typical surge irrigation setup, a surge valve is used to alternate water between 2 sets of gated or poly pipe in a series of on-off cycles or watering periods.

Figure 1 shows the internal operation of a surge valve to alternate water to the right or left side of the valve. A typical surge irrigation setup is shown in Figure 2.

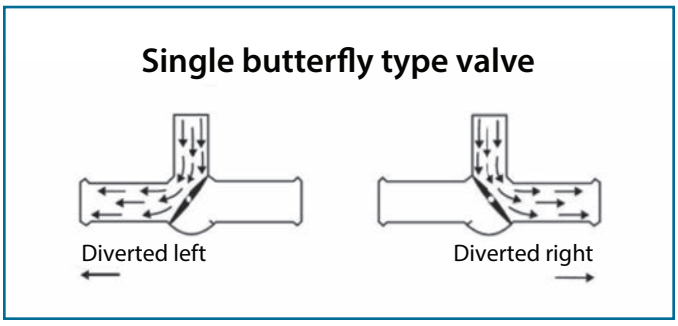

Figure 1. Surge flow valve.

Diagram of a split-set gated pipe system used in surge flow irrigation. Flow is alternated from side to side.

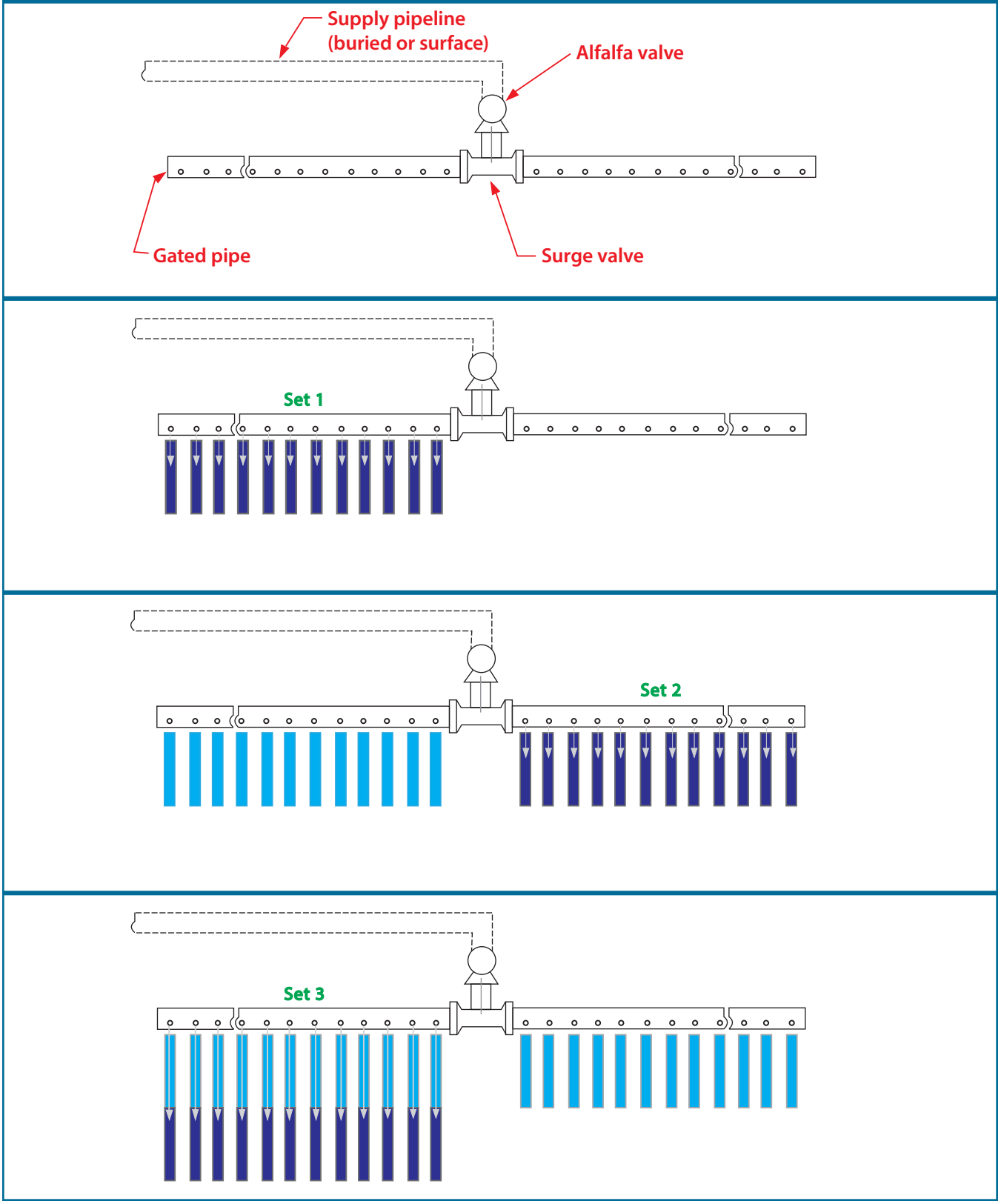

Figure 2. Typical surge flow set up as a split-set gated pipe system used for surge irrigation. Flow is alternated from side to side in on-off "cycles."

Equipment

There are two major manufacturers of automatic surge flow valves in the USA. Automatic surge valves are simple devices that consist of a valve, a programmable controller, a battery, and solar cell recharging panel (Fig. 3). Figure 4 shows the base unit of the surge valve. Each manufacturer has several different controllers with varying capabilities which sit on top of the base unit.

Surge valves come in several sizes as shown in Table 1. You should size your surge valve according to the flow that you have available. The larger valves can be quite heavy.

Table 1. Size, capacity, and weight for US manufactured surge valves.

Pipe size	Max GPM	Weight
4″	300	19 lbs
6″	700	31–37 lbs
8″	1200	44–46 lbs
10″	2000	50–54 lbs
12″	2600	67–90 lbs

Figure 3. One of two automatic surge valves manufactured in the US shown in use with plastic gated pipe during start-up.

Figure 4. Several different controllers with varying capabilities are available which sit on top the surge valve base.

Gated pipe and poly pipe

Surge is used with gated aluminum, plastic and poly pipe. With gated pipe, it is easy to balance flow to all furrows by simply adjusting each gate to the correct opening size. For poly pipe, it is important that the holes be punched precisely to achieve the targeted furrow stream size (gpm per furrow). Poly pipe manufacturers have on-line guides and soft-

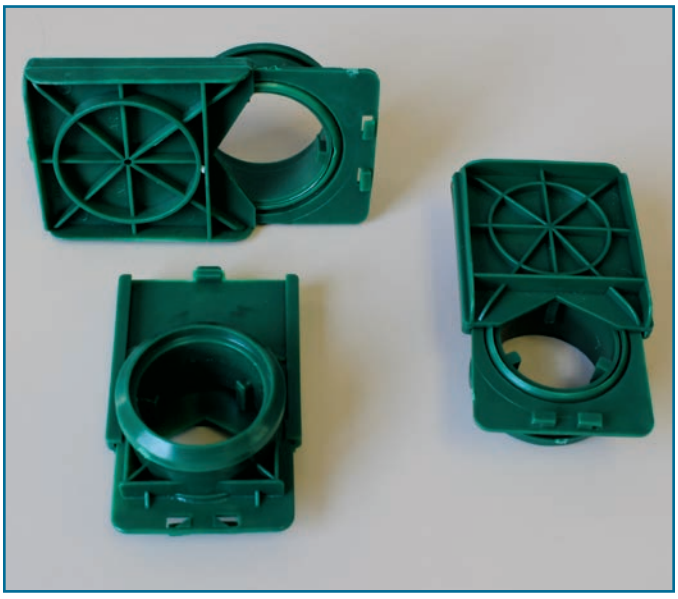

Figure 5. Recommended adjustable plastic gates that can be inserted into polypipe to balance flows in rows to improve the uniformity of furrow irrigation.

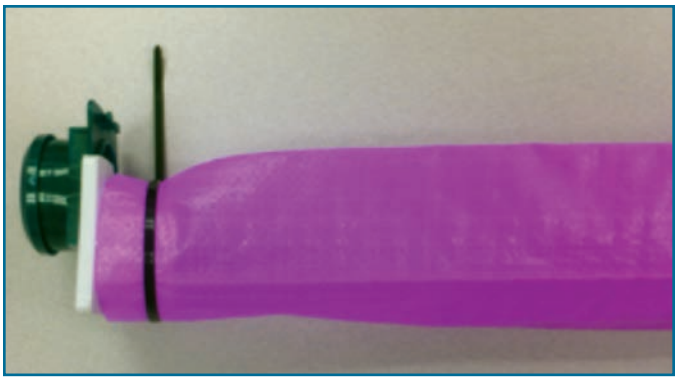

Figure 6. Insertion gate shown with sleeve used to reduce erosion at the head of the furrow.

ware and sell special hole punchers that will allow you to do this. The Natural Resources Conservation Service's (NRCS) *Phaucet* software is an example of a well-supported furrow irrigation help tool that is available on-line. When using poly pipe you can also use insertion gates which pop into the punch holes (Fig. 5). These can be adjusted like aluminum-gated pipe. Sleeves are available with connecting insertion gates and are effective at reducing soil erosion at the head of the furrow (Fig. 6).

Terms

The terms used for surge flow irrigation share many of the ones used in furrow irrigation.

Terminology shared between furrow and surge flow irrigation

Advance phase The phase or phases in which the dry furrow is wetted.

Out time The time required for water to reach the end of the furrow.

Soaking phase The phase in which the required application depth is infiltrated.

Soaking time The time it takes for the required application depth to infiltrate.

Recession phase The phase that starts when application of water to the furrow is stopped, and ends when water disappears from the soil's surface.

Opportunity time The total time that water is present at each point in the furrow.

Surge flow terms

On-time The time water is applied to one side of the surge valve before it is switched to the other side

Off-time The time water is not applied to one side of the surge valve (usually the same as "on-time"

Cycle-time The time required to complete one on/off cycle ("on-time" plus "off-time")

Cycle-ratio The ratio between the "on-time" and the "cycle-time" (note: a cycle-ratio of 0.5 is commonly used)

The advance phase of surge irrigation consists of a series of surges or cycles to get the water to the end of the furrow. Once the advance is complete, the soaking (or fill) phase consists of the cycles needed to fill the root zone with the targeted amount of water.

Determining surge cycle times

General guidelines

1. The advance phase should be completed in 4 to 6 surges.
2. The next to the last advance phase should stop just short of the end of the field.
3. Cycle times should be such that individual surges do not overlap or coalesce.
4. Furrow stream (gpm per row) should be near the maximum non-erosive value.

Surge soaking time

Once the water has reached the end of the furrow, the on-time for the soaking phase will normally be shorter than for the advance phase. As a starting point, set the soaking phase at about 75 percent of the advance on-time.

The goal is to minimize tailwater loss while still allowing sufficient soaking at the lower end of the furrow. Soaking on-times that are too long create excessive runoff; soak cycles that are not long enough, put too much water on the upper end of the furrow and not enough on the lower end.

Once you achieve the best soaking on-time, continue the surges until you reach the desired application depth. A soil probe is useful for measuring application depth.

NRCS Guidelines

The USDA Natural Resources Conservation Service (NRCS) uses two basic approaches for managing surge irrigation. Automatic valves allow you to experiment with both approaches. You can update the valve's programing based on the **time** or **distance** that the advance reaches certain points along the furrow. The controller can also automatically calculate variable cycle times based on such factors as soil type, length of furrow and slope. As with continuous furrow irrigation, NRCS recommends using the maximum non-erosive furrow stream size with the following two approaches:

I. The variable-distance, constant-time method.

You select an on-time which is usually the amount of time it takes for the first surge to advance a quarter of the furrow length. This on-time is repeated until the advance is complete.

When the advance reaches the end of the furrow, NRCS recommends reducing the on-time for the post-advance surges so the wetted advance reaches 75 to 80 percent of the furrow length by cutoff. This allows the irrigation water to roll-on to the end of the furrow and minimizes tailwater losses.

II. The constant-distance, variable-time method.

The on-time during the advance phase is set so that the advance progresses a set distance during every surge (such as 20 to 25 percent of the total furrow length). The post-advance phase is dealt with as in I above.

Cycle times in surge irrigation will vary depending upon soil texture, slope, and furrow length.

- Surge works better on leveled fields and furrows with only small slopes.
- On soils with low intake rates such as heavy clays or compacted soils, surge is unlikely to reduce advance times below those of continuous flow. It may, however, provide a more uniform application of water.
- Surge is typically the most beneficial during the first few irrigations following tillage. Later in the season when the furrows are smooth, there tends to be less difference between surge and continuous flow.

Flow requirements

As in conventional furrow irrigation, the largest stream (gpm per furrow) that does not cause serious erosion will give the best results. You need a minimum of 15 to 25 gpm per furrow to see benefits from surge irrigation.

For surge irrigation to succeed, you also need a constant flow rate. If you take water from irrigation canals, be aware that fluctuating water levels in the canal will, in turn cause the flow rate to fluctuate as well and give you poor results.

In irrigation districts, the term "head" is commonly used to refer to the flow of water at the farm turn-out. While in general, one head of water is equal to 450 gpm, this is not a precise number and is often just estimated. Your flow rate should be measured directly. Some irrigation districts and NRCS offices have portable propeller test meters (Fig. 7) and will measure the flow rate for you.

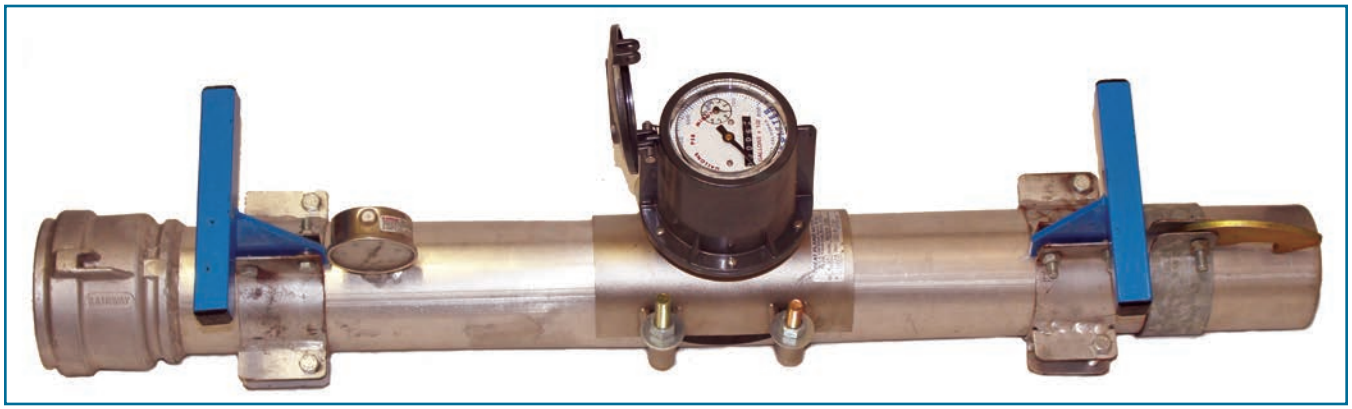

Figure 7. Potable propeller test meter equipped with a pressure gage, quick-connects and handles for insertion into existing water supply pipelines for measuring flow rates.

These portable test meters are available with handles and a pressure gauge, and come equipped with "quick-connects" allowing for simple insertion into exiting alfalfa valves and water supply pipelines. Straightening veins improved accuracy when measuring flows in pipelines with shorter straight sections. Straight sections of pipelines are needed equal to at least 10 pipe diameters downstream and 5 pipe diameters upstream of the meter for accurate flow measurement. It is usually best to use a test meter that is a smaller diameter than the existing pipeline to ensure the test meter flows full. If you want surge to succeed, don't guess your flow rate—measure it. Saddle meters are available and recommended for installation in existing pipelines for continuous flow measurement (Fig. 8).

Figure 8. Saddle flow meter which can be installed into an existing pipeline by cutting a hole in the top of the pipe. Meter shown has an optional digital output for use with irrigation control and monitoring systems.

Will surge work for you?

A simple test is to run a few furrows of continuous flow alongside furrows in which flow is interrupted and reapplied. If the rate of advance is greater with the interrupted streams, surge would work on your soils. Keep in mind that the soil in wheel rows is typically compacted which slows the infiltration rate and speeds the advance time. Do not use these rows for testing.

A more effective test would be to irrigate one block of land using surge and another block with continuous flow, then measure the depth of water penetration on both with a soil probe or soil moisture sensors. If the depth of water penetration at the lower and upper sections of the furrows is more uniform with surge, then surge would work for you.

Surge flow is not magic, and it is difficult to predict whether it will work for a particular situation. However, where it does work, there are significant benefits.

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