CO652.0907 State Supplement

Irrigation Water Management

Irrigation system application is based on managing the proper amount of water to the plant in order to: meet crop needs, apply amounts adequate for the soil, and avoid runoff while maintaining or improving water quality.

Water quality is also covered in Part 652, Chapter 13 and other NRCS references.

Water Needs of Crops

Chapter 4 of this guide discussed the crop water use requirements for your location. This information is based on past weather data calculations from crop water use equations. The crop water requirements are normally given in three ways - inches per day for the peak period of use; monthly use rates during the irrigation season; and for the entire irrigation season.

The relationship between the daily, monthly and yearly water use rates for a location is used to calculate the peak flow rate of the system (gpm) and the amount of water required to irrigate for the season (acre feet).

Example

From Chapter 4, Crops, the crop water use was calculated using IWR for grain corn in Boulder, CO. The average maximum consumptive use rate was in July and is 0.36 inches per day for a normal year. Using the attachment in Chapter 4, the daily peak use rate can be calculated from the following equation:

$U_p = 0.028 * (Um)^{1.09} * (I)^{-0.09}$

U_p – Daily peak consumptive use rate – in/day
U_m – Monthly peak consumptive use rate – in/month
I – Net irrigation application in inches

In Boulder, CO, the peak month is July at 7.32 inches. From the example in Chapter 4, the net irrigation application is 1”. The daily peak from the attachment in Ch 4 is:

$U_p = 0.034 * (7.32)^{1.09} * (1)^{-0.09}$

U_p = 0.30 inches per day

System Flow Rate

The flow rate for the system to apply this amount (0.42 in/day) can be calculated using the following equation;

Q T = D A

Q – net flow rate in cfs
T - time in hours
D – depth in inches
A – area in acres

The system flow rate for the above example on a 75 acre field operating 22 hours a day would be:

Q = 0.30 * 75 / 22

Q = 1.02 cfs

This is the net amount of flow required. Each type of irrigation system has uniformity limitations. Center pivots have variations in application along the pivot. Wind drift and evaporation from the crop also cause variation. Surface irrigation systems have high application rates near the head of the field and lower rates as the water moves across the field. Runoff and deep percolation can also be a problem with surface irrigation systems. The lack of uniform application results in needing to apply more water than the net amount to overcome the inherent system limits. This is called the efficiency of the system.

The net amount of flow required would be increased based on the efficiency of the planned system. In the example, assume that a pivot is going to be used. Assume the average efficiency would be 85%. The gross amount of water required would be the net divided by the efficiency.

Gross Flow Rate = Net Flow Rate / Eff

Gross Flow Rate = 1.02 cfs / 0.85

Gross Flow Rate = 1.20 cfs

This is the flow required at the center pivot to meet the crop need during the peak use rate. This means that during less water use periods (spring and fall) the system does not need to be operated continuously to meet the crop water use. Monitoring soil and plant water levels can provide information on both watering frequency and amounts.

Management Allowed Depletion

Not all of the water in the soil is available to the crop. The management allowed depletion (MAD) was explained in Chapter 3, Crops and is found in Table 3-3 for most crops. For the example above using grain corn the MAD is 50%.

The rooting depth of the crop is needed to determine how much of the soil profile is used. Table 3-4 provides some rooting depth for crops. For grain corn the rooting depth is 3-4 ft (Table 3-4), for this example use depth of 36”.

In Chapter 2 Soils section 652.0204 (c), the available water holding capacity (AWHC) of the soil (gross) in the example was 4.7 inches for the 36” soil depth.

The net amount of water to be replaced during each irrigation is the gross AWHC times the MAD.

Net Irrigation = Gross AWHC * MAD

Net Irr = 4.7 inches * 50%

Net Irr = 2.35 inches

This net irrigation amount is the *maximum* amount of water that the crop can use before yield reduction or plant quality can be affected.

Frequency

The frequency of irrigation is based on the net irrigation requirement and the daily consumptive use rate. The frequency of irrigations is the net irrigation divided by the peak daily use rate.

Frequency of Irr = Net Irr / Peak Daily Use Rate

Frequency of Irr = 2.35” / 0.30 in/day

Frequency of Irrigations = 7.8 days

Since the daily peak use rate was used to determine the frequency, the 7.8 days is the maximum time between irrigations during the hottest time of the year. Longer frequencies can be used during lower daily use rates, when the crop is small or during cooler times of the year.

Solid set systems (including hand lines and wheelines) use the frequency to determine cycle rates, system total flow, and design. The irrigator must cover the field in the frequency to ensure adequate water applications.

On continuous move system (linear and pivots) the system speed can be adjusted, the application time, and amount of water per irrigation can be changed. These types of systems can have a frequency that is adjustable. Therefore the frequency is generally not a concern on these types of system. The flow rate is more of a concern – to meet the daily peak use rate by the systemand to apply water without runoff.

When planning irrigation water management on center pivots operated as a wiper system (partial circle), sideroll systems, or linear move systems, the system should be operated in one direction while irrigating, and walked back dry to the starting point in the field. Walking the system back and advancing the irrigation in the same direction each time allows for a more uniform application of irrigation water, and helps to prevent crop stress.

Summary

On the 75 acre field of corn in Boulder, the pivot system must apply 0.30 inches per day net. Assuming that water is available for 22 hours with a system efficiency of 85%, the flow rate is 1.20 cfs. The pivot must apply 0.30 inches net in one day (or 0.60 inches in 2 days). The frequency of irrigation on pivots is generally a management decision. Longer frequency can usually reduce the effect of surface evaporation and get more water into the soil. However it is very possible that runoff will occur on the outer end of the pivot when long frequencies are used, especially during early stages of crop growth.

In this example the maximum frequency is 7.8 days between irrigations. At this frequency, the amount of water needed to be applied would be 2.35 inches.

As mentioned above, system application rates for pivots can be a problem on the outer end where the soil intake may not be adequate to infiltrate the water without runoff. Table 2-6, in Chapter 2, provides some soil intake ranges by soil texture.

The National Engineering Handbook (NEH) Section 15, Irrigation, has chapters to work through application rates by system. Refer to Chapter 4 for surface irrigation, Chapter 7 for Micro Irrigation systems, and Chapter 11 for Sprinkler systems for more details on application rates.

Water Measurement

Due to the number of measuring devices available and the fact that most were described in Part 652.0704 and 652.0906, additional descriptions were not considered necessary. The exception is the ramp flume, which has been developed fairly recently and therefore is included to provided the reader with new knowledge. Software for use with the Ramp flume can be found on the NRCS computer. It is also available from the NRCS Water and Climate Center web site at:

http://www.wsi.nrcs.usda.gov/products/W2Q/water_mgt/Irrigation/irrig-mgt-models.html

Example

A typical ramp flume design is as follows:

Estimated flow at site: 12 cfs
Ditch cross section is rectangular
Width 6 ft
Channel Depth 2 ft
Elevation top wall 101.2
Bottom channel 99.2

Ramp flume dimensions
Ramp length 4 ft
Slope on ramp 2.67:1
Level section width 1.5 ft
Level section height 1.5 ft

Table of flows

Depth	0.3’	0.6’	0.7’	0.8’
Flow	3cfs	8.7cfs	11cfs	13.4cfs

The Bureau of Reclamation publishes the *Water Measurement Manual*, a comprehensive guide on water measurement techniques and devices. A link to this manual can be found at:

http://www.usbr.gov/pmts/hydraulics_lab/pubs/wmm/.