# EVALUATING YOUR IRRIGATION SYSTEM

Blaine R. Hanson[1]

Keys to effective irrigation water management include applying water as uniformly as possible and applying the right amount of water. The information presented herein addresses both of these aspects.

## IRRIGATION WATER MANAGEMENT MADE SIMPLE

Effective water management requires knowing the relationships between flowrate into the field, acres irrigated, irrigation times, and the amount of applied water. The following equation can be used to provide this information:

$$Q \times T = 449 \times A \times D$$

where: Q = flow rate of water being applied to the field in gallons per minute;
T = actual hours used to irrigated the field;
A = acres irrigated;
D = inches of water applied.

The following questions can be answered using this equation:

- **How many inches of water are applied during an irrigation?**

$$D = \frac{Q \times T}{449 \times A}$$

*Example 1:* How many inches are applied to 40 acres where the pump flow rate is 300 gpm and irrigation time is 22 hours per day for 10 days?

Q = 300 gpm;
A = 40 acres;
T = 22 hours per day x 10 days
220 hours.

$$D = \frac{300 \text{ gpm} \times 220 \text{ hours}}{449 \times 40 \text{ acres}}$$

= 3.7 inches

**What flow rate is needed to irrigate the field?**

$$Q = \frac{449 \times A \times D}{T}$$

*Example 2* What flow rate is needed to apply 3 inches of water over 100 acres with a total irrigation time of 180 hours?

$$Q = \frac{449 \times 100 \text{ acres} \times 3 \text{ inches}}{180 \text{ hours}}$$

= 748 gallons per minute

[1]Corresponding Author: Blaine R. Hanson, Irrigation and Drainage Specialist, University of California, Davis, CA 95616

- **How many acres can I irrigate with my water supply?**

$$A = \frac{Q \times T}{449 \times D}$$

*Example 3.* How many acres can I irrigate with a flow rate of 200 gpm? The desired depth to be applied is 3 inches per set, each set is 12 hours long, and the number of sets is 10.

T = 12 hours per set x 10 sets
  = 120 hours;

$$A = \frac{200 \text{ gpm} \times 120 \text{ hours}}{449 \times 3 \text{ inches}}$$

= 17.8 acres or 18 acres.

- **How long should I irrigate?**

$$T = \frac{449 \times A \times D}{Q}$$

*Example 4* How long should I operate my irrigation system to apply 4 inches over 80 acres? The flow rate into the field is 600 gpm.

$$T = \frac{449 \times 80 \text{ acres} \times 4 \text{ inches}}{600 \text{ gpm}}$$

= 239 hours of operation

## SPRINKLER IRRIGATION

Efficient sprinkler irrigation requires applying the right amount of water as evenly or uniformly as possible. Applying the right amount of water, in turn, requires knowing the soil moisture depletion, the application rate, and the depth applied.

<u>Estimating Application Rate and Depth Applied</u>

The following equation can be used to estimate the sprinkler application rate:

i = (96.3 x q)/(Sm x Sl)

where:

i = average application rate (inches per hour)
q = average sprinkler discharge (gpm)
Sm = spacing along mainline (feet)
Sl = spacing along lateral (feet)

The sprinkler discharge can be estimated by dividing the pump capacity by the number of sprinklers, or by inserting a hose over the sprinkler nozzle and measuring the time required to fill a five-gallon container.

The average depth of applied water can be estimated by multiplying the application rate by the set time, or:

$D = i \times T$

where:

$D$ = average depth applied (inches);
$T$ = set time (hours)

Estimating Irrigation Efficiency

Irrigation efficiency can be estimated by dividing the depth of beneficial use by the average depth applied, or:

$E = BU \times 100/D$

where

$E$ = irrigation efficiency (%)
$BU$ = beneficial use (inches)

The soil moisture depletion is the major component of BU. The soil moisture depletion can be estimated from CIMIS data, soil "feel" method, or neutron probe data. Another common component of BU is the leaching requirement, which is normally less than 5% for areas using surface water for irrigation.

Irrigation efficiencies should be 70% to 80% for hand-move and wheel-line systems, 80% to 90% for solid-set systems, and 80% to 90% for linear-move and center pivot systems. If the actual efficiency is less than these values, the set time should be reduced using the following equation:

$T = (BU \times 100)/(E \times i)$

where:

$E$ = desired irrigation efficiency

Example

| | |
|---|---|
| pump capacity | = 300 gpm |
| number of sprinklers | = 60 |
| mainline spacing | = 60 feet |
| lateral spacing | = 40 feet |
| soil moisture depletion | = 3 inches |
| set time | = 24 hours |

1 Calculate the average application rate:

$q$ = pump capacity/number of sprinklers = 300 gpm/60 = 5 gpm
$i$ = (96.3 x 5 gpm)/(40 feet x 60 feet) = 0.20 inches per hour

2. Calculate the average depth applied:

$D$ = 0.20 inches per hour x 24 hours = 4.8 inches

3 Calculate the irrigation efficiency:

$E$ = 3 inches x 100/4.8 inches = 63%

4. Calculate the set time needed for good efficiency for a hand-move system (desired efficiency = 75%):

$$T = (3 \text{ inches} \times 100)/(75 \times 0.20 \text{ inches per hour}) = 20 \text{ hours}$$

Improving Sprinkler System Performance

The performance of a sprinkler system can be improved by the following measures

1. Know the application rate and average depth applied.
2. Avoid over-irrigating. Over-irrigation means applying water in excess of the soil moisture depletion in the parts of the field receiving the least amount of water. Reduce over-irrigation by decreasing the set time.
   Irrigate during low wind periods (wind speed of less than 10 mph). Sprinkler uniformity is greatly reduced at wind speeds greater than 10 or 15 mph.
4. Offset lateral locations to improve seasonal uniformity. In offsetting, the lateral locations of the current irrigation are midway between the lateral locations of the previous irrigation.
5. Use the same nozzle size throughout the irrigation system. Mixing nozzle sizes results in nonuniform application rates.
6. Use flow-control nozzles for excessive pressure variations. Pressure variations of more than 20 percent between the pressure of the first nozzle (closest to the pump) and last nozzle will cause nonuniform application rates. Flow-control nozzles reduce the variability in application rate caused by pressure variability. Flow-control nozzles are sized according to their discharge rates (gpm).
7. Repair leaks in the irrigation system and replace or repair malfunctioning nozzles.
8. Prevent crop interference by using properly size risers.
9. Maintain adequate pressure by adjusting the pump impeller (semi-open impellers), repairing or replacing a worn pump, or reducing the number of laterals operating.

## SURFACE IRRIGATION

Efficient surface irrigation requires reducing deep percolation and surface runoff losses. Water that percolates below the root zone (deep percolation) is lost to crop production, although deep percolation may be necessary to control salinity. Deep percolation can be reduced by improving the evenness of the applied water and preventing over-irrigation. Surface runoff can be captured with a tailwater recovery system and used on lowerlying lands or recirculated on the field being irrigated.

Uniformity of Infiltrated Water

One way to reduce deep percolation losses is to apply water more evenly throughout the field. The greater the evenness or uniformity, the greater the potential for reducing deep percolation. The uniformity of infiltrated water is measured by the distribution uniformity - an index of the evenness of the applied water.

In surface irrigation systems, uniformity depends on the time required for water to flow across the field (the advance time), the irrigation set time, and the variability of the soil. Because of the advance time, more water infiltrates at the upper end of the field (the beginning of the furrow) than at the lower end (the end of the furrow), resulting in nonuniform infiltration.

Uniformity can be improved by getting the water to the end of the field faster - that is, by decreasing the advance time. The methods recommended for decreasing the advance time are as follows:

Reducing the run length by half. This is effective for field lengths of 1,000 feet or longer. The set time must then be reduced by at least half to prevent over-irrigation. This can reduce deep percolation by at least 50 percent.

Increasing the furrow or border in-flow rate. The set time must be reduced by an amount equal to the difference between the old and new advance times. This measure may not be effective on cracking soils.

Improving slope uniformity. Grade reversals and excessive undulation can increase advance times. Laser grading can greatly reduce slope non-uniformity.

4. Using furrow torpedoes to smooth the furrow surface and to compact the soil surface. Torpedoes may have little effect on cracking clay soils.

Since these methods will increase surface runoff, tailwater recovery systems must be used to recirculate the tailwater either onto the field being irrigated or for use elsewhere. If the tailwater is recirculated, additional furrows or borders should be irrigated in order to stretch limited water supplies. Tailwater can also be reduced through "cutback irrigation," in which the furrow flow rate is decreased once the advance is completed.

Estimating Uniformity

The uniformity of a surface irrigation system can be quickly estimated by calculating the advance ratio - which is the elapsed recession time at the end of the field divided by the elapsed advance time. (Elapsed times are measured from the time the water is turned on). The following guidelines can be used to estimate the distribution uniformity from the advance ratio:

Sandy Soils/Sandy Loam Soils (Cultivated Prior to Irrigation)

| **Advance Ratio** | **Distribution Uniformity** |
|---|---|
| 1.0 - 1.5 | less than 60% (poor) |
| 1.5 - 2.0 | at least 75 - 80% |
| 2.5 - 3.0 | at least 80 - 85% |
| 4.0 - | at least 90% |

Loams/Clay Loam Soil (Cultivated Prior to Irrigation)

| **Advance Ratio** | **Distribution Uniformity** |
|---|---|
| 1.0 - 1.25 | less than 70% (poor) |
| 1.5 - 2.0 | at least 80 - 85% |
| 2.5 - 3.0 | at least 90% |

Surge Irrigation

Surge irrigation means cycling water on and off while the water advances. This cycling or surging reduces the soil infiltration rate to less than that which would occur under conventional irrigation. Under surge irrigation, at least 30% to 40% less water is required for complete advance across the field. A surge valve is used to cycle the irrigation water.

Surge irrigation is particularly effective in coarse soils, but may have little effect in clay soils

Following are some factors to consider in using surge irrigation:

Four to six cycles are recommended during water advance.

2. On-time should equal off-times.
3. The initial on-time can be estimated by dividing the normal advance time by 8 for field lengths of about one-quarter mile, and by 12 for one-half mile field lengths.
4. The furrow flow rate should be at least equal to the normal furrow flow rate.
5. During the runoff stage, on-time must be kept short (10 to 20 minutes) to prevent excessive runoff.